Soil Micromorphology of Archaeological Deposits with particular reference to floor surfaces on settlement sites in the Western Isles, Scotland

By

Adrian R Tams B.Sc. (Hons), M.Sc.

Declaration

I declare that this thesis has been composed entirely by myself and that the work for it has been carried out by myself as part of my research.

Adrian R Tams
July 2003

Acknowledgements

Abstract

The research is concerned with the analysis of four field identified floors from three multi-period archaeological sites (Bostadh Beach, Isle of Lewis, Cladh Hallan and Bornais, South Uist) in the Western Isles, Scotland.

The method employed in the analysis of these four floors is soil micromorphology, a technique that is now established in archaeological analysis, but one that has been seldom applied to deposits in the Western Isles. In particular, the application of the technique to floor sequences in the Western Isles is unique, given that floors have rarely been analysed or even substantially documented in archaeological excavations of structures in the islands.

There are three main aims in the analysis of these floors: 1) to highlight the significance and importance of microscale analysis of floors, 2) to determine their composition, formation and possible use, 3) to establish microstructural criteria and characterisation of different materials used for floors.

The analysis has revealed that the floors between the three different sites are extremely different. At Bostadh, the floors are dominated by highly organic materials, whilst Cladh Hallan and Bornais floors are sand dominated with fine organic matter. The most interesting feature of the analysis is that a floor which has been described as a singular deposit in the field, can be composed of upto 21 individual floor layers. This has implications for the information that a potential floor deposit can yield, particularly with regard to the function and use of space within a structure over a depositional sequence.

Micromorphological descriptions followed the international terminology of Bullock et al (1985) and Fitzpatrick (1984), with some adaptations. Organic description has detailed that different types of peat were used at Bostadh, whilst mineralogical analysis has indicated the possibility of cleaning or abandonment episodes. Analysis at Cladh Hallan has aided in the interpretation of the use of space within the structure, although these results only form part of on-going research elsewhere.

The research has successfully described micromorphological characteristics of floors developed from two different materials, and has highlighted the implications and importance for the archaeological record of a settlement, through the analysis of floors. Recommendations concerning the collection and sampling for future floors have also been made.

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Chapter One

Introduction and Literature Review

1.0   Introduction

The research presented in this thesis is based upon the analysis of archaeological sediments, notably proposed 'floor surfaces', through the application of thin section micromorphological techniques. Three separate settlement sites were selected for the research, the first being Bostadh Beach, Great Berneradh, Isle of Lewis, Scotland (Neighbour, 1996, 2001) and the second Cladh Hallan, South Uist, Scotland. The third was found at Bornais, South Uist, Scotland. All three settlement sites have been tentatively dated as multi-period, with Iron Age to Norse remains being uncovered at Bostadh. At the time of writing, the other two sites are still actively being investigated. Bronze Age to Iron Age remains have so far been uncovered at Cladh Hallan (Parker-Pearson *et al.* 2000) and Iron Age deposits being revealed at Bornais (Sharples, 1996; 2000).

The proposed 'floor surfaces' which form the basis of the research were taken from one figure of eight building, House 3 at Bostadh Beach and House 401, a putative Roundhouse at Cladh Hallan. At Bostadh, a series of floor levels were excavated from within structures H, J, and L, whilst at Cladh Hallan, floor levels from within House 401 were sampled on a quadrant format. At Bornais, a structure excavated within a mound in the machair was sampled. The deposits within this structure have been proposed as two successive houses on the same site, based on the presence of a recognisable floor in contexts both pre-burning and post-burning of the structure. These were labelled as House 1 and House 2 by the excavator of the site. The nature of the intervening burnt deposit is also considered.   As a possible example of

collapsed roof timbers and their covering materials, this deposit introduces the potential for this technique to differentiate between floors, narrowly defined, and other materials which originally formed components of first floor (as for example, in Broch towers, see Armit (1996)) or roofing.

Bostadh Beach was excavated jointly by the Centre for Field Archaeology, University of Edinburgh and by postgraduate students from the Department of Archaeology, University of Edinburgh. The sites at Cladh Hallan and Bornais form part of the on going research by Sheffield University Environmental Archaeology Research Campaign in the Hebrides (SEARCH), in collaboration with the Universities of Bournemouth and Cardiff.

This first chapter has been divided into two sections. Section 1.1 explains the nature of 'floor surfaces', core concepts in micromorphology, and its application to archaeology. Section 1.2 examines the concept of floor levels in archaeology and reviews the existing literature on the formation of floors. This is followed by a review of floors that have been documented in Scottish excavations.

1.1 An introduction to the concepts of micromorphology and their application in archaeological contexts.

1.1.1 The historical development of micromorphology

The microscopic examination of geological samples has a long history, but the application of the technique to unconsolidated sediments is a far more recent development. The publication by the Austrian scientist Kubiena of his manual *Micropedology* (Kubiena, 1938) is widely regarded by many micromorphologists, as the beginning of the micromorphological approach to soil fabric. By taking undisturbed blocks of soil from exposed soil faces using what have become known as 'Kubiena tins', setting these blocks in resin and carefully preparing 30μm thick thin sections for microscopic examination, it is possible to examine soil components effectively *in situ*. The great advantage of micromorphology over other soil

analytical techniques is the undisturbed nature of the samples. This allows detailed examination of the soil constituents and more importantly the elucidation of their relationships both in space and time. These microscopic features are invaluable for understanding the nature of pedological and sedimentological processes, and for determining the chronology of events through the relative spatial hierarchy of the micro-features of any given soil sample. Micromorphology is therefore underpinned by the concept of a soil as 'an ordered system with a construction of its own, a particular dynamics (of physical and chemical processes) and a particular biology (of all organisms and their activity)' (Kubiena 1970, pp3-4).

Since the initial work of Kubiena the fundamental practice of soil micromorphology has changed little, however the approach taken to the analysis and interpretation of the thin sections has seen many developments. Kubiena (1938) set out a morphoanalytical approach devoted to the description and illustration of the soil fabric, but as the applications of soil micromorphology grew, a new approach was needed. This new direction was taken by Kubiena in 1953 after the publication of his book *The Soils of Europe*, which applied a morphogenetic approach designed to help classify soil types genetically. For the first time a descriptive terminology was also offered, which implied generic interpretations of soil fabric features.

The rapid adoption of soil micromorphology as an analytical tool by a large number of different and varied disciplines led to the development of many descriptive systems, each tailored to their particular application. Typical examples of disciplines using the technique include agriculture, engineering, geomorphology, palaeoclimatology, soil microbiology and soil zoology (Fitzpatrick, 1984). These disciplines soon realised that thin sections can yield very useful information, as on the one hand the data can be used in an analytical or interpretative manner, and on the other to predict behaviour (Fitzpatrick, 1984). Comparability between the applications of soil micromorphology within disciplines demanded a single, universally applicable, morphoanalytical system. This concentrated purely upon the description of the soil features allowing scope for subsequent independent and individual interpretation of features, no matter what the application. The first attempt

at such a system was made by Brewer (1964), and later the *'Handbook for soil thin section description'* was prepared on behalf of the International Society of Soil Science (I.S.S.S) (Bullock *et al.* 1985).

This *Handbook* is now almost universally accepted although disagreements over generic interpretations of soil fabric features still arise. A study by Murphy and co-workers (1985) found that a high degree of concurrence exists in the basic descriptions of thin sections amongst researchers using the handbook. More recently, Stoops (1998) produced a simple key as an aid to the handbook. This key aims to rationalise some of the terminology used and to provide simple, practical distinctions among the various classifications. Stoops is also currently rewriting the *'Handbook'*, the new version of which is to be published during 2002. This is largely the result of consultation with other micromorphologists, working in pedology and archaeology. Members of the Soil Micromorphological Working Group in Archaeology have also contributed to the new Handbook, as a result of the vast amount of micromorphological research that has taken place over the last decade. This research has revealed that the original *Handbook* was not particularly suitable for the description of all archaeological sediments, new chapters have therefore needed to be included in the new text.

An alternative description to that of Bullock and co-workers (1985), is that proposed by Fitzpatrick (1984), who states that there is considerable controversy over the use of some descriptive terms in micromorphology, namely 'fabric' and 'structure'. Fitzpatrick (1993) argues that some of this divergence is due to the progressive development of the subject, while a considerable part is due to the translation into English of some of the concepts that were initially developed in other disciplines and languages.

Fitzpatrick maintains that the major problem in micromorphology is concerned with the notion of soil fabric. For example in geological terms, and in the German language, the concept of fabric is termed *Gefuge* which correctly translated into English means structure, but it has been erroneously translated to mean fabric

(Altemuller, 1962; Sander, 1970). In the German concept, *Gefuge* means all of the features in rocks, their relationships and internal characteristics. Whereas for most workers in soil science, fabric is the mutual arrangement and relationships between particles within the soil as a whole and within the various features, while structure is the type and degree of aggregation (Fitzpatrick, 1993). These concepts are well-established in English language soil science and there seems little need to change them and thereby to introduce confusion. Fitzpatrick (1993) suggests however, that there is a need for a comprehensive concept for totality of all the features in a specimen of soil and for this the terms 'ensemble' or 'assemblage' can be used.

This author believes that micromorpholology is already filled with too many alternatives for the description of soil characteristics, and there is no need to re-introduce or re-phrase terms that are already universally accepted and in use. Archaeological micromorphology however, is still a relatively new method and the present systems of soil description did not evolve with this application in mind. Therefore, at present, there is a large amount of confusion amongst archaeological micromorphologists, due to there still being a relative lack of well-published field evidence and a general lack of descriptions of one particular feature. This is especially so with the description of floor surfaces in the British Isles, as the present limited research on Near Eastern floors (Matthews 1995, 1996, 2001 Matthews *et al.* 1997) is not applicable to the organic-rich deposits found in later prehistoric floors of the Outer Isles in Western Scotland.

Fitzpatrick (1993) argues too that the situation with regard to the descriptor 'soil matrix' is also confusing. Generally, the 'matrix' refers to the fine material enclosing coarser material, without the definition implying any particular size limits. Thus, a matrix may be dominantly clay surrounding sand particles or silt enveloping particles of gravel. In an attempt to overcome this difficulty Brewer (1964) introduced the concept of 's-matrix' which refers specifically to material including sand, silt and clay sized particles and also discrete pores within peds or massive soil material. Bullock and others (1985) however, propose that this should be termed 'groundmass', whilst Stoops and Jongerius (1975) suggested that soils can be divided

into two particle size classes based on analysis of the particular soil thin sections. Fitzpatrick (1993) argues that this system has a number of deficiencies, the main one being the assumption that soils generally have bimodal peaks in their particle size distribution. Although this may be the case for certain highly weathered soils of tropical countries where the silt fraction is either very low or absent, it certainly does not apply to soils developed from sediments such as glacial deposits. Based on these arguments Fitzpatrick (1993) suggests that the terms illustrated in Table 1.1 should be applied when dealing with the concepts of fabric and matrix.

For the purposes of this research, the thin sections were described using the universally accepted system of Bullock and *et al* (1985), with the exception of the organic components of the sections, which were described using Fitzpatrick's nomenclature and concepts (1984). Bullock *et al.* (1985) was chosen for the descriptions because it is an internationally standardised terminology accompanied by procedures which are based on morphological attributes, rather than genetic classifications. These attributes allow micromorphology to be applied to a wide range of natural and anthropogenic deposits (Bullock *et al*, 1985; Courty *et al*, 1989).

However, this system proved to be not so suited to the description of the organic components, as there were not enough visible plant residues. Hence, Fitpatrick's system was much more suitable in providing descriptive terms in relation to well decomposed organics, and was deemed much more suited to the research.

As well as the traditional use of micromorphology in determining soil genetic classification, the potential applications for such information are great. In soil science the investigation of evolutionary pathways of soil formation, including the weathering of primary minerals (e.g. Nater and Bouboid 1990; Read 1998) and the elucidation of specific pedological processes (e.g. Aurousseau 1983; Farmer *et al* (1983), are key areas of research. In geomorphology the relationships between erosional and stable periods of landscape development have been analysed (Macphail 1992) and arid environments (Stoops and Poch 1994) have also been examined in detail. Soil micromorphology has been used in agricultural research to study the

effects of tillage practices, crop species, and remedial measures upon soil structure and fertility (Fortun *et al.* 1989, Mackie-Dawson *et al.* 1989). Land management studies can also make use of micromorphological techniques. By providing information on soil fertility and the likely response of particular soils to tillage, areas of prime agricultural land can be identified. Details of the soil's physical response to compression is needed in civil engineering, whilst a knowledge of soil drainage properties is important to developers, farmers and conservationists alike.

The time scales over which micromorphology has been applied have likewise been diverse. In some agricultural applications the concern lies with changes in soil structure that may occur over a matter of days following tillage. Archaeologists on the other hand are concerned with soils and sediments that may date from a few thousand years, although in some cases the anthropogenic influence upon these soils may only cover tens to a few hundreds of years, and in some instances even briefer spans. Quaternary scientists frequently look at the micromorphology of palaeosols to interpret the events of the past 2.5 million years (Kemp 1985).

The main crux of micromorphological interpretation involves the comparative description and analysis of samples within and between different soil units (horizons and pedons). These analyses are based upon the nature and organisation of the soil's microfabric, and interpretation relies upon the collected body of experience and comparison with reference slides. The experience of the researcher and their access to relevant literature and collections of reference samples from known contexts are, therefore, very important. A study of the comparability between researchers found that it was during interpretation that significant differences appeared, these differences being based largely upon the frame of experience of the individual researcher (Murphy *et al.* 1985). Much emphasis has, therefore, been placed upon the use of micromorphology in conjunction with other micro-, and also bulk analytical techniques in order to bring as much objectivity as possible to the discipline (Brewer 1964, Carter and Davidson 1998, 2000 ; MacPhail 1998).

This author believes that the coupling of micromorphology with other techniques such as image analysis, SEM, magnetic susceptibility and amino acid residue analysis, has enabled micromorphology to be much more quantitative in its analytical approach. The use of image analysis with micromorphology has enabled the quantification and estimation of pore space and porosity of a soil or sediment to be much more reliable than the use of point counting. This latter technique relies on the judgement and accuracy of the researcher, and introduces much more error when compared with computerised analysis. Image analysis equipment is also useful for determining the amount of charcoal, bone fragments and other anthropogenic inclusions within archaeological sediments. Pioneering work using image analysis with micromorphology has been carried out at the University of Stirling (Adderley *et al.* 2000, 2001a,b). This work has been very successful, not only in advancing the awareness of micromorphology as a discipline, but also introducing a whole new sub-discipline into the scientific field.

1.1.2 The role of micromorphology in archaeology

In Britain the first application of soil micromorphology to archaeology was made by Cornwall (1953) to soils buried beneath Bronze Age monuments in England. Cornwall continued to look at archeologically buried soils, but throughout the 1970's very little attention was paid to the discipline as an archaeological tool. Valentine, Dimbleby, Dalrymple and Romans were amongst the few active researchers to keep the application of micromorphology in archaeology alive in Britain at this time. In these early years much of the focus was upon archaeologically buried soils in terms of their pedological or environmental development rather than their anthropogenic history (Dalrymple 1958, Romans and Durno, 1971, Romans and Robertson, 1975). The 1980's, however, marked a turning point in the archaeological study of buried soils as micromorphology was used to illustrate the impact of man directly upon the soil. This approach became the focus of research, with major publications appearing from the end of that decade (e.g. Courty *et al.* 1989; Davidson and Carter. 1998; Gebhardt 1992; MacPhail *et al.* 1990).

Micromorphology has become a familiar method of analysis in archaeology. Due to the very generalised scheme of description, micromorphology has been successfully applied to a whole range of archaeological materials and has helped to provide answers to a few of the perennial archaeological questions when applied thoughtfully and appropriately. For example, Canti (1997, 1998) has provided answers to questions concerning the presence and formation of calcitic spherulites. Microscopic spherulites have been reported from a number of archaeological sites, frequently associated with fresh or burnt animal dung. Theories to explain their presence have centred around the views that they represent plant derived calcium oxalate that has passed through animal gut, and secondly, an unspecified calcium salt produced by the animal itself. In the 1997 paper, Canti investigated the presence of these features from Herbivore dungs. He concluded that the spherulites can be found in the dung of a range of herbivores grazing on calcareous pastures. On the limited evidence at the time, they appeared to be most common in sheep and intermediate in cow faeces, but were largely absent in rabbit dung.

Micromorphological analysis has also been applied to the remains of pottery and mortar. In this thesis the principal concern is the application of the technique to elucidate the formation of sequences of possible floor deposits within structures, more specifically upstanding stone-walled buildings in Iron Age settlements in the Outer Hebrides. Such substrates, under microscopic examination, as will be argued in more detail below, reveal clues not only about their sedimentological and pedogenic history, but may also include evidence about the nature of the ancient occupation and use of space within a structure.

The identification of the differential use of space in extensive occupational deposits by micromorphological means has been considered in well preserved Near Eastern 'tell' sites (Matthews, 1995, Matthews *et al.*, 1997). Exaltus and Miedema (1994) have addressed similar questions in studying deposits from Dutch Neolithic sites. Closer to the geographical focus of the present research, a study carried out on recently abandoned Scottish sites looking at activity areas including hearths and byres, identified microscopic soil features associated with settlement contexts

defined by other means, and supported this approach by the use of ethnographical material (Davidson and Carter 1998; Quine 1995.)

Soil pollen, ash, phytoliths, diatoms and molluscs may all be seen in thin section and alongside the pedological features of each analysed horizon/sample their presence has implications for both environmental landscape reconstruction and localised anthropogenic impacts. The origin of anthropogenic sediments, the souring of constructional materials and the elucidation of construction techniques are also archaeological questions for which micromorphology is ideally suited. For example, the origin of Roman-Saxon 'dark earth's' has been successfully investigated using micromorphology (MacPhail 1983). Furthermore, Canti (1994) showed a deposit previously assumed to be a soil material actually to consist of dumped weathered rock, and MacPhail *et al.* (1997) were able to identify the likely source of trees and sediments infilling a 1st century AD funerary shaft.

Goldberg and co-workers (1996) have successfully used thin section micromorphology to aid in the interpretation and identification of palaeobotanical remains within archaeological deposits. These authors revealed that smaller fragments of charcoal and botanical remains, examined in undisturbed artificially indurated samples and which would escape collection with standard flotation and sieving techniques, can furnish palaeobotanical information about the types of vegetal matter found on a site. Botanical remains are important on archaeological sites because they further furnish light on both natural conditions (climatic, edaphic or biotic) and on anthropogenic activities.

The main aim of their research was to cast more light on botanical material, which is usually lost or overlooked using only traditional palaeobotanical methods, by demonstrating how such material can be identified using micromorphology. The authors state that by using this technique, the original integrity of the sample and the geometry and composition of all its constituents are maintained.

The application of the micromorphological technique is a powerful tool when used alongside routine palaeobotanical analysis. The major advantage lies in the fact that thin sections provide botanical remains that are still in their sedimentary context and the plant material studied is also composed of much smaller particles that those recovered by traditional methods. Furthermore, the thin section technique is particularly suited to sites where human activities and diagenetic processes can bring about significant degradation of the botanical material, resulting in extremely small sized fragments.

The work of Goldberg and co-workers (1996) has also demonstrated that botanical analysis using thin sections is an efficient method for the ecological study of ancient environments on sites where traditional methods of analysis are not adequate to collect suitable material. Many archaeological materials, for example ceramics, plaster, daub and bricks contain botanical remains, particularly small tissue fragments. Employing traditional techniques, it is difficult to extract botanical remains from these samples, given the indurated nature of the material, but as Goldberg et al. (1996) state, thin sections represent a suitable method to overcome such situations.

This author believes that this application of thin section micromorphology is particularly suitable in archaeological contexts, given that all size ranges of fragments can be identified in a sample. However, these smaller fragments and also even some larger fragments do not always in fact survive: for example, fragments in floor layers may often have no visible structure due to fragmentation by compaction or the intervention of some other forces. This has been evident within the samples analysed for this thesis. Further, botanical fragments within daub and other building materials might not also survive in some circumstances, given the nature of the manufacture of such materials.

The production of thin sections is also expensive and very time consuming, therefore some element of selectivity must be borne in mind if the use of the thin section technique is to be employed for this kind of analysis. It would be a costly lesson to

learn if a set of thin sections were manufactured with the aim of investigating the botanical remains of floor deposits or a hearth for example, in any instance where it is highly likely that the charcoal and plant fragments structures are already destroyed beyond the point at which their recovery is feasible.

Finally, soil micromorphology has been used extensively in Europe for the identification of prehistoric agricultural activity. Just as modern agriculture affects soil structure and composition, ancient tillage has been assumed to have had similar effects. Evidence to support this assumption comes from experimental work (Gebhardt 1992) as well as from micromorphological examination of soils buried beneath prehistoric sites. However, the lack of structural indicators of agriculture in thin section must be treated with caution and cannot be assumed necessarily to indicate the absence of cultivation. Davidson and Carter (1998) found no such evidence in their study of recently abandoned traditionally cultivated soils on Papa Stour, Shetland.

1.1.3 The integration of micromorphology in archaeology

Micromorphology, whilst an undeniably analytical tool, can be criticised because of the element of subjectivity involved in the interpretation of thin sections. The integration of micromorphology within a holistic sampling scheme is therefore very important. The results of several analyses carried out upon the same material will not only maximise the information that is retrieved, but will usually also help to guide and support the interpretation offered. Traditional soil analytical techniques with direct relevance for archaeologists, including soil phosphate and magnetic susceptibility, have been successfully used alongside micromorphology in a number of projects (Allen and MacPhail 1987, Dockrill *et al.* 1994, MacPhail *et al.* 1997). More recently the analysis of lipids and amino acids as bio-markers for manuring and cultivation practices (Evershed *et al.* 1997, Simpson *et al.* 1997) has been successfully applied alongside traditional micromorphology. Further analysis at the microscopic and sub-microscopic level may also be used. Notable archaeologists are beginning to see the benefits of the application of image analysis techniques (Bryant

and Davidson, 1996) and of SEM and EDXDRA techniques (Fechner and Kleiner 1998, MacPhail *et al* 1997).

Today micromorphology has become a generally accepted practice in field archaeology. This acceptance has come about largely as the profile of micromorphology as an analytical tool has risen within the archaeological world, and its possibilities have expanded. Micromorphology is often associated with research work as opposed to being widely used in standard archaeological analysis, but this is changing with contract micromorphologists being employed more frequently by archaeological units in recent years to investigate a growing number of excavation related questions.

1.1.4 The applications of soil micromorphology in Scottish Archaeology

The application of soil micromorphology as an aid to archaeological interpretation is, in general, now well established (Bryant and Davidson, 1996). However there has been little application of the technique to research in the Western Isles of Scotland. Although the technique has been well exploited and successfully used for a large number of archaeological investigations in the Northern Isles (Simpson and Barrett, 1996, Simpson 1997, Simpson *et al.* 1998 a, b, Adderley *et al.* 2000,) as well as on South Uist (Schwenninger 1999) and Sutherland (McCullagh and Tipping, 1998, Acott, 1993).

Romans and Robertson (1983) first undertook the application of micromorphology in an archaeological context in Scotland. These authors used micromorphology to research the identification and interpretation of textural pedofeatures within ancient soils and sediments as their primary means of inferring past agricultural land use. However, the specific application of micromorphology to the archaeological context began in 1988, when the Archaeological Operations and Conservation (AOC) unit, of the then Historic Buildings and Monuments, began to collect samples from all archaeological excavations which the unit undertook (Davidson *et al.* 1992). At that

time, samples from 17 sites were prepared at the Department of Environmental Science, University of Stirling, and it was hoped that the collection of these samples by field archaeologists implied the existence of questions that could be answered by micromorphological interpretations (Davidson *et al.* 1992).

The first use of the technique in the Scottish archaeological context was to determine if there was any evidence for soil disturbance, for example, from cultivation or truncation prior to the construction of an ancient monument. This notion was first tested at the site of Castle of Wardhouse, Insch, Aberdeenshire. Three samples were collected from a 20 cm thick horizon buried beneath two phases of rampart construction. This horizon was interpreted in the field as a buried cultivated horizon and the aim of micromorphological examination was to check this interpretation and to determine if greater detail could be added. The micromorphology revealed greater detail than was initially thought, confirming the field hypothesis that the material represented a buried cultivated soil, but also revealed that the soil had been reworked by faunal activity (Davidson *et al.* 1992).

In 1992, Davidson and his co-workers stated that the potential of micromorphology as an aid to site interpretation was being gradually appreciated, with the result that questions regarding the origin of materials and sediments within archaeological deposits were becoming more common. Today, almost ten years on, the use of micromorphology in archaeology, and especially Scottish archaeology has grown immensely. The technique has been successfully used in pioneering research at the University of Stirling, where the technique has been applied to ancient farming and land use in the Northern Isles, particularly Orkney. This work is reviewed in section 1.1.4.2.

1.1.4.1 The Outer Hebrides

The most recent evidence for the technique being used in the Outer Hebrides is the contribution by Schwenninger (1999) to the publication of the excavation at Dun

Vulan, South Uist (Parker-Pearson and Sharples, 1999). This forms a part of the Sheffield Environmental and Archaeological Research Campaign in the Hebrides.

Schwenninger proposed three aims for this research:

- to provide essential extra information for the sequential reconstruction of pedo-sedimentary and post depositional processes.

- to furnish a sound basis for determining the properties and genesis of particular archaeological contexts.

And

- to derive evidence of past environmental change and human activity.

Schwenninger (1999) indicated that the general composition of the coarse grained and well-sorted groundmass in the set of observed sections was comparable with that of the surrounding coastal dune and machair sediments (Schwenninger, 1996) and the bulk of the material that was analysed appeared to be derived from this supply. In addition however, the thin sections from the site clearly reveal high frequencies of gneiss rock fragments, as well as opal silica, mainly derived from phytoliths and diatoms, which are often associated with microscopic inclusions of collagen, ash, charred plant material, calcareous spherulites and baked clay. Most of these special components can occur in natural soils, but their combined incidence in high concentration may be regarded as diagnostic indicators of artificially thickened and anthropogenically modified sediments directly associated with sustained human occupation and activity (Schwenninger 1999).

Samples for micromorphological analysis of floors were also collected at Cille Pheadair, South Uist (Parker-Pearson et al. 1996). Here four consecutive longhouses with associated outbuildings and midden deposits, forming a stratified occupation sequence from the late 10th of early 11th to mid-late 13th century were excavated. The

floors within the longhouses were mostly intact, with excellent preservation of materials both on and within the deposits. Detailed environmental sampling of the floors was undertaken with the aim of understanding the activities leading to the formation of deposits and subsequent post-depositional activities that have influenced the archaeological record (Smith *et al.* 2001).

Unfortunately the soil micromorphological analysis of these floors has not yet been undertaken. The descriptions of the floors of House 312 undertaken in the field, state that the floors appear to be constructed from a thin spread of dark brown clay sediment (Smith *et al.* 2001). However, as detailed from the micromorphological analysis in this thesis, field descriptions of floors are not reliable, as the floors in the Western Isles are often constructed from peat or fire ash, with no clay presence identified.

1.1.4.2 The Northern Isles and Northern Scotland

Elsewhere in Scotland, archaeological micromorphology has concentrated on the Northern Isles, primarily on excavations carried out by the Universities of Stirling and Bradford Here authors such as Simpson (1993, 1994, 1995, 1997, Simpson *et al.*, 1999) Carter (1998), Davidson *et al.* (1992), Davidson (1996), Adderley (2000).

The first published use of micromorphology in this area occurred in 1994, in an integrated paper (Dockrill *et al.* 1994). This paper outlined results from a number of varied environmentally related approaches, which were used to study Neolithic and Bronze Age soils, surrounding a multi-period prehistoric settlement site. These approaches included the study of magnetic susceptibility enhancement to the soils, as well as the molluscan faunas, phosphate analysis, soil thin section micromorphology, the carbonised botanical remains, and an analysis of the carbon isotope ratio within the soil and animal bone (Dockrill *et al.* 1994).

This approach was followed by the coupling of soil micromorphology with image analysis applied to cultivated soils from Papa Stour, Shetland (Bryant and Davidson,

1996). This paper presents data from the first part of a major project designed to investigate the micromorphology of cultivated soils. In particular, the initial phase of the project was concerned with an investigation into methods for the identification and quantification of cultivation features in thin section using image analysis techniques. Bryant and Davidson (1996) revealed that image analysis can contribute significantly to micromorphological description and interpretation of old cultivated soils, but image analysis should not be seen as providing a replacement for the standard description of thin sections.

Simpson et al (1998a) used micromorphology to examine land management activity associated with Neolithic, Bronze and Iron Age settlements at Toft's Ness, Sanday, Orkney. Here, the technique was used to identify soil conditions to improve the understanding of early land management at Toft's Ness. This was followed by the publication of an integrated paper by Simpson et al (1998a), again on Toft's Ness. This was an investigation of early anthropogenic soil formation, using soil micromorphology and free soil lipid analysis.

Investigations have continued in the Northern Isles to include the excavation of a 'farm mound' and underlying sediments at St Boniface Church, Orkney (Carter, 1998). Carter has also investigated the use of peat and other organic sediments as fuel in Northern Scotland, with results being derived from soil thin sections (Carter, 1998). A variety of organic sediments occur in this area, but they have rarely been identified from archaeological excavation. The results indicated that thin sections can be used to identify carbonised fuel fragments and mineral ash from different organic sediments.

Further, soil micromorphology has also been used as an aid to the interpretation of midden formation processes at Robert's Haven, Caithness (Simpson and Barrett, 1996). In 1992 and 1993 an archaeological sampling programme was implemented to investigate the physical character and socio-economic implications of cultural deposits at the site. Representative soil micromorphology samples were collected as

an integral component of the project to provide a preliminary assessment of the three inter-related issues.

The micromorphological research in the Northern Isles was the first series of major research of its kind to be undertaken in Scotland. In this respect, it was pioneering research that has since grown in strength. As discussed earlier in this chapter, the investigation and understanding of the plaggen soils in this area has vastly increased with the coupling of soil micromorphology and image analysis. This research has also been enhanced with the use of more detailed chemical analysis, such as lipid biomarker and amino acid analysis (Simpson *et al.* 1999) Overall, the research in the Northern Isles has been a great example of the multidisciplinary approach that micromorphology and archaeological investigations have adopted. It is also a great example of how future large scale excavations should be undertaken, so that the most information possible can be gained from such investigations.

1.2   The concept of floor levels/occupation surfaces in Archaeology

1.2.1   Definition of floor

Using concepts similar to those employed in soil science, an occupation surface can be defined as the interactive zone between the atmosphere and the bio-lithosphere which is affected not only by human agencies but also by other factors, external and internal. Human actions can be subdivided into four types of elementary processes: accumulation, depletion, redistribution and transformation. Referring to general principles of sedimentary formation processes can identify the nature of the factors that control these different mechanisms. Universality of the sedimentary signatures recognised is founded on the comparison of a large diversity of contexts in order to discriminate the influence of local factors (natural and cultural) on their morphological variability (Ge *et al.* 1992).

In archaeological contexts, the sequence integrates two types of phases: a) phases of occupation characterised by sedimentary signatures induced both by human agencies

and by natural factors, and b) phases of "non-occupation" which comprise sedimentary signatures induced only by natural agencies (Ge *et al.* 1992).

One of the principal aims of archaeological research is to reconstruct past human activity systems and overall behavioural patterns as inferred from the study of artefacts, structural materials, and environmental context. In an archaeological perspective, the soil-sedimentary matrix has been shaped by cultural and natural processes that interact at the interface between the atmosphere and the lithosphere (Courty *et al.* 1994).

Application of soil micromorphology to the characterisation of depositional and post depositional alteration of archaeological contexts by natural factors has largely benefited from research in sedimentology and soil science. These disciplines provide comprehensive principles of the general laws that describe sedimentary processes associated with depositional and pedological processes that take place in the formation and functioning of soils (Courty *et al.* 1994).

Our knowledge on the microscopic expression of human induced mechanisms on formation and modification of the soil-sedimentary matrix is only in its infancy. Specific types of anthropogenic accumulations, such as those relating to firing activities for example have been more extensively documented by using soil micromorphology.

1.2.2 Soil micromorphology and the formation of floors

Micromorphological characterisation of structural transformations induced by human occupation has recently become an important research trend for an accurate identification of activity surfaces in habitation areas. Microstratigraphic studies of multiple occupation sites now demonstrate how soil micromorphology can throw a new light on the archaeological understanding of spatial and temporal variability in the use of space (Courty *et al.* 1994).

Archaeological exploitation of micromorphological data requires the elucidation of the relationships between the spatio-temporal patterns of human activities and the physical expression of human intervention.

The main types of functionally discrete activities that can be presently recognised, based on the interpretation of anthropogenic fabrics, are the following:

-activities related to processing, cooking or consumption of food,

-movement activity either of human beings, or of animals or both,

-resting activity,

-stabling activity and maintenance of a stabling area,

-surface maintenance by using covering materials or organic residues,

-management of refuse: type of wastes and periodicity of dumping.

Marked changes in some significant micromorphological characteristics help to delineate boundaries between specific activity areas. For example, a fabric characterised by a continuous accretion of human refuse and evidence of water percolation would point to intensive trampling. Close juxtaposition with a fabric typical of a well maintained activity surface with an absence of features induced by percolation can be interpreted as indicative of a covered activity surface protected by a superstructure, such as a roof or tent (Courty *et al.* 1994).

Micromorphological interpretation of natural induced transformations of each anthropogenic unit and interlayered natural deposits helps to reconstruct the evolution of environmental conditions and assist in estimating the relative duration of each occupation phase. For example, in the pre-ceramic Neolithic site of Dja'de in Syria, Courty and co-workers (1994) observed an alternating sequence of well structured, constructed mud floors with Microstratigraphic units formed of loosely packed rounded aggregates of human and natural origin; these were crushed by secondary crystallisation of gypsum and slightly reworked by wind. This sequence was interpreted as reflecting a temporary occupation with an increase in aridity during a phase of abandonment which may possibly represent seasonal events. This

tentative interpretation illustrates how soil micromorphological research in archaeology is stimulated to extend its limits for deciphering changes of environmental conditions that are significant at a human time scale (Courty *et al.* 1994).

Reconstruction of prehistoric activities requires an accurate interpretation of spatial distributions and the resolution of occupation surfaces. Reconstruction of behavioural activities can only be achieved through the recognition of cultural and natural formation processes (Ge *et al.* 1992).

Archaeological investigations must therefore be oriented toward the identification of the relationship between the sedimentary matrix and artefactual distributions within the archaeological units. Occupation surfaces are considered to be the most favourable units for achieving palaeoethnogarphic reconstruction's (Ge *et al.* 1992).

For over two decades archaeologists have exhibited an increased awareness and interest in the complexity of processes that are responsible for the formation of archaeological sites (Schiffer 1987). This is particularly true of the anthropogenic processes that are related to the activities that create sites. Our ability to infer distinct past human behaviour is controlled, first by the resolution of the stratigraphic record, and second, by our ability to recognise individual stable surfaces that are commonly identified as "living" floors (Schiffer 1987).

Considerable attention has been paid to the archaeological implications of living floors as evidence for distinct events in the past, but the recognition of an actual living floor or stable surface is often a difficult task. Even if they can be distinguished, it is not always clear what types and varieties of activities truly took place on their surfaces and which activities pre or post date the surface.

Joukowsky (1980) states that:

"floors are often hard-packed, and are generally associated with some sort of wall or ledge. A hard packed floor created by trodden earth can be detected in the feel of the excavation tool. In some cases, the debris collected over it will seem to peel off it."

Using these criteria alone, there are several problems associated with the identification of "living floors" or stable surfaces in an archaeological context. For one, the different lines of evidence cited above are often poorly developed or only partly present in archaeological deposits because of post depositional bioturbation. This makes recognising living floors very difficult. More importantly, the processes and the diversity of anthropogenic activities associated with the formation of stable surfaces in archaeological sites are rarely well documented. Trampling, treading, cleaning, flint knapping, cooking and a variety of hearth focused activities are commonly linked to living floors and can be inferred but clear, irreproachable criteria for reliable recognition of these varied and ephemeral features are just being developed in archaeology (Courty *et al.* 1989).

Archaeological materials attributable to human activities such as ash, bone and organic matter are evident under the microscope and can be clearly interpreted. Consequently, a number of features that should be associated with anthropogenic activities include:

-more organic matter, charcoal and ash near hearths;

-more organic matter, dung and hair in areas where animals are penned -greater compaction in trampled or transit areas, which might vary according to specific activity;

-in areas that have been excavated in antiquity, there should be looser fabric and more voids;

-in filled areas (e.g.: postholes for door supports) porosity should be reduced (Courty, *et al.* 1989),

-cleaning in sleeping or non-eating areas might be characterised by low organic matter and elongated voids.

Matthews *et al.*, (1997, 2001) have conducted the most substantial and recent micromorphological research on occupation surfaces. Her project has focused on the depositional sequences at Catalhoyuk, Turkey. Here, the principal objective in studying depositional sequences is to contribute to interpretation of human uses of space and behaviour. The type, thickness and frequency of floors and occupation deposits within buildings at Catalhoyuk vary both spatially in different areas within rooms, and through time during the life-story of each building, in both their physical and chemical characteristics. Matthews *et al.*, (1997) states that, as observed in previous studies of uses of space at this and other archaeological sites, variation in floors and overlying residues can furnish new information on socio-cultural behaviour, spatial conventions, and conceptual schemes as well as providing information on micro-environment (Matthews *et al.*, 1997).

At Catalhoyuk, the research aims and procedures included the analysis of:

I) the materials and technology of floors/surfaces
II) the impact of activities on floors and surfaces
III) the type, taphonomy and contextual relationships of artefacts, organic remains and sediments in occupation deposits,
IV) post depositional alterations

Analysis of the microstratigraphy of occupation deposits enables the identification of variations in the formation of depositional sequences and uses of space in different sociocultural and environmental contexts.

Ethnoarchaeologists and geoarchaeoloists working in the Middle East have recorded similar contextual variations in the character of occupation sequences. Kramer (1979) in particular noted that:

'The floor of each area within a house compound is peculair to that kind of area and therefore diagnostic of primary fuction....it is likely that an excavator could readily

distinguish between roofed and unroofed areas, and identify stables, storerooms, kitchens and living rooms....by evaluating variations in floors'.

Previous applications of micromorphology to studies of occupation sequences and use of space within archaeological sites include the analysis of deposits within Palaeolithic and Neolithic caves (Goldberg 1987, Wattez *et al.* 1990; Courty *et al.* 1991), and a range of settlements in the Near East (Matthews and Postgate 1994) and elsewhere in the world (Courty *et al.* 1989, Davidson *et al.* 1992; Courty *et al.* 1994; MacPhail 1994).

Ge and co-workers (1992) have provided a model of the zone of impacts on sediments that are detectable in floors, using soil micromorphology.

In this thesis, passive and reactive zones described by Ge *et al.,* (1992) are easily identified, although as the floor layers had been buried after abandonment of the site, the active zone is largely missing. This author tends to favour the notion that the passive zone is incorrectly defined by Ge and co-workers (1992), as the definition assumes that there is only one floor layer accompanied by underlying deposits. In the context, as considered in this thesis, the underlying deposits themselves have undergone trampling and compaction both at the time of use, and also after another layer has been formed overlying that deposit. The passive zone must also still undergo impacts of activities, as it is thought by this author that compaction would not impact only the surface layer, as the effect would be passed through the sequence of layers. Also, the reactive zone is mis-defined, as the impact of compaction and other activities must occur on the surface layer. This author finds it difficult to believe that cracks form after the floor layer has become an underlying deposit: surely the cracks and other microstructure would form on impact.

1.2.3 The archaeology of floors in the Western Isles

Research into the archaeology of floors in the Western Isles is little documented. In fact, it can be said that published evidence for the presence and documentation of excavated floors is relatively scarce.

Of all the excavations of structures in the Western Isles, only a few have documented floor levels, and even though documented, only the sites at Bostadh Beach, Isle of Lewis and Cladh Hallan, South Uist have had floors sampled exclusively for investigation. It is interesting to note and question why the presence of floors has not been well documented, as they are usually a well preserved and important archaeological feature, especially in terms of reconstructing site formation processes and ethnographic aspects in the use of space within a structure.

Floors have taken various forms in structures. For example in broch towers, there will have been a primary floor at ground level, but also a secondary floor in the gallery. It is interesting to note that these secondary floors are rarely mentioned in site reports, and one questions what has been the fate of the floors post-abandonment. Are the floors removed and reused elsewhere, a particularly credible fact given that the floors are likely to have been formed from wood, or is the floor left behind to collapse and decay. If so, why has this not been documented in excavations?

Typical examples of floors being documented, but not sampled are the Wheelhouse at Cnip (Armit 1988), Eilean Maleit (Armit 1996), Dun Vulan (Parker-Pearson *et al.* 1999), and Dun Bharabat (Harding and Gilmour 2000). These instances are described in the following section.

1.2.4 Flooring material in the Western Isles

In this research, peat appears to have been the favoured material that has been used in the construction of floors, this being applicable to Bostadh Beach, Isle of Lewis, Cladh Hallan and Bornais, South Uist.

There has been little documented evidence for the material used for flooring materials in the Western Isles, however, at Sollas in North Uist, Atkinson (1951) excavated the primary floor levels of a wheelhouse structure. Although the Sollas wheelhouse had been previously excavated by Beveridge (1911), he had not penetrated the lowest layers of occupation and a wealth of deposits remained to be excavated during these second campaigns. The excavation of Atkinson (1951), revealed that at various times during the occupation of the site the wheelhouse had been re-floored with clean machair sand, sealing two accumulations of debris formed during occupation. Armit (1996) states that more detailed analysis of the primary wheelhouse floors, excavated under modern conditions would enable the full understanding of the specific functions of the wheelhouse and begin to approach the underlying structural principles of the construction of the house. Armit recognises that analysis of occupation levels could help interpret the important divisions between back and front, right and left of the house, which were possibly associated with different members of the community and with different activities. This notion is being used to understand the use of space within House 401 at Cladh Hallan, South Uist, which forms part of the basis of this thesis.

The excavation of occupation surfaces at Cnip, Isle of Lewis (Armit 1988) revealed evidence that small cellular buildings at the site and which had been inhabited after the wheelhouse had gone out of use, were periodically scoured of floor deposits and restored to a clean sand floor (Armit 1988). However, he contends that at Sollas, North Uist, it would be suprising if any of the excavated occupation deposits relate to the primary use of the structure because of the possibility that the primary floors have long since been scoured away.

During the excavation of a complex Atlantic roundhouse at Dun Bharabhat, Cnip, Isle of Lewis (Harding and Dixon 2000), a series of occupation horizons were revealed, with the main horizon proving to be an extensive level of dark brown to black speckled earth, which was interleaved with thin lenses of grey-green or orange clay. The suggestion from Harding and Dixon (2000) that this is a primary occupation surface stems from the presence of a scatter of water worn cobbles and several flat slabs around the edge of the interior wall of the roundhouse. Furthermore, 8 kg of very small pottery sherds were recovered from the dark brown material.

The finding of these pottery sherds in the material is interesting, and is a possible indication of adapting the floor to living in difficult conditions. Harding and Dixon (2000) suggest that the large volume of sherds are present as a result of being deliberately embedded into clay patches on the floor surface, and repeated periodically, to combat the muddiness of the floor surface in the wet environment in which this site sits. The authors speculate that the grey-green and orange lenses of clay could be indicative of deliberately laid floors, but state that the presence of the orange lenses may represent nothing more than hearth scrapings. The laying of a clay floor would be quite unique in the formation of floors so far excavated in the Western Isles, and is suggestive of a change in technology in the laying of a floor surface, as the documented evidence so far, including the analysis of material for this research, suggests that the primary material used is peat in various stages of decomposition.

In the Pre-Atlantic phase of occupation in the roundhouse, an extensive layer of black peaty soil overlying large cobbles was excavated. Included within the organic matrix were lenses of red or orange clay, which extended particularly into Gallery One of the structure. Unfortunately, further excavation of the floor at this level was prohibited due to the flooding of the site, but Harding and Dixon (2000) suggest that these floors may well represent a pre-Atlantic phase of occupation at the site.

Carter (1998) investigated a floor layer in the Broch at Scalloway, Shetland. Only one thin section was taken for analysis of the floor, and was primarily taken with the view of investigating the micromorphology of red ash layers. The key piece of

evidence to emerge from the analysis of the thin section is that the layers of plant material now represented by ash were penetrated by earthworms before they were burnt. Carter therefore concluded that the plant material was present on the broch floor and was not a roof brought down in the fire. Context 680 was therefore an organic floor deposit consiting of an accumulation of various types of plant material mixed with small quantities of sand and stones (Carter 1998). The thin section did not provide much information about the precise identification of the plants used for the flooring, although some woody material was present although most material was described as herbaceous tissue.

In South Uist the first floors to be excavated and analysed micromorphologically were floors identified from with building C at Dun Vulan (Parker-Pearson and Sharples, 1999) and analysed by Schwenninger (1999). These proposed floors were identified in the field as being anthropogenically derived due to the abundance of hearth and food refuse, together with large components of charcoal, pottery remains, bone gneiss and flint. However, although Schwenninger applied micromorphology to these floors, he did not describe in sufficient detail the micromorphological characteristics of the floor, rather he described the anthropogenic inclusions that were present. Therefore, no basis for the characterisation of the floors was provided, or not was a possible interpretation of the composition and formation of the floor deposits suggested.

However, this research formed a basis for the possible identification and highlighted the possible application of soil micromorphology to the analysis of floor sequences from within the settlements of archaeological excavations. As the application of the technique looking specifically at floor and occupation surfaces had previously not been performed in Scottish archaeology and was considered unique by the excavators of the site.

Further floors were identified within the course of the excavations at this site (Parker-Pearson and Sharples, 1999). However, it is disputed as to whether these descriptions are actual floor depoists or rather accumulations of material formed

through the use of the Broch tower. For example, the first apparent floor was described as a sticky clay layer, which had possibly been overlain by a timber floor. There was no evidence of the timber floor in the deposits that were excavated, but micro fragments of the timbers would not have been readily distinguishable by eye, therefore it is proposed that micromorphology analysis of these deposits would have proved helpful. Further proposed floors in the structure varied in composition and colour. For example, floors were described as being reddish brown sand, blacky sticky layers, sandy clay deposits, black sandy loams and charcoal flecked sandy deposits. None of these floor layers were analysed for micromorphological analysis, therefore rendering it difficult to call them floors. These descriptions are good examples of how floors have been described archaeologically for long periods, although the research at Dun Vulan introduced a new approach to the sampling and investigation of floor deposits in the Western Isles.

Floors have also been identified in the Norse longhouses at Cille Pheadair, South Uist (Parker-Pearson et al. 1996). These have been previosuly discussed in Section 1.1.4.1. The micromorpholgical analysis is presently being undertaken by Karen Milek at the University of Cambridge, England. Further, spatial studies have been undertaken on the floors using bio-archaeological remains together with the application of other analytical techniques in an attempt to understand the formation of the deposits and the distribution of artefacts across them (Smith et al. 2001). This site provides a good example of the integration of standard archaeological excavation with the incorporation of environmental sampling and analysis, and provides an insight into the information that can be gleaned from the joining of the two disciplines.

From the application of the environmental techniques, use of space within the house was detected, where an abundance of bone fragments were identified in the west of the building, which these authors state is consistent with the are being used for food preparation. The analysis of the distribution of pottery, cereals and charcoal was also undertaken. Pottery fragments were concentrated in the far west and east ends of the building, with the concentrations in the west reflecting the position of the second

hearth. These fragments were also concentrated close to the central hearth in the east of the building and bear to the doorway.

Although the location of the pottery fragments were described within the house, Smith *et al.* (2001) do not postulate the reasons for the distribution of these fragments within the floors of the house. However, much more detailed consideration is given towards the concentration of charcoal fragments, which were concentrated in the two western areas of the house. The authors postulate that the distribution of charcoal might reflect general trampling and sweeping of material derived from hearths. In this instance, the micromorphological analysis will detail the processes involved in the distribution of these fragments, and will determine the deposition of the fragments.

Even though the outcome of the micromorphological analysis is not yet known, the application of the other investiagtive techniques in House 312 at Cille Pheadair has provided an insight into the formation and use of the floors within the structure. This was the first excavation on which environmental sampling was so detailed and formed the standard for the future excavations undertaken by Smith *et al.* (2001).

1.3   Case Studies: Previous research on the Isle of Lewis and on South Uist

1.3.1 Previous Archaeological research on the Isle of Lewis

It was during the nineteenth century that the study of archaeology in the Western Isles began to evolve and it was mostly through the work of a few individuals since the latter part of that century that ideas on the nature of Hebridean archaeology have emerged (Armit 1996). The birth of archaeology in the Western Isles, in particular Lewis, can be traced to 1857 when, under the instruction of the landowner Sir James Matheson, the thick blanket peat was removed fully to expose the Calanais stones.

However, after this time very little excavation work was carried out on that island, as the great majority of excavation was carried out on North and South Uist. It was not until the mid 1980s that substantial excavation of later prehistoric settlement sites was resumed on the Island (Harding and Armit 1990, Harding and Gilmour 2000).

Within Lewis two areas have received detailed archaeological research attention. The first lies to the west of Calanais on the Bhaltos (for location see Figure 2.1) and Uig (for location see Figure 2.2) peninsulas and the second on the island of Great Berneradh, the site of the research for this thesis. On the Bhaltos peninsula the research has included three major excavations aimed at understanding the origin and development of Atlantic Roundhouses: Loch na Beirgh (Harding and Gilmour 2000), Dun Bharabat (Harding & Dixon 2000) and a wheelhouse on Traigh Cnip (Armit 1988).

The second major area where investigations have taken place is the Uig peninsula, where a landscape survey and excavation of three key sites has been undertaken by the Uig Landscape Project. The programme was originally developed as a field survey exercise, but continued with the excavation of a possible Norse promontory fort at Gob Eirer, a Bronze Age islet at An Dunan and a relict landscape dating from the Bronze Age to Early Medieval at Guinnerso (Burgess and Church 1996, Burgess et al. 1997 a,b,c, Burgess et al. 1998, Church et al 1999 a, b.).

More recently, two seasons of excavation have been undertaken at Calanais Farm, Isle of Lewis. Here the presence of an extensive field system and related archaeological monuments buried beneath 2 metres of blanket peat has been demonstrated. Evidence for spatial patterning of land use is becoming available from palaeoecological analyses of the palaeosols and overlying peats. On the basis of comparisons with other regions and the likely date for peat initiation in the area, the excavators suggest that the field system is probably later Neolithic or early Bronze Age in origin (Flitcroft et al., 2000, 2001).

In terms of their contribution to research related to floors and the sampling of occupation deposits, the excavations by Neighbour (1996) at Bostadh Beach are unique, as this was the first site where floor deposits were sampled extensively to permit subsequent analysis. No other excavated site on the island has received such attention to date, although the presence of floors has been observed on site and documented in the associated site reports. Where this has been the case, the evidence for the nature of these floors have been reviewed in this thesis.

1.3.2 Previous research on South Uist

The first archaeological survey work on this island was carried out by Captain F. W. L. Thomas, who surveyed an unusual Iron Age settlement in Glen Usinish (1868), on the remote east coast amongst his considerations of other 'primitive dwellings' and 'hypogea'. In 1928, the Royal Commission for the Ancient and Historical Monuments of Scotland published a survey of all the then-known archaeological sites in the Outer Hebrides, Skye and the Small Isles. The results of this survey were however limited due to the difficulties of access and transport the Commission staff encountered in journeying around the islands. On South Uist, the survey none the less identified many of the Neolithic chambered tombs, island brochs and duns (Parker-Pearson and Sharples, 1999).

Leithbridge (1951-1952) undertook the first archaeological excavation on South Uist on the site of Cille Pheadair, a wheelhouse structure that had walls surviving to a height of 8 feet (c. 2.4 m). In 1956 a major programme of excavation was undertaken on South Uist in preparation for the building of the rocket range in the north of the island. Accompanying excavation was undertaken on Drimore machair and a number of settlement mounds were identified, with two wheelhouse sites (A'Cheardach Mhor and A'Cheardach Bheag), a Viking Age structure and a group of hut circles being excavated (Parker-Pearson and Sharples, 1999). The two wheelhouses were apparently structurally the beginnings of long sequences of occupation spanning perhaps four centuries at A'Cheardach Bheag (Fairhurst 1971) and about a

millennium from the Iron Age to the Norse period at A'Cheardach Mhor (Young and Richardson, 1960; Fairhurst 1971).

Following coastal surveys, 1984 saw excavations by Barber on sites that were under threat from erosion, with Hornish Point, a wheelhouse like structure accompanied by substantial midden deposits being examined. The radiocarbon dates for this site, the first from South Uist's Iron Age, were unfortunately taken from marine shells, and are hence subject to the reservoir effect of containing ancient carbon, and their 5th to 6th century BC date range may be argued to be too early (Armit 1991).

Figure 2.3 illustrates the location of South Uist in relation to Scotland and also displays the major sites which have been excavated on the island.

1.3.3 South Uist in the Iron Age

The remains of Iron Age settlements can be found throughout the Uists and a number have been excavated. In the Uists, as is now generally accepted throughout the Atlantic Province the Iron Age has been defined as running from the end of the Bronze Age to the beginning of the Viking Age (circa AD 800) (Parker-Pearson and Sharples, 1999). The Iron Age in these southern islands, as has essentially been argued for the remainder of the Atlantic Province can also be sub divided into three phases:

Early Iron Age (700 – 100 BC)
Middle Iron Age (200 BC – AD 400)
Pre-Norse Late Iron Age (AD 300-800)

The most notable structural types in these islands for these periods, are very similar to those found on the Islands to the north, mainly the Isle of Lewis, with the excavated structures to date including brochs, duns, wheelhouses and cellular buildings (Parker-Pearson and Sharples, 1999). Brochs, such as Dun Vulan, are thought to have been built between 400 and 100 BC, this being by analogy, since Dun Vulan is the only broch in the Western Isles whose lower settlement layers have

been excavated. Wheelhouses may also have been constructed around the same time (Parker-Pearson and Sharples, 1999). Between AD 300-800, cellular buildings are thought to have been built.

1.4   Monument types considered typical of the Iron Age Western Isles

1.4.1 Simple and Complex Atlantic Roundhouses

Many definitions have been proposed for each of these structural types: most of them have been recently redefined by Armit (1996), who offers a coherent scheme which has been adopted by subsequent commentators and is used here. For example, he suggests that most of the substantial round dry-stone buildings (including those comprised within such conventional terms as brochs, duns, galleried duns and semi-brochs) may usefully be grouped as 'Atlantic Roundhouses'; thereby condensing many different type of structures into one group (Armit 1996). This group is then sub-divided on the basis of their relative architectural simplicity or complexity: simple Atlantic roundhouses (the Early Iron Age massive-walled, isolated roundhouses generally dating to 800-400 BC, initially at least discovered only in the Northern Isles) and complex Atlantic roundhouses, which are architecturally elaborate buildings identified as beginning in the 4th century BC (Armit 1996).

This complex group is also split further into sub groups encompassing broch towers and small brochs or duns. Figure 2.4 illustrates the distribution of roundhouses throughout the Western Isles. In comparison to the view of Armit (1996), an alternative definition of brochs has been proposed by Parker-Pearson and Sharples, (1999) after research in the South Uists. Their view recognises 'Atlantic roundhouses' as a general category, but identifies an unequivocal category of 'true Broch' or broch tower with monumental proportions which exceed / are greater than those of other stone houses. This monumentality is marked by the construction of a round stone tower with stone built walls in excess of 3 m thick at ground level , the provision of a scarcement for an upper internal floor, and the provision of stairs,

gallery and chambers within the wall (Parker-Pearson and Sharples, 1999). Such broch towers are therefore only identifiable from particularly well preserved remains.

Armit dates the construction period of brochs and small brochs between the 4th and 1st centuries BC. According to MacKie, brochs do not occur until much later, after 100 BC, but continued to be built at least into the 1st century AD and possibly into the 3rd and 4th centuries in some areas (MacKie *et al.*, 1965b). Currently excavated examples of Brochs in the Western Isles are on the Isle of Lewis: Dun Carloway (Tabraham 1979), and Loch na Beirgh (Harding and Armit 1990, Harding and Gilmour 2000) and on South Uist, at Dun Vulan (Parker-Pearson and Sharples, 1999).

To date, only secondary structures have been excavated inside and around the original complex Atlantic roundhouse at Beirgh (for location see Figure 3) on the Bhaltos peninsula. This was originally located on an island in Loch na Beirgh, situated on the lower machair zone behind the Traigh na Beirgh beach and sand dunes (Gilmour 2000). The prehistoric and early historic settlement site lies on the western edge of a low-lying inlet at around 3 metres O.D.. The creation of the machair behind Traigh na Beirgh, corresponding to Ritchie's model B of machair development (Ritchie 1966), and its progressive retreat inland, has resulted in the silting up of both the Loch na Culic, which lies at the foot of the ravine leading up to Loch Bharabat, and Loch na Beirgh (for location see Figure 2.1), a process which is reflected in the alternating bands of windblown sand and organic deposits identified in the coring of the land adjacent to the complex Atlantic roundhouse (Harding and Gilmour 2000) at Beirgh.

It is the unique environmental situation of the Beirgh site that is the key to its archaeological importance. The dynamics of the local geomorphology are extremely complex with the outcome being the progressive silting up of Loch na Beirgh, with the consequential rise in the water table threatening to flood the occupation levels of the site (Harding and Gilmour 2000). Excavation of the upper horizons within this site revealed that each successive phase of occupation entailed the partial levelling of

previous structures and the infilling and raising of the living surface of the site (Harding and Gilmour 2000). This waterlogging of the site has led to excellent preservation of the organic materials, but unfortunately the occupation surfaces that were encountered and examined were not sampled exclusively for micromorphological analysis.

This Atlantic roundhouse is one of the largest in Scotland with an overall diameter of 17m and two concentric drystone wall faces 1m wide, set 1m apart. Within the intra-mural space thus provided are a series of cells and longer galleries at ground floor level, the north western of which accesses an intra-mural staircase winding clockwise (Gilmour 2000). The surrounding machair environment has now encroached upon the loch, gradually infilling it with layers of sand and peat, thus raising the water level within the structure. Excavations have so far determined that a complex sequence of at least twelve major phases of construction occurred on this site and none of the material recovered to date is conclusively related to the original occupation levels (Harding and Armit, 1990; Harding 1984; Harding and Gilmour 2000), which have in general not been attained in the excavation project. Reference to the earliest radiocarbon date places the original construction of the complex Atlantic roundhouse in the late first millennium BC at the latest (Harding and Gilmour 2000). Recent radiocarbon dating combined with artefactual studies has shown that the currently excavated material from Loch na Beirgh dates from 2nd century AD to 9th century AD (Gilmour 2000).

1.4.2 Wheelhouses

The last centuries BC saw the introduction of an entirely new and highly distinctive form of architecture for the Hebrides, in the form of structures that are now known as Wheelhouses (Armit 1996), sometimes with a variant named 'aisled' round houses. The locations of Wheelhouses in South Uist are illustrated in Figure 2.5. These are so called because of the spoke-like radial piers which supported a central roof as well as those of peripheral cells (Parker-Pearson and Sharples, 1999). Where the piers are

free standing and do not meet, or are not bonded into, the house wall, the presence of this narrow gap has led to certain wheelhouses being called 'aisled'. Armit (1996) suggests that these aisled wheelhouses may well be earlier than those with bonded piers. The contrast between the appearance of wheelhouses and brochs in the landscapes of the Hebrides is very marked: as the floors of wheelhouses were sunken and the walls revetted into standing faces of sand, they were largely subterranean with only the roof showing above the ground. These structures are unique to the Western Isles, with the exception of those at Jarlshof and Old Scatness on Shetland, where they similarly occur in association with machair dune systems. Unfortunately, only the wheelhouse at Cnip on the Isle of Lewis has been radiocarbon dated, and in, association with occupation dates from other wheelhouses, it indicates that these structures were probably constructed between the 4th and 1st Centuries BC. They went out of use in the 1st and 2nd centuries AD (Armit 1996).

The majority of excavated wheelhouses in the Hebrides are found in machair terrain and are revetted into sand dunes or accumulations of midden. Others are set into the ruins of earlier Atlantic roundhouses, for example at Garry Iochdrach and Cnoc a Comhdhalach, North Uist. Armit (1996) reports that a few appear to have been built as *de novo* free standing structures away from the coastal belt, for example as at Allasdale, Barra (Young, 1952). A further example of a structure of this type being built into earlier dilapidated buildings is found at Clettraval, North Uist, which was partially free standing but also partially quarried into the remains of the Neolithic chambered tomb on the site (Scott, 1947).

Two of the most fully published wheelhouses in the Western Isles are Cnip, Isle of Lewis (Armit, 1988) and Sollas (Campbell 1991). The main wheelhouse at Cnip appears to have been typical of Hebridean wheelhouses in general although Armit (1996) states that there were local variations in their characteristics. Examples of these variations include bonded piers that could indicate structural development, with the piers being designed to stabilise the building. Armit continues his argument by stating that if this were the case, then this would have altered the use of space within the structure, by necessitating that all communication pass through the central space.

In terms of their suitability to the Hebridean environment, wheelhouses had several advantages over Atlantic roundhouses. Their tendency to be dug into sand hills or ruined buildings would have provided insulation and warmth. The low roofs of these structures would have been much less affected by high winds compared to the exposure produced by the height of Broch towers. The relatively small central spaces of wheelhouses which required to be roofed meant that short timbers could be used for construction rather than the substantial lengths of structural wood that would have been required for the roof and upper floors of brochs (Armit 1996).

1.4.3 Sollas Wheelhouse

The rescue excavations conducted by the late Richard Atkinson at Sollas, North Uist (location is illustrated in Figure 2.5) in 1957 investigated a well preserved Iron Age wheelhouse and a more ruinous circular building (Campbell 1991). These excavations were part of one of the earliest large scale rescue projects in Scottish archaeology, undertaken in 1956 and 1957. As a previous investigation here by Beveridge (1911) had revealed a large wheelhouse and nearby souterrain in a low dune north of Sollas (Beveridge 1911), it was proposed to locate and excavate all sites in this mound in advance of their destruction by the rocket range development.

Campbell's account of this fieldwork, published in 1991, was the first publication of such an excavation for twenty years, and has important implications for the structure, chronology and function of wheelhouses in the Hebridean Iron Age (Campbell 1991). Although excavated more than thirty years previously the site remains of considerable importance in a number of respects. First, it is the first fully published account of a modern excavation of a wheelhouse. Secondly, there is a detailed account of stratified groups of pottery from closed contexts of short duration. Thirdly, the wheelhouse had an early phase consisting of numerous pits, some of which contained a collection of special animal burials and cremations.

The excavated site lay on the northern boundary of the machair on the north-west coast of North Uist. The wheelhouse was set in the southern end of a large low dune, the dune being on the southern margin of a wide expanse of hummocky dunes lying behind the high coastal dunes. The two excavated sites are not the only known structures in this part of the dunes. Beveridge records the partial excavation of a souterrain at the north end of the same sand hillock, about 90m north of the wheelhouse (Beveridge 1911). The Sollas site lies within the Vallay area of North Uist which is known to be rich in Iron Age structures, many of them having been investigated by Beveridge in the early years of the last century.

In terms of occupation deposits, the Udal wheelhouse has produced the most well excavated material so far, although unfortunately no samples seem to have been taken for subsequent analysis of these floors, as the value of the application of soil micromorphology to the description and analysis of occupation deposits had not been realised when it was excavated. Although Beveridge (1911) had previously excavated the house it was soon found on excavation that Beveridge had not penetrated the lowest layers of occupation material and a wealth of deposits remained to be excavated. Campbell (1991) remarked that at various times during the occupation of the site, the wheelhouse had been re-floored with clean machair sand. This cleaning process had also sealed two accumulations of debris formed during the occupation along with their associated stone furniture. Campbell (1991) does not state whether he thinks that these accumulations of debris themselves are floors or not, but this author would tend to support the assumption that the accumulated debris was floor material. The association with furniture that Campbell identified is very similar to what was encountered in House 3 structure L, phase 5 at Bostadh.

Armit (1996) has stated quite rightly that more detailed analysis of primary wheelhouse floors excavated under modern conditions may yet enable us to understand the specific functions of the wheelhouse bays and to begin to approach the underlying structural principles that guided the formation of these structures and their contained deposits. This author agrees with this notion, but would wish to expand that idea to stress that all excavated structures should have their associated

floors sampled for micromorphological analysis. The sampling of only one set of floors rather than the entire occupation sequence as represented by floor deposits is relatively worthless, if the use of the structure through its entire occupation is to be established.

Unlike the Atlantic roundhouses where space could be divided vertically between floors used for different functions, wheelhouse settlements had to be more horizontally organised if they were to maintain a similar range of differentiated spaces for various domestic activities (Armit 1996). Most of the Hebridean wheelhouses, therefore, had one or more subsidiary cells leading off from the main structure. At Sollas this subsidiary room took the form of a fairly substantial oval cell which revealed little evidence for its original function.

So far, the only inland wheelhouses to be excavated are at Allasdale in Barra and Clettraval in North Uist (Young 1952, Scott 1947). In both these sites the wheelhouses occur within enclosures that contain outbuildings as well as subsidiary cells attached to the wheelhouse structures themselves. Clettraval is described as an aisled roundhouse with outbuildings, lying within an enclosure wall, the later buildings themselves overlying a chambered cairn. Pottery was recovered which indicated a date at the end of the 1st century BC, although sherds dating to the 5th-6th centuries AD were also recovered.

Armit (1996) states two possible explanations for the presence of these outbuildings at the sites, the first being that the settlements may be multi-period accretions where subsequent settlement has usurped formerly isolated wheelhouse sites; the Hebridean tradition of building on or next to a handy stone coursed wall being applied here. Secondly, it is possible that these structures represented unitary wheelhouse farmsteads to which the outbuildings are integral, and which have survived due to their inland location.

1.4.4 Cellular Houses

The third main group of houses and those most associated with this research are the so called 'figure of eight' or ventral structures. These are cellular buildings which have a sub-circular or sub-rectangular room with one or more circular or irregularly shaped cells coming off this main room (Parker-Pearson and Sharples, 1999). These structures are sometimes free standing, as at the Udal, but have more often been recognised built into earlier structures such as at Cnip wheelhouse, the Loch na Beirgh broch and probably the Dun Cuier broch on Barra (Armit 1996, Harding and Armit 1990, Young 1956). The most recent of these buildings to be excavated are those of Bostadh Beach on the Isle of Lewis, which was excavated in 1996 (Neighbour 1996). This is one of the settlements being considered in this research, the archaeology of which is discussed in a later section. Cellular buildings are broadly identified with the pre-Norse or Pictish period attributed to the Late Iron Age within the Atlantic Province, between AD 400 and 800 (Parker-Pearson and Sharples, 1999).

1.5 Overview

This chapter has revealed how micromorphology is a rapidly expanding, multidisciplinary tool, having been applied to many detailed and varied archaeological investigations. In some cases, the application of the technique is very much in its infancy, especially where archaeological floors are being investigated, but this is in contrast to the investigation of other archaeologically important investigations, such as in the re-creation of landscapes, where the technique has been and still is, being used to its full capacity. The chapter has also investigated how the application of micromorphology is being coupled with other analytical tools, namely image analysis, but also biomarker and palaeobotanical analysis. The application of image analysis to thin sections is still in its infancy, and research is being carried out on the problem of distinguishing between charcoal fragments and dark amorphous features. This is being undertaken at the University of Stirling and will hopefully

reveal some very interesting results, enabling the quantification of these features to be much faster and accurate in the future.

Chapter Two

A review of the archaeology and floor sequences of Iron Age Settlements at Bostadh Beach, Isle of Lewis, Cladh Hallan and Bornais, South Uist

Aim of Chapter

The chapter describes the general structural archaeology of the settlement sites under investigation for this thesis, followed by the description of the floors associated with the structures, and their significance to the sites. A notable shared trait of all the architecture discussed here is that building in dry-stone construction is the dominant trait recorded.

The chapter details the archaeological structure of the three settlements under consideration in this thesis. Each settlement is thought to span a different period within the Iron Age, with the floors at Bostadh forming the latest under investigation. It is hoped that the research has contributed further to the formation and construction of floors in the archaeological record of these islands, and that it provides a building block for successful application of micromorphology to occupation deposits in future excavations, both in the islands and on the mainland. Illustrations for this chapter are shown in Volume Two.

2.1   Introduction

The enormous range of Iron Age structures in Atlantic Scotland has been the subject of many classification schemes which have identified a wide variety of dry-stone architectural types. These include brochs, broch towers, duns, late duns, island duns,

galleried duns, defended enclosures, promontory forts, wheelhouses, aisled wheelhouses, roundhouses, cellular houses, souterrains, hut circles and ventral houses (Scott 1947, Young 1966, MacKie 1965a,b, Armit 1996).

The Iron Age of the Western Isles of Scotland has long been characterised by several well known monument types (Gilmour 2000). The fine preservation and architectural distinctiveness of brochs and duns, now known collectively as Atlantic roundhouses, and wheelhouses has led to their dominance in the archaeological record. Over the last few decades however, several other monument types have been the subject of increased attention in the Iron Age building repertoire. For example, cellular structures are seen as the settlement/structural type that succeeded the more monumental Atlantic roundhouses and wheelhouses (Armit 1990, 1992). Yet the nature of settlement patterns during the Iron Age has been difficult to elucidate (Gilmour 2000). However, researchers have attempted to elucidate the settlement patterns in the Outer Hebrides (Parker-Pearson and Sharples, 1999), although recent excavations at Guinerso and An Dunan in Lewis show more features in the landscape, and this will consistently change as more excavations are undertaken.

2.2 The archaeology and floor sequences of Iron Age Settlements at Bostadh Beach, Isle of Lewis, Cladh Hallan and Bornais, South Uist

2.2.1 Site One: Bostadh Beach, Great Berneradh, Isle of Lewis, Outer Hebrides

2.2.1.1 Introduction

This Iron Age settlement is located on Bostadh Beach, Great Berneradh, Isle of Lewis, Scotland. Great Berneradh is a small island located off the West Coast of Lewis, and is connected to the larger island by a short road bridge, as illustrated in Figure 2.6.

The settlement itself is located within an eroding dune system that has now undergone stabilisation, and is situated approximately 1 m above the beach. The local environment of this settlement is documented in some detail elsewhere in this thesis (Chapter 3).

The history of discoveries from the site at Bostadh beach have been well documented elsewhere. However, particularly severe erosion of the site occurred during January 1993, when storm force winds and unusually high tides removed a depth of sand in excess of 1 m from the surface of the beach and scoured the dune face back, revealing some of the walls of the settlement for the first time (Neighbour 1996). After three years of monitoring, it was decided that the degree of erosion happening to the remains had become unacceptable and rescue excavation was considered to be the only cost effective response (Neighbour 1996). Fourteen weeks of excavation were then undertaken, revealing the Iron Age settlement that was lying underneath the dune system.

2.2.2 The Settlement Sequence

Only a brief consideration of the structure of the settlement will be entered into here, as it is not the aim of this thesis to document this. These structures have been documented in greater detail elsewhere in publications by members of the excavation team and others (e.g.: Neighbour 1996, 2001, Gilmour 2000).

The development of the settlement at Bostadh has been divided into three broad periods, described as Early, Ventral and Norse. A diagram of the structural sequence is found in Figures 2.7a and b. The chronological period covered is from the $3^{rd}/4^{th}$ century AD to $8^{th}/9^{th}$ century AD, the timescale being based upon artefact analysis and on analogies with the structural forms identified on sites such as the Udal on North Uist (Crawford 1964, 1965 and 1966), Beirgh (Gilmour and Harding, 2000) and Buckquoy on the mainland or Orkney (Ritchie 1976).

It is possible to demonstrate the development of the settlement at Bostadh using a combination of conventional stratigraphic information and a consideration of structural typology, the latter of which forms Armit's fifth and most unreliable means of deriving chronological information (Armit 1992). A plan of the later phase structural modifications to Cnip wheelhouse (Armit 1990) provides a reasonably-securely dated structure typologically similar to an example present in one of the early phase at Bostadh. Towards the end of the sequence, by the later first millennium AD, it has been argued (Gilmour 2000) that the evolution of architectural types allows the definition of more precisely defined chronological periods than is possible in the earlier part of the same millennium.

The pre-Norse houses at Bostadh (Houses 1-4) shared a number of architectural features otherwise commonly known in the Atlantic Scottish Iron Age. Essentially they were drystone houses which structurally were designed to be largely subterranean. The walls had roughly-coursed drystone inner and outer skins, generally infilled with cores of sand and midden material although an exception to this constructional sequence will be noted below. Relatively little of House 4 was exposed during the excavation due to time constraints and the nature of the rescue excavation itself, but it appeared to be roughly rectangular in plan. The three ventral houses (Houses 1, 2 and 3) each had a southern entrance and in each case at least one annex conjoined to the main structure and entered through a door from it. House 3 was in danger of collapse when sand was blown from the eroding dune face in the mid-1990s, and was completely dismantled during the excavation, allowing a detailed insight into the mode of construction. It is therefore apparent in this example that the stratification of sand and other materials contained within the wall core of the eastern wall matched that identifiable in the standing dune outside the house. This evidence strongly suggests that in this instance at least it is most likely that the walls of the house had been built by excavating a hole and then building what subsequently became the inner wall face of the house. After this inner face had been built, an external trench was dug leaving a berm of well-compacted dune sand *in situ*, and the outer face of the wall was constructed. Thus the core of the wall was formed of unaltered natural deposits.

The early period for development at Bostadh has been divided into two blocks: there are no stratigraphic links between the two blocks, nor any other evidence that permits them to be separated chronologically.

With House 3 was directly associated structure J: this was a small cell, which was later incorporated into a rectilinear structure, similar to that encountered at Cnip wheelhouse Phase 3, illustrated in Figures 2.7 A and B. The similarity between these structures could be an indication that J was a bay in a wheelhouse that had formerly stood at Bostadh, but had been very substantially altered in a subsequent remodelling of the settlement. However, supporting evidence is lacking because of subsequent erosion, so that the existence of a putative wheelhouse phase at the start of the Bostadh sequence is unconfirmed and is best regarded as very tentative (Neighbour 2001).

Structure H, conjoined with House 3, is claimed to be (Neighbour 2001) a 'ghost' of a rectilinear structure, similar to that encountered at Cnip Phase 3 (Armit 1990). This structure had subsequently been substantially altered during the construction of House 3, and in places it appeared to have been entirely dismantled and reassembled. A petal-shaped hearth beneath the north-eastern wall of Structure H, house 3, has parallels at Beirgh broch (Harding and Gilmour 2000) and at Jarlshof (Hamilton 1956). At Beirgh a petal shaped hearth was stratified between two structural phases and can be dated to between 1700 +/- 50 BP and 1650 +/- 55 BP. Hamilton suggested that the petal-shaped structure at Jarlshof was a barrel or water butt stand. Neighbour (2001) suggests that this is highly unlikely, particularly at Bostadh where a fill of *in situ* peat ash was discovered.

Structures P and Q (comprising House 4) were the most deeply buried constructions that were encountered during the excavation at the site. Their excavation produced the earliest artefacts discovered during this fieldwork. These structures were separated by an accumulation of windblown sand approximately 0.5 m thick. The excavator suggests that this is a single event accumulation, but this author suggests

that it is difficult to ascertain this without scientific analysis. Structure Q lay stratigraphically below P, indicating that it probably represents the earliest use of the site recovered in the fieldwork; structure P contrastingly appeared to have continued in use for some time during which House 3 was occupied (Neighbour 2001).

In this research the floor sequences in House 3 are considered in some detail. A series of samples were collected from floor deposits in Structures L, J and H. Each of the structures and their floor sequences are considered independently in the following accounts.

2.3   Bostadh Beach: House 3, Structures L, J and H

2.3.1 Introduction

This House was the most extensively sampled in terms of floor deposits, with samples being collected from Structures L, J and H. Each of these structures will be described individually given that they each have their own sequence of phasing and deposits. However, at the outset, a general view of the construction of House 3 is given, which is followed by individual sections for each of the structures.

House 3, consisted of four cells (G, H, J and L), the shape and structure of these cells being indicated in Figure 2.8, the diagram also showing the interlinking between each of these cells. It is probable that at one time all these cells were in use contemporaneously. However disturbance caused during the subsequent development of the settlement and the lack of secure stratigraphic links between the components of this building with the exception of those layers that could be traced through doorways, means that it is impossible to be certain about this. Thus, the hearth in structure H could not be demonstrated stratigraphically to be contemporary with the central hearth in structure L, and there was equally no stratigraphic link between the pits below the floor in structure G and that in structure L to argue that

these were contemporary. The lack of stratigraphic links is even more problematic in the case of structures J and H, which are suspected to have had a longer period of use than the rest of house 3. Some of the deposits within structure L may have related to the putative wheelhouse, discussed above, of which structure J may be surmised to have formed the only surviving remains (Neighbour, 2001).

For ease of interpretation of the phasing, each of the structures comprising House 3 will be considered separately. Firstly however, the construction of the house will be briefly described.

Context descritions for the contexts illustrated on Figures 2.10 and 2.11 are detailed in Appendix Three (Pg 330).

2.3.2 The construction of House 3 at Bostadh

The eastern portion of House 3 (structures L and G) was similar to Houses 1 and 2. However, this house also had two annexes (H and J) to the west of structure L, both of which had been visible in the erosion face at the start of the excavation (Neighbour 2001). At least one of these structures (J) must initially have been part of a larger construction, possibly a wheelhouse.

Excavation revealed that a floor layer (context 252), which respected the Western wall of H and the walls of J (context 133), lay beneath the wall between H and L. A petal shaped hearth had also been cut through that layer. It is therefore clear that the wall of structure J and the western wall of structure H had been constructed before the wall between phase structures H and L, including the western inner wall skin of structure L. Structures J and H are similar in size and morphology to the later of Cnip wheelhouse (Armit, 1990). It is therefore suspected that structures L and G were added to an already existing building, using the original wall faces of that building as the outer skin of a double skin wall, where possible (Neighbour 2001). If the morphological comparison with Cnip (Armit 1990) is correct, much of the south-eastern portion of the wall of structure H must have been dismantled and

reassembled to accommodate the drain which ran down the entrance to structure L and had an off-shoot running beneath southern wall of structure H. The capstones of the drain had been sufficiently well joined to prevent much of the sand above from falling through the cracks (Neighbour 2001).

The eastern wall of House 3 existed of two phases of construction. Initially its outer wall skin respected the outer wall skin of structure P, suggesting that this structure was in use at the same time as the latter structure. The core of the eastern wall of structure L was formed of *in situ* standing dune sand, as has been described above. After this, a trench was dug and the outer wall skin erected. Wall core material was placed between the two skins and compacted as required. The external left between the external face of the house wall and the edge of the excavated hole had either been deliberately backfilled, or else had filled naturally. Given the presence of clean sand, it was not possible to distinguish between these two possibilities (Neighbour 2001). Table 2.1 illustrates the comparative phasing between the structures. It must be noted that each structure has been provided with its own sequence of phasing.

2.4   House 3: Structure L

Structure L was the largest structure within the House, measuring some 6-m in diameter. It forms a circular structure akin to House 1, composing the main body of the House. A total of nine occupation phases are represented in the House. Within these phases, three are considered to be important to the research, these being Phases I, IV and V, representing a total of 35 floor layers.

As Table 2.3 illustrates, three separate phases of occupation are identified with Structure L, House 3. The most noteworthy contexts are contexts 227 and 276, which should reveal similar characteristics in the floor samples if they are from the same period of use within the House. Phase V is also the most common occupation phase. One of the aims of this research is to identify the floors of the house and the

similarities of differences between them, thus, these samples provide an excellent opportunity to explore this.

The thin sections in Sample 161 were taken from the north-west to south-east section, immediately adjacent to the wall. Unfortunately, no organic materials are represented in these thin sections, and they are dominantly composed of sand. The material represented in these contexts also span the phase range from I to VI or later. There is very little archaeological information that can be gleaned from these sections.

2.4.1 Phase I

Figure 2.10 illustrates the deposits associated with this phase and the locations for the collection of the samples.

Phase I of the structure is assigned to the occupation phase 'Early'. According to the phasing and context descriptions (Neighbour 2001), this phase relates to pre-wall construction deposits. These pre-wall deposits are represented in thin section number 1 (sample 161/1), as the section is dominated by sand.

However, the material represented in the thin sections (160 1 & 2) does not support this view, as they appear to be floor deposits. If the material was Pre-wall in origin, then it would be expected that the deposits would appear to be more natural in appearance. This author postulates that it is possible for the floor having been laid before the construction of the wall, although this author also suggests that this is an inappropriate action, given the difficulty in building the wall and impracticality of having a floor laid during construction.

2.4.2 Phase IV

This phase was assigned to 'Hearth and Furniture' given the findings of a central hearth and due to the lowest was course of the eastern wall in the structure being set

slightly in towards the centre of the house. Neighbour (2001) states that it is unclear whether this was a by product of construction, or was designed to provide a bench.

The hearth was central to this structure. The form of the hearth is illustrated in Figure 2.9, and it is notable that two of the edge set stones which formed this hearth were still *in situ*. The voids where stones had been removed demonstrated that the hearth had originally been rectangular and was formed of three stone-defined sides with the open end of the feature facing southwards (Neighbour 2001).

The thin sections were collected from either end of the north-south section (Figure 2.10) and in the centre of the east-west section (Figure 2.11) close to the central hearth. All of these thin sections are important, given that the information gleaned from them may enable aspects of the use of space within the structure to be determined. The thin sections taken from close to the hearth (Samples 120 1-3) are especially important, as these may provide possible information on the fuels used for burning and the temperature at which the fire burned. This has implications for the use of the hearth, in terms of domestic or other uses. Further, the presence of accumulations of ash within the thin sections should enable the determination of frequency at which the hearth was cleaned.

Within the hearth, a sub-oval hollow cut an earlier circular pit, which was bowl shaped and measured c. 0.20 m in diameter and 0.10 m deep. The fill material of the pit was dark brown clayey sand, containing the sherds from a single pot. Neighbour (2001) states that it is probable that this find is a votive deposit made immediately prior to the construction of the hearth. The sub-oval depression itself, measuring 0.62 m north-south by 0.40 m east-west and 0.08 m deep, was probably caused during the use of the hearth, perhaps when scooping out embers. This was filled with peat ash.

2.4.3 Phase V

This phase is assigned to the overall structural phase 'Ventral', and is the only phase described as 'Floor' in the phasing for the settlement (Neighbour 2001).

The description of these floor deposits at the time of their excavation states that the layers were dark brown peaty sand interspersed with layers of yellow shell sand. The floor was described as being thinnest at the centre of the structure, but was up to 0.30 m thick at the walls and where the floor passed through doorways. This is an interesting feature, as it is possible that the 0.30 m thickness encountered adjacent to the walls represents the original thickness of the floor, as it is likely that the area immediate to the wall was seldom used.

However, the notion that the floor consisted of a thick deposit through the doorways is quite remarkable, as it would be thought that the floor would be at one of its thinnest points here as in the centre of the structure, since this would be a much-used sector of the building. This considerable thickness could be representative of successive accumulations corresponding to maintenance of the floor, with a succession of deposits being laid down when the floor becomes thin after use. Micromorphological analysis of Samples 178 A-C should enable the determination of these features, because if a succession of deposits have been laid down at the doorway, then this would be easily detected.

On the basis of these seemingly successive floor accumulations, Neighbour (2001) states that it is impossible to determine from field observations, whether the floor was formed as a single event or over a period of months or years. This is a fundamental question when investigating floors, as a context described as a single layer in the field can easily be composed of successive layers when viewed under the microscope. Neighbour (2001) also states it is possible that the house was regularly cleaned out, a process which is also thought to have occurred at Cnip Wheelhouse (Armit 1990). If any maintenance processes had occurred in the period of use then these should also be detected in the micromorphological analysis.

2.5   House 3: Structure H

This structure along with Structure J is thought to have had a longer history than the other structures within House 3 (Neighbour 2001). Structure H has a similar size and morphology to the later phase of Cnip wheelhouse (Armit 1990). The dimensions of Structure H are 5.5m in length by 2 m in width. The foundation on which the structure was situated is also different to that found in the other structures, since it was found standing upon sand dune material, as opposed to being revetted into it. A plan illustrating the shape and form of the structure is found in Figure 2.8.

Thirteen phases (See Table 2.4) are assigned to the structure, this being the highest number for any element in the whole house.

As illustrated in Table 2.4, of these thirteen phases, only phases II and X are of any significance for this study. Unfortunately the floor represented by Phase II of the structure is not represented subsequently, as thin section samples were not collected for analysis. These samples would have been very beneficial, in that they would have been from the primary floor, and therefore, would have enabled direct comparisons between the early floor and the floor in Phase X. Also, as this is proposed to be one of the first structures built on the site, the floor might also have been one of the first constructed, and it would have provided a unique insight into the form and function of an early floor.

Unfortunately, the section drawing illustrating the sequence of deposits in the structure has been lost, therefore it is not possible to provide an illustration of these deposits.

2.5.1 Phase II

Archaeologically, for reasons discussed above, this phase is important and requires some consideration because it contains the earliest hearth and floor found in the settlement. Neighbour (2001) states that a rectangular spread of black, red and

yellow material, probably peat ash ,was present on this floor. This spread he assumes to have been a hearth, even though there were no edge set stones defining such a feature. However, in terms of this research, the most important feature is the presence of a floor composed of dark brown sand. This floor was cut by the petal shaped hearth of Phase III, confirming that the floor is perhaps the earliest floor on the site. Again, it is unfortunate that this floor was not sampled.

The petal shaped hearth of Phase III is of significance because it represents one of the earliest hearths in the settlement and also because it displays a new technique in the construction of the hearth. The hearth is formed by five edge set slabs, with dimensions of 0.5 m by 0.5 m, and 0.25 m in height. The primary fill of the hearth was yellow and red ash, possibly peat, accumulated to 0.03 m in thickness. The disuse of the hearth is indicated by the sealing with a layer of dark brown sand, described in the field as having a similar matrix to the earlier floor surface in Phase II (Neighbour 2001).

2.5.2 Phase X

As Table 2.5 indicates, this is the only floor from this structure to have been sampled for micromorphological analysis. In the field, this floor was described as a single layer of dark brown silty sand. The micromorphological analysis can confirm that there are in fact multiple floor layers in this deposit.

Of particular importance for this floor is its association with the upper floor in structure J and the floor in Structure L. Neighbour (2001) has very little definitive to say about the possible function of this structure, but postulates that it was possibly used as a byre, given the presence of a wide entrance on the western side of the structure. The micromorphological analysis should confirm whether the floor was used by animals or served an alternative function.

2.6   House 3: Structure J

This small cellular structure was located at the western side of House 3, having an internal diameter of c. 1.8 m. The dimensions of the structure render it the smallest structure within the settlement. A plan of this structure is found in Figure 2.8. Neighbour (2001) postulates that unless its use was intended for a small child, then the size of the structure could indicate some kind of storage function.

In total, eight occupation phases (shown in Table 2.6) were identified here, with structural phasing extending from the Ventral period to the Norse (Neighbour 2001).

Floors were identified in Phases V and VI of this structure, as indicated in Table 2.7. This Structure was composed of eight phases, with phases IV and VI recording a possible floor layer, however, this author regards the description of the floor in phase IV as unreliable, because in the field the floor is described as a layer of white sand (165), and in thin section this does not appear to be the case. The floor in phase VI was described as a layer of mottled red and brown peaty sand (164=148) which lay in the entrance area between J and H. Above this layer was a layer of greyish brown peaty sand (163). Neighbour (2001) states that it is probable that these layers were floor surfaces, representing the same phase of occupation as that phase in Structure H which post dates the use of the central hearth.

As in structure H, it is not possible to illustrate the section of the floor deposits, as the section drawing has been temporarily misplaced during the post-excavation process.

2.7 Archaeological background to the South Uist research sites

2.7.1 Introduction

The two sites under investigation in South Uist are Cladh Hallan, a Late Bronze Age to Early Iron Age site, and Bornais, a site that dates from the 6th/7th Century AD to 13/14th Century AD. However, at Bornais, only the samples relating to the Late Iron Age occupation are under investigation. All excavations at these two sites are components of the Sheffield Environmental and Archaeological Research in the Outer Hebrides (SEARCH) programme. This was initiated by the University of Sheffield, but was later joined by teams from University College of Wales, Cardiff and also Bournemouth University. The locations of Cladh Hallan and Bornais on South Uist are found in Figure 2.3.

The surveying of the South Uist machair by the University of Sheffield for Archaeological monuments was begun in 1993 and lasted until 1996. The survey began in the extreme south of the island at Cille Bhirghde (West Killbride) and stretched to Baile Gharbhaide (Balgarva) in the north of the island, a distance of 35 km. Along this stretch, the width of the machair varies between 300 metres and 2 kilometres, averaging 1 kilometre (Parker-Pearson 1996). Before the survey, RCAHMS records for prehistoric and early historic settlement sites number around 40 locations within this zone, however at the end of the recent survey, this number had increased to 176 (Parker-Pearson 1996).

Of particular importance to this project are the settlement sites which lie in the machair of Cille Pheadair (Kilpheder), where a total of 20 sites have been discovered in an area of 3 square kilometres (Parker-Pearson, Brennand and Smith, 1996). The site of Cladh Hallan, the settlement under investigation here, is located within this machair zone.

2.8   Site Two: Cladh Hallan, South Uist, Outer Hebrides

2.8.1 Introduction

The excavations within the vicinity of Cladh Hallan began in 1989 and continued from 1994 to 1996, when a small settlement in the sand quarry located to the north of the graveyard in Cladh Hallan was excavated. This excavation revealed a double roundhouse from the Early Iron Age (c.750 – 200 BC) dug into a midden which dated to the Late Bronze Age (1400 – 1000 BC) (Parker-Pearson 1996). From 1996 to 2001, the remains set within a quarry situated to the south of this original excavation were under investigation. Here, was found a second double-roundhouse and a north-south row of three roundhouses, which were joined together by a wall of sand faced with stones (Parker-Pearson *et al.,* 2000). A plan of the settlement site, showing the relation and form of Houses 401 and 640 is shown in Figure 2.12.

In terms of this thesis, samples from two floor sequences, one from Phase III and one form Phase IV were collected from House 401 at Cladh Hallan. This is the house from which most of the samples were collected. However, the floor level from House 640 was also sampled and is included into this research with the aim of comparing uses for the structures and also to try to determine if the houses were contemporary in their use.

Context descriptions for Figures 2.14-2.22 are detailed in Appendix Three. The descriptions were undertaken during excavation and the information in Appendix Three is derived from field drawings and interpretations of the appropriate excavator.

2.8.2 Location of the site within South Uist

South Uist composes one of the Uist Islands which are part of the Outer Hebrides, the islands lying off the West coast of Scotland.

South Uist itself, is some 35 km in length, measuring 10 km at its widest point. The detailed environment of the islands and local environment for Cladh Hallan itself have been documented elsewhere in this Thesis (See Chapter 3), and are not under consideration here.

Cladh Hallan itself, lies within an active machair system on the west coast, around 2 kilometres from the Southern tip of the island. The area in which the settlement lies is under quarrying for sand, which itself is encouraging active degradation of the machair. As previously stated, the machair varies in width from 300 meters to 2 km throughout the island, although the average is one kilometre (Parker-Pearson and Sharples, 1999).

2.9   Cladh Hallan House 401: Structure and Floors

This structure is the central double roomed roundhouse of the excavated site at Cladh Hallan. The western room of the structure has an overall diameter of 12.1 m, whilst the eastern room is somewhat smaller at c.4 m. There are now over 600 contexts from the structure, with deposits inside the structure reaching a depth of 1 m (Parker-Pearson *et al.* 2000). A plan of the House is illustrated in Figure 2.12.

The positioning of this House almost directly on top of House 726 hints at a significant longevity of the house according to Parker-Pearson and co-workers (1996). Within the depositional sequence, ceramic change from flat topped to rounded rims suggests that occupation straddled the Late Bronze Age to Early Iron Age transition, perhaps over many generations. The same authors state that the practice of living on top of ancestral house foundations and floors may well be part of a significant change within the British Isles away from the Middle Bronze Age practice of relocating new houses at a distance from the old ones. In terms of House 401, Parker-Pearson and co-workers (1996) also state that the deep build up of floors together with the continuous renewal of walls indicates that deposition within the house was a long-term continuous process. The authors do not believe that the deposits represent an episode towards the end of the house's occupation as a

dwelling. This author does not believe that the longevity of a house can be based solely on the depth of deposits because the deposits could have been accumulated successively over a very short period of time. Perhaps by investigating the differences between the deposits in terms of composition, we can start to elucidate the formation of the deposits.

2.9.1 Sequence of floors encountered during the pre-1998 excavations

Unfortunately the floors revealed in the pre-1998 excavations were not sampled exclusively for micromorphology, although their nature and characteristics were described in the field. These floors represent the latest floors in House 401, with the earliest floors not being revealed until the 2000 field season.

In 1997, the deposits covering the entire of house 401 were removed down to the primary floor sequences at that time. As had been revealed through the excavation of the North-east corner of the house in 1996, a sequence of fill layers covered the floor layers. In the field, these floor layers were described as silty sand, brown and grey in colour, which contained large quantities of limpet shells, often in association with dumps of bone (Mulville and Parker-Pearson 1997).

The primary occupation layers revealed an absence of substantial internal divisions (Mulville and Parker-Pearson 1997), with the floor being composed of compacted burnt peat ash layers which appeared to have emanated from an unbounded hearth. A secondary floor surface suggested re-use of the house, as it was associated with modifications to the southern and western walls (Mulville and Parker-Pearson 1997).

Further floor layers are described in the data structure report for this season of excavations in the house, with the floors appearing to take different forms. On this basis, it is difficult for the reader to determine whether the floors are deliberately laid

floors or simply accumulations of material that have derived from activities within the house. Briefly, the floors occurred in the following forms and locations.

The secondary wall of the structure on a sticky dark patch which was described as a localised deposit in the field. Below this was a light sandy context (495), which extended into the house for over 1 m from the edge of the inner wall. Underlying this context was a compacted red/brown sandy silt, which in turn had a deposit of peat ash and charcoal lying beneath it. This layer did not extend to the outer edges of the house, but petered out within a metre of the inner wall. The most extensive floor layer in the house was an orange sandy layer (465), which extended across most of the house. The deposits underlying this are described in the 1997 Data Structure Report as unexcavated floor layers: however, these floor layers were excavated in the 1998 field season.

2.9.2 Sequence of floors post-1998 excavations

The house is remarkable in having a sequence of eight floors, according to field description, but this is somewhat expanded after micromorphological analysis. In the field, the floors appeared to have been constructed consecutively, each separated by a layer of sand. Archaeomagnetic dates from two of the hearths in this structure indicate that the lowest three or flour floor phases were occupied in the Late Bronze Age, whilst the upper four to five were inhabited in the Early Iron Age (Parker-Pearson et al. 2000). The duration of the house was probably around 500 years or more, which is very unusual in a period when most houses seem to have been abandoned after only a short period of use (Parker-Pearson et al. 2000).

Access into this east-facing house was sunwise, as was also the case in House 801, and involved stepping from the entrance passage onto a defined area, raised relative to the rest of the floor deposits, in the southeast corner of the house. Entry into the central roundhouse was gained through a small circular room, with an interior of c. 2

m across, leading into a 3 m passage which opened out into the roundhouse's interior. This small circular room had six successive floors but these, and the passage that connected it to the larger room, had been dug into by five large Late Bronze Age or Early Iron Age pits (Parker-Pearson *et al.* 2000).

During the house's eight phases of occupation, its architecture changed radically although the use of space within the roundhouse seems to have remained relatively constant (Parker-Pearson ans Sharples 1999). The entrance constantly faced due east and one of the large doorway postholes was recut and reused throughout much of the building's use. The south side, and especially the southeast area of the house was consistently full of red peat ash and pottery, suggesting its use as a kitchen and cooking area. The West End of the house has consistently produced deposits of pottery and antlers at its excavation during 1999. The north side of the house has raised areas, which were covered with turfed patches and appeared as shallow depressions, which the excavators suggest are remnants of sleeping accommodation. As with later phases, the southern half of the floor was strewn with sherds and bones, some embedded into the floor, especially in the Southeast quadrant of the house (Parker-Pearson *et al.* 2000).

The building's shape underwent several changes during its occupation, with it beginning as a 'heart-shaped' structure with inset doorway and entrance passage. The house was initially linked to a small circular room immediately to its east beyond the doorway. The purpose of this smaller roundhouse is unknown because its six floor layers were cut through by four later storage pits, but it may have been a storeroom. The smaller roundhouse not only had an interior stone wall but also an exterior wall which raised the house above the low ground to the east. By the time that the floor with context number 595 in the house was installed, the main house was fully circular and the smaller roundhouse seems to have gone out of use.

Of the eight phases of occupation in the House, only phases III (Floor 655) and four (Floor 595) are under consideration in this research, since these were the two lowest floors in the structure at the time analyses were undertaken, but lower floors have

since been excavated in the 2000 field season. Unfortunately, samples that have been collected in subsequent excavations can not be included due to time constraints with the production of the thin sections, and also due to the timing of funding applications, the results of which will not be known until the final stages of this project.

2.9.3   House 401: Phase III, Floor 655

Figures 2.13-2.19 illustrate the depth of the floor deposits in each area of the transect and the location of the thin sections collected for analysis. Figure 2.20 represents the extent of Floor 655 and the associated features.

Layer 655 is the first level at which it was possible to appreciate the house's architecture and layout. The walls survive on the south and north sides and on the south side of the eastern entrance. The house's interior dimensions were at their largest during this phase, 8.30m north-south and 7.30m west to east (9.10m including the entranceway).

The floor was clearly visible over most of the house's interior except on the east side in the northern part of the entranceway. The reason for this absence is probably due to the fact that the area was eroded and disturbed by its later use as the entrance area. The floor was also missing in the south-western area of the house, but there was no indication as to whether it had been removed or disturbed (Parker-Pearson *et al.* 2000).

During excavation, a number of features were revealed within different areas of the house. These are being used to identify the use of space within the building, but this is currently on-going research, and only interim results are available. The soil micromorphology of the floor layers mentioned above is only part of this research.

Briefly, in the southeast part of the house, a succession of thick organic layers stained red and black with hearth ash and charcoal flecks, particularly in the area

near the hearth, was identified. The lowest of these layers (1392) was a floor on which lay a remarkable group of two large smashed coarseware jars, along with bone and antler tools, utilised stones and raw clay lumps. Parker-Pearson and co-workers (2000) interpret this area as a kitchen and food preparation area based on the association with these objects.

In the southwest part of the house, the floor was either thin or non existent. However, substantial quantities of pottery sherds were recovered, and the excavators have surmised that due to the distribution of this pottery, the area may have been used for activities related to the kitchen since sherds are mainly restricted to the house's southern half. Parker-Pearson and co-workers (2000) state in their Data Structure Report that it is likely for this area to have been a storage space where pots and other containers could be stood on soft sand.

In the west section of the house, the floor layer was thick, but there has been no assumption made regarding the use of space in this area. The finds appear to represent a series of placed deposits. Alternatively in the northwest area, there is a raised area 5m long and 2.20m wide, set back 1.80m from the central hearth. This area has been interpreted (Parker-Pearson et al. 2000) as for sleeping, based on the evidence of machair turf residues buried between sand deposits. It is hoped that the micromorphological analysis can confirm or dispute that this area was used as a sleeping area. Unfortunately there is little documented evidence elsewhere for machair turves being used as mattresses, hence there are problems with the identification of the deposits and their interpretation.

On the basis of Archaeomagnetic dating, the first three or four phases of occupation are thought to relate to the use of the structure in the Late Bronze Age. Therefore, the floors represented in the thin sections for this phase could represent the floors of a Late Bronze Age occupation. This is interesting in terms of the floors in this investigation, as the floors represented in thin sections collected from the following phase, are thought to represent Early Iron Age floors.

2.10   House 401: Phase IV, Floor 595

The section drawings for these floor layers are illustrated in Figures 2.13-2.19. Figure 2.21 illustrates the extent of the floor deposits and associated finds

During this phase, the house appears to have been remodelled into a circular roundhouse, 7.10m east-west and 6.80m north-south. As was attempted in the case of floor 655, the floor has been divided into quadrants, based on the sampling strategy and the results of excavation. Hearth 489 from this phase (Phase IV), has been archaeomagnetically dated to 800 – 650 BC, placing this floor in the Early Iron Age (Parker-Pearson *et al.* 2000).

Briefly, the southeast floor surface was much redder than that in the rest of the house. The differential cover is possibly derived from the hearth's peat ash. In the southwest quarter, a hypothesis similar to that proposed for the same quadrant in floor 655 is made: the area was used for storage, given that there was either a bare surface, represented by a sand surface with no organic deposits overlying, or a very thin covering of organic material. There was also a pit full of- pottery dug into this area. In the northwest, the floor sloped steeply northwards on account of the raised turf floor underlying it. The northeast section of the house was again covered in a thin floor deposit, and no hypothesis about the use of space in this area has yet been made. (Parker-Pearson *et al.,* 2000).

2.11   Cladh Hallan: House 640

This multi-cellular House in the area to the Northeast of House 401, was the second major discovery of the 1998 excavations (Parker-Pearson *et al.,*2000). The field

section of the floors is illustrated in Figure 2.22, and a diagram illustrating the form of House 640 is provided in Figure 2.23.

The House was entirely excavated and consisted of an eastern entrance opening into a sub-circular eastern room. This then led into a sub-rectangular western room, into which the west facing wall were two niches, one large and one small (Parker-Pearson *et al.* 2000). There was a single small hearth in the eastern room, with the floor on the South side of the house being littered with cooking stones and a broken pot.

Parker-Pearson and co-workers (2000) state that House 640 provides a useful comparison for the partial but previously unique double roundhouse, about 100 m to the west (House 112) of House 640. It also highlights a dichotomy between these two multicellular houses and the roundhouse, House 401 in terms of their small size, absence of deep occupation layers and peripheral locations, which seems not to be chronological. The most likely current interpretation is that both multi-cellular and roundhouse architectures were in contemporary usage and were used in different ways, or were created at different times or by different people (Parker-Pearson *et al.* 2000).

2.11.1 Floors of House 640

The sequence of floors in House 401 was not present in House 640: instead one floor layer composed of grey soil and no thicker than 0.04 m was found. The floor area covered an area of 21 square metres, compared with the 38 square metres of House 401. There is not really a lot of detail written in the Data Structure Report for the floor of this House. The excavators have not assumed any specific use of the floor, but have instead employed micromorphology to determine the features and use of the structure and its floor (Parker-Pearson *et al.* 2000). The location of floor samples is illustrated in Figure 2.22.

2.12 Site Three: Bornais, South Uist, Outer Hebrides

2.12.1 Introduction

The excavations are part of a continuing project designed to document the development of settlement in the Southern Hebrides from the Mesolithic to the present day. These excavations were directed by Niall Sharples, Department of History and Archaeology, University College Cardiff, Wales. The location of Bornais in South Uist is found in Figure 2.3.

Three substantial mounds dominate the machair plain of the township of Bornais, South Uist, Outer Hebrides (NF 792302). The Bornais mound complex is one of the most extensive and complex Norse settlements known on the Western Isles and one of the largest rural settlements of this type known in the British Isles (Sharples, 1999).

A geophysical survey revealed a complex of over 20 houses covering an area of over 0.8 ha, with the occupation of the site being demonstrated to begin as early as the sixth to seventh century AD and continuing to around the thirteenth of fourteenth centuries AD (Sharples 1999). The preservation of the site is excellent with substantial stone walled houses surviving for over 1m below the present day surface. The intact floor layers and midden deposits contain large quantities of mammal and fish bones, carbonised plant remains, ceramics and a range of artefacts (Sharples, 1999).

2.12.2 Mound One

The main feature of concern from this site is Mound 1, which was first explored during 1996, when a trench 23 m long and 2 m wide was excavated (Sharples, 1999).

The trench was laid out to explore some striking variations in the gradiometer survey of the monuments and to examine the area that was particularly threatened by erosion.

Following excavation, the stratigraphy of the mound has been divided into seven units, these units being shown in Table 2.8.

Briefly, the Late Iron Age units are restricted to the south-west end of the trench, the sequence beginning with the early structures which remain unexcavated. These are overlain by the Late Iron Age House, filling in above this structure are a series of charcoal layers. The bulk of the Norse material lay to the North-east of the trench, the material comprising the walls of at least one substantial rectangular building (Sharples, 1999).

Sharples (1996) originally suggested that the principal Late Iron Age building might be a wheelhouse, but by 1997 he thought this to be unlikely. However, after excavations during 1999, Sharples states that this structure was originally constructed as a wheelhouse which was transformed after a conflagration into a sub rectangular structure which retained the original round east side (Sharples, 1999). The structure is described by the existence of a distinct charcoal and ash stained sand and three short stretches of walling. These features make up a rough rectangle over 7m long and 6m wide, though the south west edge is difficult to define. The building has rounded corners and two or three piers which project into the interior into the interior from the north and east sides. A trapezoidal hearth was present in the west quadrant, which was oriented E-W, with three sides consisting of slabs placed end on end, whilst the fourth on the west side was open. The East and wider end was embellished by the presence of an arc of 14 cattle metapodials which abutted two hammerstones placed at the corners of the hearth.

The detailed structure of the Mound and the Late Iron Age house (See Sharples 1999) are not for consideration in this thesis, which is primarily concerned with the

occupation deposits from within the dwelling. On this basis, the proceeding sections detail the floors from each of the two phases within the house.

2.12.3 Mound One: Late Iron Age House

Four samples were collected from contexts representing floors from the two occupation phases in the house, the location of samples is shown in Figure 2.24. These phases represent the period before the charcoal layer, and the period after the charcoal layer respectively. The thin section samples were collected to enable a representation of the three layers, and to answer specific questions regarding the formation of the floors and the identification of the charcoal material, as an aid to detecting whether the material analysed came from a collapsed roof or floor layer.

The phases are labelled House 1 and House 2, but these are not two different structures. House 2 is the period after the burning of House 1, which underwent some structural adaptations (Sharples, 1999).

2.12.3.1 Mound One: House 1

The occupation of this house is represented by a complex deposit comprising the vestigial remains of an original floor layer, a large number of features cut into the underlying brown sand and a thick deposit of charcoal rich sand. This charcoal layer contained a large number of carbonised planks, overlying all of the layers and features. Figure 2.25 illustrates the form of the structure and the extent of the floor within House 1.

Occupation layers associated with the hearth were patchy and difficult to define during excavation (Sharples, 1999). Two layers were identified on either side of the hearth. The first of these was a brown sand which remains unexcavated. The second was a compact red brown sand which extended to the entrance of the structure from

the hearth. Both of these layers were restricted to the south side of the house, and it was possible that they were more extensive, except that north of the bulk the floors were removed as part of another context (Sharples, 1999).

The most important feature of this house apart from the floor deposits, was a thick layer of charcoal rich sand (Sharples, 1999). He states that it was difficult to separate this layer from the overlying layer of red ash, which identified the second floor of the house. Often, this red layer dipped down and appeared underneath the black charcoal sand. However, as Sharples (1999) indicates, this mixing is not surprising if one considers that the charcoal layer was soft and one would expect the layers to be churned up by any activity after formation of the layer. Further, within the charcoal layer were large quantities of carbonised planks and other fragments of burnt wood (Sharples, 1999).

The charcoal layer was interpreted (Sharples, 1999) as the result of a massive fire which destroyed the house. However it is not clear exactly whether the deposit represents a floor layer or a collapsed roof, and in particular, what the planks within the layer represent. To date, there is no indication of when this event is supposed to have occurred.

Sharples (1999) indicates three opinions as to what the planks could be:

1. The main timbers that covered the central roof space and supported a turf roof.
2. The remains of a timber floor or the supports for a more flimsy organic floor.
3. The remains of collapsed upstanding timber partitions.

To have become carbonised in the manner which the planks were found, they would have to be *set alight* then sealed in an oxygen free environment (Sharples, 1999). He continues by stating that this is most likely caused by the collapse of a turf roof, however, this does not help in the theory that the charcoal represents either a collapsed roof or floor. This problem is the main reason why the use of

micromorphology has been included into the project, as it is hoped that the identification of the roofing material and the form of deposition will be established.

2.12.3.2 Mound One: House 2

The second house involved the retention of the walls and piers from House 1. However new structural features were also introduced in the form of a hearth, which was built to the west of the original hearth, and a new entrance directly south of the new hearth. Both of these features were cut through the charcoal layer (Sharples, 1999). The form of house 2 is illustrated in Figure 2.26.

The principal occupation layer of this house was a compact orange red sand layer. This was a very patchy layer, and was difficult to separate from the underlying layer. In many places a layer of charcoal had to be removed to identify the red sand layer. Sharples (1999) states that it is clear that a considerable mixing of these different layers took place and this is presumed to reflect the problems of re-occupying a building that has been burnt down. Although the red layer may be a deposit formed through the burning down of the structure, it was clearly evident that the deposit was reused to create a deliberate surface in some of the areas within the house (Sharples,1999).

This red floor layer was not the only floor within the house, with three outlying floor patches also being identified (Sharples, 1999). He states that in the south-east corner, behind orthostats was a discrete oval of orange-brown sand, with two deposits to the north of the house directly in line with the hearth, of compact dark brown sand. Immediately to the west of these layers was another small patch of dark brown sand.

The author of this thesis postulates that these deposits do not present floors in the strictest sense, and have been misidentified in the field. These patches could well be evidence of maintenance of the red compact floor, especially as the floor in the

structure was stated as being very thin anyway. Thus, these dark brown patches could be localised repair patches, especially as they do not extend over the whole floor.

2.13 Overview

This chapter was concerned with an archaeological review of the structures and floors associated with those structures in the Outer Hebridean Iron Age. However, as stated at the outset of the chapter a comprehensive review on the detailed structural aspects of dry stone structures is not the aim of the research. A brief review on archaeological research has highlighted that in Lewis although the research has been running for over twenty-years, this research is still very much in its infancy. Archaeological research in the Uists has a greater longevity, although the excavation and information regarding floors of structures is still in its infancy here too.

Only recently have floors been investigated in archaeological structures, the first of these being the Broch Tower at Dun Vulan, South Uist (Schwenninger, 1999). However, here the floors were not thoroughly investigated, and even though micromorphology was used, detailed and comprehensive information regarding the archaeological use of the associated floors were not attained.

As will be revealed in the results for each of these settlements (Chapter 6 to 8), the materials used for the construction from the Early to Late Iron Age varies, although whether this variation is a time variation or simply a reflection of the use of a house remains uncertain.

From this review and the research that it encompasses it is certain that more floors need to be sampled exclusively for analysis in future excavations and, where they are not sampled, require greater written documentation.

Chapter Three

The geographical and environmental background to the Outer Hebrides

3.1 Introduction

In this chapter, the key characteristics of the physical geography of the Outer Hebrides will be outlined. The chapter begins with a description of the past climate including that of the Iron Age in the islands, followed by a discussion of the characteristics of the present day climate that is not dissimilar to the conditions that would have prevailed in the period under study. Brief consideration is then given to the geology of the islands, as this is deemed important because of its effects on the formation of the landscape and the soils that have developed on it. The geology is also important as an aid to understanding the source of the strong mineral grain presence (quartz, feldspar and calcium carbonate especially) in the thin sections collected from the sites. Reference is then made to the soils of the islands, and in particular the soils around the examined sites of Bostadh, Cladh Hallan and Bornais.

Peat is considered only briefly in this section, as it is given greater importance in Chapter 4, where it is considered along with the description and distribution of another important component of Hebridean landscapes, the machair. A chapter has been devoted to these sediments given the dominance of these materials in the on-site samples and also the location of each settlement. Finally, the vegetation history of the islands is described, as this is important given that the peat has been formed from decaying vegetation matter. Furthermore, the vegetation provides information on past climate and land use changes within the islands.

The geography of the Outer Hebrides is a complex product of the interplay of physical and human factors, with powerful historical undertones. Peripheral position, the friction of distance, the lack of natural resources and an absence of low cultivable ground combine to provide a restricted and disadvantaged economic base (Ritchie, 1994).

The islands themselves lie approximately 60 km off the West coast of Scotland; the location of the islands is illustrated in Figure 3.1. The 200 km long island chain that constitutes the Outer Hebrides has 119 named islands of which only 16 are now permanently inhabited (Boyd and Boyd 1996). The archipelago is a unique series of landscapes, that have been produced by a combination of physical characteristics and geological development. Exposure to the Atlantic Ocean on the west gives rise to a cool, moist climate that is characterised by periods of powerful winds. The Archaean bedrock of Lewisian gneiss provides a stable basement platform upon which recent land-forming events such as glaciation, sea level changes and ubiquitous peat development have been superimposed (Ritchie, 1994). The climate and soils have helped establish the potential for economic development, whilst the topography has compressed settlement into certain areas and established some of the prevailing patterns of communication (Armit 1996).

3.2   The evidence for past climates and climate changes in Scotland

As this thesis is concerned with the period from the Early to the Late Iron Age as these terms are now used in the study of the Atlantic Iron Age in Scotland (800 BC to 1000 AD), then only the climate for this period will be discussed in this section. However, there is very little published literature on this period, as it is generally thought that the climatic optimum was relatively stable.

As Whittington and Edwards (1997) have stated, the description of and explanations for, changes in the Holocene climate of Scotland must be regarded not only as being at an interim stage but also in a state of flux. Much of the proxy evidence available is

still at a crude level of interpretation and perhaps also suffers from misinterpretation. Pollen data is the principal form of information, but even this needs to be viewed much more critically, and as demonstrated in the past, often leads to circular arguments in trying to establish records of long term climate change. This section of the chapter on the environment of the Outer Hebrides, illustrates some of these arguments and also the research that has been undertaken by many workers to try and establish this record of change. However, in approaching this evidence it is important to realise that, as Whittington and Edwards (1997) have stated, palaeoclimatology in Scotland is still incompletely understood.

3.2.1 The Holocene climate

With the end of the Younger Dryas (Loch Lomond Stadial) period c.10 ka BP, a major change in climatic conditions was initiated. Temperatures rose significantly, although not without temporary downward fluctuations (Whittington and Edwards, 1997), so that by about 7-5 ka BP the climate in Scotland would have been about 1-3 °C warmer than it is today. There is debate as to overall climatic trends from that period onwards, although temperatures seem to have experienced a downward trend; it is probable, however that two warmer periods lasting several centuries occur between 3.1-2.8 ka BP, and again from 1.1-0.6 ka BP (Edwards and Whittington 1993). It is possible that fluctuations may have been local rather than global in nature, thus rendering them difficult to identify. Numerous research papers has been published on this debate, with some of the relevant projects being discussed in the next section. However, much of this research is localised within specific areas of Scotland, and, for several issues, there has not been complete coverage of the country, so that, for example, it is still difficult to prove that the onset of cooler and/or wetter conditions c 2.5 ka BP, is a phenomenon that covered the whole of the country.

3.3   Climate in the Iron Age of the Outer Hebridean Islands

The research on past climatic history of Scotland have revealed that the Iron Age had a similar climate to today.

The last thirty years have seen major advances in our understanding of environmental change during the Late Quaternary period (Walker and Lowe, 1987). Data from deep sea sediments and cores taken from the polar ice sheets have provided new insights into the timing, frequency and intensity of glacial and interglacial episodes. Superimposed upon these long term global changes are climatic fluctuations over much shorter timescales, during which hemispherical changes in temperature and climatic regime appear to have occurred over time intervals measurable in hundreds of years or less, and at rates which would have been considered totally unrealistic only a decade or so ago. These, often dramatic, short term changes can be detected in a range of proxy climatic records, not only from marine and ice core data, but also from the terrestrial sources (Walker and Lowe 1987).

The closest major published study concerning climate change between 1000 BC and 1000 AD is that of Anderson and co-workers (1998), who published evidence for abrupt climate change in northern Scotland between 3900 and 3500 calendar years BP. These researchers used palaeohydrological and palaeoecological data from peat and lake sediment sequences derived from five locations in northern Scotland. The sequences were located in Wester Ross, with the exception of the fifth sequence which was located in Sutherland. The data revealed a distinct and large scale shift to wetter climatic conditions between about 3900 and 3500 cal. BP (Anderson *et al.* 1998). The research of Anderson and co-workers (1998) was conducted using humification of peat samples the results showed that the widespread shift to less humified peat probably reflected a distinct and rapid shift to wetter and/or cooler conditions which enhanced peat growth and reduced peat decomposition rates on mainland northern Scotland. Pollen analyses from the five locations investigated

showed little evidence for human land use at the time, suggesting that human causation of the shift to wetter mire conditions is unlikely in these cases. At around C14 4000 years BP, pollen and macrofossil evidence for large scale Scots pine deforestation in northern Scotland has been documented at several locations (Birks 1972, Charman 1994), and it could be postulated that changes in catchment hydrology following widespread deforestation may account for the shift to wetter peat forming conditions. However, upon closer investigation, the nature of the mid-Holocene pine decline reveals a complex picture in which permanent reductions in pine pollen occurred at different times in different areas of northern Scotland between c.4200 and 3500 C14 years BP (Gear and Huntley 1991). As this is the case, and due to the lack of documentary evidence of climate conditions during the Iron Age, the present day characteristics are discussed.

3.4   Present day climate of the Outer Hebrides

The islands of Lewis and South Uists experiences a maritime climate, with much of the weather originating from the west. The main features of a maritime climate are a small annual variation in mean air temperature relative to latitude with extremes of both low or high temperatures very rare, high wind speeds at sea level, and high rainfall fairly evenly spread throughout the year.

3.4.1 Precipitation and Humidity

Recorded annual precipitation ranges from just over 1000 mm in parts of the Broad Bay area of Lewis to over 2400 mm on some of the higher summits of Harris. The totals at Stornoway and Balivanich are 1094 mm and 1220 mm respectively (Angus, 1994). The high ground of Harris and Uig receives proportionally more orographic rainfall, with summits receiving about 1000 mm more rain per year even than adjacent western coasts. North and north-east Lewis lie in the rain shadow of these hills whilst the Uist machairs are too low lying to receive much orographic precipitation (Angus 1994). The distribution of the rainfall is illustrated in Figure 3.2,

a rainfall distribution map for the islands. This map is based on data from the Scottish Meteorological Office.

Days with measurable rainfall (> 0.2 mm) are fairly evenly spaced throughout the year. Monthly rainfall averages range from 17 to 26 mm *per diem*, with 200 annual 'wet' days, a wet day described as 1 mm of recorded moisture (Manley 1979). The average relative humidity is high throughout the year, with a range of 80-88% saturation (Angus 1994).

The lowest average annual rainfall occurs on both the east and west coasts of north Lewis (1000-1200 mm), partly a result of the rain shadow effect from the prevailing rain bearing south westerly winds of the North Harris hills, but mainly due to the low altitudes in north Lewis (Hudson *et al.* 1982). Along the remainder of the coastline, the rainfall varies from 1200 mm in North Uist, South Uist and Benbecula to 1400 mm in west Lewis and Harris.

In common with much of Scotland, the driest spell of the year occurs from April to June. The wettest months (October to January) each have approximately 10-12% of the annual total, whereas the drier months of April to June each have about 5-6% (Hudson, 1994).

Probably the most conspicuous feature of the climate in the Outer Hebrides is the frequency of strong winds, the velocities of which are among the highest in the world. Most of these winds result from air circulating around the deep depressions coming in from the North Atlantic where there are mean speeds of 10 m/s in winter and 5 m/s in summer (Manley 1972). According to Birse and Robertson (1970) who constructed a map with an assessment of exposure, the Outer Hebrides are very exposed, with a wind speed which ranges from 6.2 – 8.0 m/s, with gales being recorded on 50 days of the year (Manley 1972).

3.4.2 Sunshine and Temperature

Average daily sunshine at Stornoway is 3.40 hours (Manley, 1979). This low figure for Stornoway may be caused by a greater tendency for cloud formation over the land to the west and south west (the sources of prevailing winds), while exposed western coasts tend to have good sunshine records, at least at sea level (Green and Harding, 1983). Figure 3.3 illustrates the average daily duration of bright sunshine for two months, June and December. As seen from the map, there is an average of 1 hr *per diem* of bright sunshine in December for the islands, rising to 6-6.5 hours daily in June.

The sunniest months are May and June, owing to the tendency for anticyclones to develop over the Atlantic. The relatively high latitude of the islands means that days in midsummer are long, with very long twilights, but shorter days mark the winter (Manley 1949). The latitude also reduces the angle at which the sun's rays strike the earth, lengthening shadows and increasing the filtering effect of the atmospheric haze.

The truly maritime nature of the climate of the Western Isles is reflected in the way that air temperatures tend to be more influenced by sea temperatures than sunshine. Thus, according to mean daily temperatures, the warmest months are July and August, with a mean temperature of 12.9 °C, rather than the sunnier months of May and June. In contrast, the coldest months are January and February, with a mean temperature of 4.1 °C. These two figures provide an annual range in temperature of only 8.8 °C., one of the lowest ranges in Britain (Angus, 1994). The mean daily temperatures for January and July are illustrated in Figure 3.4. The temperatures are measured in degrees Celsius.

The incidence and number of hours of sunlight are important considerations for subterranean dwellings and the use of the space within Iron Age dwellings in the Hebrides. For example, longer daylight hours could mean that the house is used less, as more activities could be occurring outwith the dwelling, and the higher impact

would be occurring during the darker hours. Therefore, sunlight and the length of the day are potentially important factors when considering the impact of activities on floors and structures. Supplementary information gleaned from future excavations may assist in understanding the pattern of use of buildings in this northern environment.

3.4.3 Wind

The prevailing winds originate from the south and south west, a consequence of the frequency with which depressions with their anti-clockwise circulation, pass to the north of the islands (Angus, 1994). The average wind speed at Stornoway is 14.4 knots (Birse and Robertson, 1970) and gales are recorded on average 50 days of the year (Manley, 1979).

This wind is usually salt laden, particularly when it has come from the west or south-west, having passed over long distances of wave torn ocean. The salt content of the air drops off significantly with increasing distance from the sea, though local variations in topography affect this relationship. When maximum gust speed exceeds 30 knots, the salt content of the wind increases proportionally as there is more sea spray, and that spray tends to be carried further inland (Randall, 1973).

3.5   Geology of the islands, with particular reference to Lewis and South Uist

The geological formations of the islands are of some importance to this research, given that the geology influences the formation of the landforms and the materials overlying those landforms. Further, materials derived from the solid and drift geology are present in various quantities and forms throughout the thin sections which have formed the basis of the research, meaning that an understanding of the origin of these minerals is fundamental in understanding their on-site presence as

identified in the samples. It is not the intention of this section to enter into depth concerning the geological origin and formation of the minerals that have been detected, but to provide an indication of their natural presence and locations in the islands with particular respect to the settlements here studied and the other minerals present in the floors of these sites.

Research into the geology of the Outer Hebrides has a long history, dating back to the first publication by MacCulloch (1819). Since this time, many workers have followed in their research on the geological formations of the islands, culminating with the production of a new geological map for the region by the British Geological Survey (1981). As seen on the map (Fig 3.5), the Outer Hebridean islands are dominated by a bedrock of Lewisian Gneiss.

The Outer Hebrides are composed primarily of metamorphic gneisses and igneous rocks of Precambrian age, apart from a small area near Stornoway in Lewis, which has rocks of either upper Palaeozoic or lower Mesozoic age resting upon the Precambrain rocks. These Precambrain metamorphic rocks formed during the late Archaean-early Proterozoic eras, roughly indicating a time span of from c.2800 Ma to c.1600 Ma (Gribble, 1991). The Outer Hebrides consist almost entirely of Lewisian Gneiss, and as such they constitute by far the largest area of such rocks in the British Isles. The term 'Lewisian' was proposed by MacCulloch (1819) from the predominance of the gneiss in the Isle of Lewis (British Geological Survey, 1989).

The Lewisian gneiss comprises either quartzo-feldspathic gneiss or hornblende gneiss, often with intercalated amphibolite sheets. The quartzo-feldspathic gneiss contains quartz, feldspar and hornblende as the principal minerals, as well as variable though small amounts of biotite; iron ores and apatite are the common accessory minerals present (British Geological Survey, 1989). In general the gneiss is quartz rich but variable in character, and with hornblende patches and acid veins occasionally present. The grain size varies from coarse to fine grained and the rock has a banded appearance (Gribble, 1991). The textures and general characteristics of

the gneisses suggest that these rocks have been metamorphosed to high grades such that they are migmatised in places (British Geological Survey, 1989).

The quartz and feldspars mentioned previously are indeed the dominant mineral grains present in the thin sections examined throughout the research, as indicated in the thin section descriptions. The exceptions to this are the thin sections which are dominated by calcareous sand; the origin for this material is described in the Peat and Machair chapter (Chapter 4). However, both the quartz and feldspar components are still evident in the latter sections.

3.6   Soils of the islands, with special reference to Lewis and South Uist

The soils in the Outer Hebridean chain are of relatively recent origin, having formed since the end of the glacial epoch, during which the pre-existing soils and regolith were wholly destroyed (Hudson, 1994). The glacial drifts on which many soils are developed are widespread in Lewis and occur sporadically in Harris, North Uist, Benbecula, and South Uist. Some soils however are on yet younger materials, notably the peats and windblown shelly sands which formed subsequent to the glaciations. The principal factors influencing the processes of soil formation in the Outer Hebrides are climate, parent materials, topography and vegetation, and the distribution of soil types in the islands reflects variations in the importance of these factors (Hudson, 1994). The distribution and types of soils on the Isle of Lewis and South Uist is illustrated in Figure 3.6.

The cool wet climate (Birse 1971) of the islands affected soil formation in two ways. The low potential water deficit has resulted in many waterlogged soils having subsoils with anaerobic, reducing conditions, which restrict plant-rooting systems. Secondly, the waterlogged soils remain cold in spring, and organic matter resulting from vigorous plant growth breaks down slowly, resulting in peat accumulating widely through the islands (Hudson 1994). The soils developed on the machair systems, (see Chapter 4), are different from the waterlogged soils. The machair soil

are coarse textured, readily permeable and base rich, resulting in organic matter breakdown being more rapid under aerobic conditions and with a good nutrient supply in the calcareous soils (Hudson 1994).

The Soil Survey of Scotland recognises six different parent materials within the Hebrides (glacial till, morainic drift, outwash and raised beaches, colluvium, aeolian sand and montane frost-shattered detritus). Each of these substrates has a range of soil developed upon it.

The main soil groups that have been identified are:

1. Peat
2. Peaty Gleys on indurated parent material, gleyed beneath the iron pan and induration
3. Peaty Podzol with iron pan, freely drained beneath the pan
4. Non-calcareous gley
5. Podzols and peaty brown soils
6. Brown Earth
7. Calcareous brown earth
8. Calcareous gley and peaty calcareous gley
9. Saltings on estuarine alluvium
10. Anthropogenic soils (Lazy beds)

Not all of these soils have been identified in the thin sections forming the basis of this research, with only peat and calcareous soils being evident. This is as would be expected, given that this research is focussed entirely on the investigation of internal occupation deposits and not external site formation processes. Also, as the settlements are located within the machair zone and with peat covering the majority of the landscape, it is expected that these sediments would be dominant in the thin sections.

The distribution of the soils is indicated in Figure 3.6, but a brief description of their occurrence through the landscape is better formulated using a transect from the machair at the coast and upslope through the landscape. Five major landform regions related to soil parent materials have been identified (Hudson 1994), each of them associated with their own soils associated with them. These five landscapes are: machair and associated dune systems; till-covered plains; hummocky moraines; rock-controlled lowlands and low hills; and mountains. For this research, the machair and associated dune systems, and soils of the rock controlled lowlands and low hills are of particular importance, again because of the location of the archaeological settlements under investigation. Therefore, only the soils associated with these landscapes are considered here.

3.6.1 Machair and associated dune systems

The formation and location of the machair system is considered in Chapter Four of this thesis. Briefly, however, the machairs are undulating shell sand deposits occupying the Western seaboard of South Uist, Benbecula and North Uist. Many bays on the west of Lewis and Harris also have areas of these shelly sands, often confined between rocky headlands (Hudson 1994).

The lime rich soils overlying the dune systems have high values of certain soil properties, particularly pH, which is typically between 7.5-8.0 in subsoils and 6.5-7.5 in topsoils in machair areas (Soil Survey of Scotland 1984). The soils reflect the activity of the machair systems. There are four main subdivisions of these systems: dune systems, gently undulating land lying above the influence of the groundwater table, level land close to the water table and rocky terrain with sand (Hudson 1994).

The principal soils on the dune systems are calcareous regosols (Soil Survey of Scotland, 1984), which have a weakly developed A horizon overlying raw sand. They often have buried A--horizons indicating former land surfaces (Hudson 1994). Poorly drained calcareous ground water gleys found in hollows between the dunes,

are locally extensive in areas having dune slacks and where deflation of sand has reached the water table (Hudson 1994).

Occupying the zone behind the dune systems are freely drained brown calcareous Regosols, where the water table lies below the soil profile. The soils in this landscape are relatively stable and have a dark grey-brown A horizon over a light brownish-grey or pale brown B horizons and white, shelly sand C horizons. Humus in the top soil reduces infiltration into these soils, allowing water to accumulate on the surface after periods of heavy rain, though such flooding is of short duration (Hudson 1994).

Thirdly, the level land soils which lie largely close to the water table, comprise calcareous groundwater gleys. Moist or wet soil conditions prevail, the effects of gleying under anaerobic conditions increases with depth, rendering the subsoils blue or blue-grey in colour. These lie under dark greyish-brown topsoils (Hudson 1994). Locally, where the machair borders the gneiss landscapes, the lowest elevations are occupied by eutrophic peats or peaty gleys. Very poorly drained mineral soils form narrow corridors of wetlands fringing lochs or adjoining land (Hudson 1994).

Lastly, wind blown sand has accumulated up to a height of 150 metres OD, where rock where rock cored hills with gentle slopes lie close to the beach or an eroding dune system which furnish a steady supply of sand. The gneisses have little influence on the soils apart from creating local shelter, where wind blown sand can accumulate. The soils developing in such circumstances mainly comprise calcareous regosols (Hudson 1994).

3.6.2 Rock controlled lowlands and low hills

Covering about 55% of the Outer Hebrides, landscapes with the underlying rock near the surface have shallow drifts in hollows and crevices. Near the machairs on North Uist, Benbecula and South Uist and amongst the morainic drifts on these islands are areas of slightly to moderately rocky undulating lowlands. The shallow, stony, sandy loam till carries a wide range of soil types, including brown forest soils on well

drained knolls, and non-calcareous or peaty gleys in the hollows. These areas are dominated by crofting, where fences have been constructed around agriculturally productive areas and soil improvement measures have been undertaken (Hudson 1994).

Peaty gleys and peat are developed in shallow stony tills widespread on hills and level areas throughout the islands. These soils typically have organic surface horizons in excess of 50 cm and peat cutting is practices in easily accessible areas around lochs and roads. Peaty gleys occupy slopes, mounds and ridges (Hudson 1994).

On the western seaboard of Lewis and Harris from Great Berneradh, the location of Bostadh Beach, to South Harris, there are extensive areas of very rocky land comprising dissected lowlands and hills. Drift is largely absent in this terrain, where glacial erosion was severe and the very shallow soils that are present here are mainly peaty lithosols and peaty rankers with some peaty gleys of peat in hollows (Hudson 1994).

3.6.3 Peat

A large proportion of the Island of Lewis is covered by peat. According to the Scottish Peat Surveys report, the peat deposits of Lewis were estimated in 1910-11 as covering approximately 595 square kilometres, averaging 1.5 m depth. This figure is not easy to derive, and is far from accurate, due to the south of the island having a very irregular topography where peat fills numerous hollows and depressions in the gneiss bedrock (Goode and Lindsay 1979). In the north of the island however, peat is much more continuous, blanketing all but the steepest slopes and covering most of the interior. By using aerial photography it has been estimated that in this northern plateau of the island, peat covers approximately 430 square kilometres, representing about 79% of the island (Goode and Lindsay 1979). This figure is now substantially out of date, but is the most recent calculation of the extent of peat on the island. Twenty one years of peat cutting and land use change will have altered this figure

somewhat, and it is probable that this figure will have decreased from the original estimation.

The formation and location of peat is described elsewhere in this thesis (Chapter Four).

3.7 The soils of Great Berneradh, with particular reference to Bostadh and the South Uist research sites

According the the Soil Survey of Scotland (Hudson *et al.* 1982) the soils of Great Berneradh belong to the Lochinver Association. This is the most extensive association in Western Scotland, covering 2152 km^2 (38.2% of the land area), the bulk of which occurs in the Outer Hebrides.

The island of Great Berneradh lies within map unit 385 (Hudson *et al.* 1982). This unit is confined to the Isle of Lewis and covers 22 square km, representing 1% of the Lochinver Association as a whole. The landform is typical of the Lewis till plain; gently undulating with gentle and strong slopes, non rocky and mostly below 50 metres altitude.

3.7.1 Bostadh

The soils of the Bostadh locality belong to the Lochinver Association, which are developed on drifts from crystalline rocks of Lewisian age. There is a wide variety of metamorphic rocks in the formation but they are classified as gneisses and schists. The gneisses are dominant and consist largely of granitic gneiss with small plutons of granite in West Lewis. These rocks are slow to weather, having both acid and basic properties. Their drifts have sandy loam to sandy textures with stony soils overlying them.

The soils are non-calcareous and humic gleys with some humus-iron podzols and are developed on deep, stony till of sandy loam texture. The soils are distributed around

the periphery of the large peat covered till plain of north Lewis and parts of the map unit have been reclaimed from the peaty gleys, peat and peaty podzols. There are still some small areas of peaty gleys in wetter hollows, and the mineral gleys often have humose topsoils. The poor drainage of these soils is largely due to a combination of gentle slopes and compact or indurated subsoil. Freely drained humus iron podzols are found where sites are less well waterlogged.

This description by the Soil Survey of Scotland is very generalised, covering the wide northern area of Lewis. A more specific description of the soils around Bostadh is that of Hudson (1994), who states that on the western seaboard of Lewis and Harris from Great Berneradh to South Harris, there are extensive areas of very rocky land comprising dissected lowlands. Drift is largely absent in this terrain, where glacial erosion was severe. The soils are described as very shallow, mainly peaty lithosols and peaty rankers with some peaty gleys in the hollows. This description describes exactly the soils that were found during a survey of the soils undertaken by this author, in the area to the South of the settlement. However, to the east, the soils are much more similar to those described in the machair and associated sand dune systems in Chapter 4.

3.7.2 Cladh Hallan and Bornais

The soils around Cladh Hallan and Bornais belong to the Fraserburgh Association (Soil Survey of Scotland 1984). This association has been identified along the western coastline of the Outer Hebrides from North Uist to Barra, where there are long stretches of windblown shelly sand. This extends for approximately 90 kilometres along this coastline and accounts for 80% of the association as a whole. A very high proportion of the association is low lying. Mather and Ritchie (1977) state that 87% of the machair of the Outer Hebrides occurs below 50 metres and approximately 18% lies below 10 metres.

The texture of the material is sand, with 100% of the particles measuring greater than 50 μm, consisting of comminuted shell fragments which are lime rich. This soil has high values of some biologically significant chemical properties, especially pH, exchangeable calcium and percentage base saturation.

The soils around Cladh Hallan and Bornais lie within map unit 261, the most extensive in the association, covering 52 square kilometers representing 40% of the association as a whole (Hudson *et al.* 1982). The principal soil type is the calcareous regosol, which has a weakly differentiated A horizon, brown to grey in colour, with, overlying the light grey C horizon. These soils, found on the dunes, are thus susceptible to drought in the warm, dry weather. Calcareous groundwater gleys and, occasionally, peaty gleys are found in the low-lying dune slacks. Active erosion of the sand parent material is frequently observed.

3.8   The vegetation of the Outer Hebrides, with particular reference to Lewis and South Uist

3.8.1 Introduction

The present day landscape of the Outer Hebrides is one of the most distinctive in the British Isles, being almost completely treeless and having a near-continuous blanket of infertile acid bog and moorland dotted with lochs of all shapes and sizes (Birks, 1975). However, the vegetation of these islands has been the subject of much debate. The traditional view is that the islands have been treeless throughout the Holocene, with many pollen diagrams from the islands appearing to support this view, the most quoted example being that examined by Birks and Madsen (1979).

Lewis is a wilderness of bog and loch, whilst the Uists are more mosaic-like, bordered on the west by a fertile coastal strip, composed of calcareous wind blown shell sand edged by sand dunes, this more productive band forming approximately 10% of the land area (Birks 1975). Away from the species rich machair, the present day flora is species poor, with only around 25 phanerogram species comprising most

of the vegetation of bog, moorland and loch. In a few sheltered rocky glens and on inaccessible cliff edges and islands in larger lochs, dense stands of scrub of *Salix aurita* and *S. cinerea* subsp are found. *Oleifolia* occur with scattered bushes of *Betula pubescens, Corylus avellana, Lonicera periclymenum, Populus tremula, Rosa afzeliana* and *Dryopteris dilatata*, and tall shrubs such as *Angelica sylvestris* and *Filipendula ulmaria*. The montane flora is also poor, reflecting the widespread, strongly acidic bedrock, the abundance of blanket peat unsuitable for many montane species, and the limited extent of open ground at high altitude (Birks 1975).

Palaeoecological investigations have been undertaken at numerous sites within the Outer Hebrides to establish a record of flora, together with an environmental history of the islands. However, even with the great abundance of bogs and freshwater lochs, several of these are unsuitable for detailed investigation. The reasons for this, include the use of almost all the bogs for peat-cutting for domestic fuel. Further, some of the machair lochs contain little or no sediment because of intensive wind fetch and wave erosion. Deposits of late glacial age that accumulated in small closed basins within glacial drift in the valleys are now often covered by a thick mantle of peat, rendering them difficult to locate except by extensive, systematic borings. In addition many promising lochs and undisturbed bogs (Goode and Lindsay 1979) are remote and difficult to reach.

Figure 3.7 illustrates the pollen spectra from four sites on the Isle of Lewis, representing dates from 12,000 to 0 years BP. The implications of the vegetation changes represented in these diagrams are discussed in the proceeding sections.

3.8.2 Vegetational History before the late-glacial (pre-13,500 years before present)

Nothing is known about the vegetation of the Outer Hebrides in any previous interglacial, as no unambiguous interglacial deposits have, so far, been discovered. A possible interglacial sequence occurs at Toa Galston, northern Lewis (Sutherland and Walker 1984). The pollen assemblage of this deposit is dominated by *Graminea,*

Cyperaceae and Ericaceae, with a variety of other open ground herbs, all of which occur today on Lewis. The age of the Toa Galston peat bed is not known, as it lies beyond the range of radiocarbon dating, which is more than c.47,000 year BP (Sutherland and Walker 1984).

An organic rich silt lens at Tolsta Head, Lewis is overlain by 2 metres of glacial till. The silt has been dated about 27,000 BP and its fossil assemblages suggest a herb dominated vegetation with Salix and Juniperus and open ground taxa such as Artemisia, *Lycopodium selago* and *Armeria maritimia* (von Weymarn and Edwards 1973, Birnie 1983).

3.8.3 Late glacial vegetational history (13,500 – 10,000 years BP)

This period comprises the time of deglaciation after the last glacial maximum, and reflects major climatic amelioration. This trend was interrupted at abround 11,000-10,300 BP by a widespread climatic deterioration that resulted in the redevelopment or expansion of corrie glaciers and small ice caps in the Scottish Highlands: this is described as the Loch Lomond stadial (Birks 1991). Unfortunately, at present no pollen analysis of undisputed late glacial deposits from the Outer Hebrides have been published, due to the difficulty in locating appropriate deposits due to the extensive peat cover in the lowlands.

Pollen spectra of early post-glacial deposits from Lewis (Birks and Madsen, 1979), South Uist (Bennett *et al.,* (1990) and from St Kilda (Walker, 1984) provide an insight into what the late glacial flora and vegetation may have been like. Open species rich grasslands with Ranunculus sp, *Plantago maritima,* Thalictrum sp and scattered Juniperus heaths were probably widespread. Tall herb and Salix communities with *Rumex acetosa*, Filipendula and abundant ferns may have been common in wetter areas. On shallow soils and exposed sites, open communities occurred with, for example, *Lycopodium selago, L. alpinium, L. clavatum, Armeria maritima* and Artemesia sp. The vegetation as a whole may have resembled, physiognomically at least, the modern species-poor sub alpine vegetation of western

Norway. All the indications are that the Hebridean flora and vegetation were more diverse than today, presumably as a result of the widespread more fertile, unleached mineral soils present immediately after the deglaciation and the cessation of periglaciation. Almost all the species present then still occur today on the Outer Hebrides (Birks 1975)

3.8.4 Post glacial vegetational history (10,000 – 0 years BP)

There are only a few detailed pollen diagrams from the Outer Hebrides that cover all or part of the last 10,000 years. Early investigations in Lewis (Erdtman 1924), South Uist (Harrison and Blackburn 1946; Ritchie 1985) are unfortunately insufficiently detailed to permit any useful reconstruction of the Post-glacial floristic or vegetational history. However, all of the sequences show very high frequencies of non-tree pollen, mainly *Ericaceae* and *Poaceae*, and when calculated on an appropriate pollen sum, suggest that there was never any extensive, continuous forest cover present in the area (Birks 1975). Figure 3.7. illustrates vegetation change in cores from the Calanais area of Lewis (After Edwards and Whittington, 1993).

The most complete and reliably dated sequence is that obtained from near Little Loch Roag, Lewis (Birks and Madsen 1979). Here the pollen and macrofossil record suggests that, after a phase with species rich grasslands, tall herb, fern and willow communities, the vegetation cover became complete about 9000 BP The major vegetation types at this time were species rich grasslands, with tall herbs and fern dominated stands and small areas of birch and hazel scrub in sheltered areas, perhaps similar to the vegetation today. However, by 7700 BP *Calluna* heaths expanded, presumably as a result of acidification and podsolisation. The dominant vegetation was still grassland and tall herb communities with *Angelica sylvestris*, *Filipendula ulmaria*, *Succisa pratensis*, and ferns including *Osmunda regalis*. At this site, the evidence suggests that there was never an extensive cover of woodland, only scattered birch, willow, hazel and rowan scrub (Birks and Madsen 1979). However, this perspective has been challenged by Wilkins (1984) on the grounds that birch, pine and willow wood remains occur in peat deposits near to Little Loch Roag, and

these indicate "the extensive growth of *Pinus* on Lewis prior to 4500 BP." (Wilkins 1984, p.258). Remains of birch, hazel, and more rarely alder and pine have been recorded from Lewis, Harris, Benbecula and the Uists (Birks and Madsen 1979). There is, however, no irreconcilable disparity between the wood remains on Lewis and the interpretation of the Loch Roag sequence (Birks 1975), but both can indicate small areas of scrub in local, sheltered situations and a predominately treeless regional vegetation. Birks (1975) states that it is perfectly feasible to have sparse tree populations at densities of 0.25 trees/ha that are largely undetected pollen analytically (Bennett, 1989). However, this disparity largely reflects the fact that pollen primarily provides an integrated record of regional vegetation over a large area, whereas macrofossils reflect strictly local patterns (Birks 1975).

Pine stumps on Lewis date from 4800 to 3900 BP, suggesting that pine was a late arrival there, reaching Skye at about the same time (Birks and Williams 1983). The species became extinct over areas of North-West Scotland, including Lewis and Skye, between 4300 and 3900 BP (Birks 1975; Bennett 1989).

The reasons for this widespread and spectacular demise are not fully understood, but a combination of climatic change and human activity may have accelerated the replacement of pine on flat and gently sloping ground by treeless blanket bog.

Birks and Williams (1983) suggest a change to a more oceanic climate with increased precipitation and strong winds at around 4300 to 4000 BP, possibly resulting from shifts in the Atlantic storm tracks themselves the outcome of changing positions and strengths of the Azores high and Iceland low pressure areas. Such a climatic change would have severely limited pine growth by causing waterlogging, encouraging bog expansion and inhibiting regeneration by reducing the number of good seed years. There is also evidence for increased storms and winds at this time elsewhere in the Inner (Birks 1975) and Outer Hebrides. The former occurrence of coastal stands of birch, as indicated by submerged wood remains of mid-post glacial age off Pabbay, between the Sound of Harris and North Uist, and on the west coast of Benbecula and South Uist (Ritchie 1966, 1979, 1985;

Currie 1979) also notes that the frequence of westerly storms must have been less prior to 4000 BP. As Currie (1979) notes, "the stumps remaining are not likely to be an indication of forest, but rather the evidence of such sheltered locations where small woods survived the climatic conditions, often in areas which are now submerged by the sea" (Currie 1979, p.227). Sea level was 3-5 metres lower between 8000 and 5100 BP, as evidenced by abundant submerged terrestrial deposits along the west coast of the Uists (Ritchie 1985).

Although climatic changes occured during the post glacial, it appears that the principal determinants of regional vegetational change in the Outer Hebrides have been natural soil changes, with widespread leaching, podsolisation and bog development beginning at about 7000 BP (Birks 1975). From around 5000 BP or even earlier (Bohnke 1988), human influence has also been an important factor. In terms of climatic change, the major change in the Outer Hebrides appears to have been about 4000 BP leading to an extinction of Pinus in Lewis and Harris. Changes in wind appear to be more important ecologically than changes in temperature of precipitation (Birks 1975).

By around 5000 BP the widespread regional vegetation had become a mosic of acid grassland, *Calluna* heath, and bog. Tall herb and fern rich communities becamse increasingly rare, presumably confined to areas of locally fertile soils. There is evidence for significant human influence on the vegetation from about 4000 BP, leading to further expansion of heather moor, reduction of willow scrub and tall herb stands, and the spread of grassland and pasture (Birks 1975).

Changes in wind, appear to have been more important ecologically than changes in temperature or precipitation. A total of 158 taxa have been identified as pollen, spores, or macrofossils from the Outer Hebrides. Of these, Tilia, Fagus, Juglans, Abies, Picea, Ephedra, *Sacrobatus vermiculatus* are almost certainly the result of long distance pollen transport or secondary redeposition. Of the remaining 146 taxa that, in terms of their present day pollen representation, almost certainly grew on the Outer Hebrides, several are now extinct there. These include: *Pinus sylvestris,*

Quercus, *Ulmus glabra, Alnus glutinosa, Mercurialis perennis, Hoenigia islandica and Cannabis sativa* (Birks 1991). The timing and explanation of these extinctions vary from taxon to taxon. Soil deterioration, competition and climatic change may, as on Skye (Birks 1972) have eliminated *Helianthemum* in the early post glacial. Soil acidification, bog development and scrub and woodland reduction in the mid or late post glacial may have exterminated Ulmus, Alnus, Quercus, and *M. perennis*. Climatic change around 4000 BP probably caused the exctinction of *P. sylvestris*; *K. islandica* could have been affected by competition and loss of habitat, as it is confined today to very open, mildly basic wet gravel flushes (Birks 1975).

The data presented by Bennett and co-workers (1990) of their studies at Loch Lang, South Uist, indicate that at least part of the island supported some woodland during the early postglacial. The woodland was diverse and included *Quercus, Ulmus, Fraximus excelsior* and *Alnus glutinosa* as well as the dominants *Betula* and *Corylus*. Previous reconstructions of former woodland in Scotland (McVean and Ratcliffe 1962; Bennett 1984) have indicated only that the Uists may have had some birch woodland. Therefore, it appears that there may have been some degree of north-south variation of woodland vegetation within the Western Isles, from species rich woodland in South Uist to unforested areas with scattered pockets of birch woodland in western Lewis (Birks and Madsen 1979; Bohncke 1988). If this is the case, then Bennett *et al.* (1990) state that the former vegetation cover in the Western Isles would have resembled that on the Scottish mainland at equivalent latitudes, and at least in the early postglacial there would not have been the strong east-west gradients seen in modern vegetation reconstructions.

3.9   Overview

This chapter has documented the environmental characteristics of the Outer Hebridean islands, most noteably the Isle of Lewis and South Uist. The climatic characeteristics of the Iron Age have changed very little from the climate experienced in the islands today. However components of the physical landscape

(soils and vegetation) have changed since that period, with the accumulation of peat that is so ubiquitos in the islands and the extension of the machair from the coastal margins to inland areas, particularly on South Uist.

The vegetational history in these islands during the Iron Age has been little documented and is still largely undetermined, with many alternating theories concerning changes that have taken place. Some workers still maintain that the islands were treeless, whilst others argue for the presence of trees. However due to the constraints imposed on the collection of suitable cores for analysis, these arguments will remain sceptical.

For certain, the vegetational history of the Outer Hebrides can be summarised as one of progressive impoverishment. Because of their insular ecology, distance from mainland sources, and limited habitat range the flora has always been restricted, simply because of the vagaries of dispersal, establishment and extinction. The acidic bedrock and associated soils and extensive podsolisation and bog development, in conjunstion with oncreasing storm frequency and human impact since about 4000 BP have lead to progressive impoverishment of the flora and vegetation over thousands of years resulting in poor botanical diversity of the Outer Hebrides in the present day (Birks 1975).

The soils of the islands are also shown to vary according to the topography and the underlying geology of the island. The Isle of Lewis is predominantly covered in a blanket peat that has been developing since around 6500 BP, whilst the accumulation in the Uists has been relatively unexplored and a date of inception remains tentative. South Uist is dominated by peaty gleys in the eastern and central areas of the islands, with calcareous regosols dominating the machair plains on the west coast.

Detailed information regarding the formation and extent of peat and machair in the islands is providing in the following chapter (Chapter 4).

Chapter Four

Peat and Machair Formations of Lewis and South Uist

4.1   Introduction

As mentioned in Chapter 3, both the peat-covered and the machair landscapes of the relevant Outer Isles are fundamental components of this research project. Peat is the dominant organic component in the thin sections taken on site either in its natural form, or through its use as a fuel source. Throughout the habitation sequence at Bostadh in particular, peat in its natural or combusted form is the dominant material used for flooring that could be recognised archaeologically.

The machair zone is important because it is in this landscape that all three settlement sites under consideration are located. The machair landscape, as should be emphasised, is a dynamic system, and together with peat, covers extensive areas of the Outer Hebrides. Given the fundamental importance of these two facets of the landscape to the nature of the on-site deposits, it was decided that a chapter should be devoted to these two components of the landscape.

In the Outer Hebrides, the distribution of peat is closely controlled by climate, and is restricted to those regions where precipitation is high, generally exceeding 1200 mm per year, or where evaporation is low. Estimates as to the amount of peat worldwide vary considerably, and most are probably still an under estimation due to the inaccessibility of some areas and the total lack of figures from others. Clymo (1983) states that the true figure of distribution is about 500 million hectares, covering at least 2% of the total land surface of the earth (Clymo, 1983) Coverage is most

extensive in the cool and moist land masses in the northern hemisphere, especially to the north of 60° N. In Britain and Ireland, peat is thought to cover 2, 694 291 hectares, equivalent to 8% of the land surface. Of this total, 1 095 958 hectares is found in Scotland (Lindsay 1995), representing over 10.4% of the land surface of the country.

4.2   Peat in Scotland: a brief review

Peat within Great Britain is more extensive than in many other areas of Europe: a summary of statistics on the coverage of various peat types in Britain is presented in Figure 4.1.

Peat or peaty soils cover 10% of Scotland (Edwards, 1996) with blanket peat composing 1.1 million ha of this percentage (Lindsay *et al.* 1988) (Figure 4.1). The podzolic and gleyed soils of Scotland together with a cool temperate climate and base deficient underlying geology predispose many areas to peat initiation. The timing of peat accumulation however, varies widely from site to site. The general view of researchers in this field is that the accumulation of organic matter and the formation of peat are functions of local conditions of climate, hydrology, topography, geology, vegetation and anthropogenic activity. Although the first basin mires have been dated to c.9500 BP, substantial peat accumulation began during the mild, wet conditions of the Atlantic period (7500 BP) (Evans and O'Connor, 1999).

Remarkably for a country so enveloped in blanket peat and so concerned by the effects arising therefore, there has been relatively little research into peat initiation in Scotland. A problem with these wetland features lies in the lack of knowledge as to their date of inception in Scotland. The possible beginnings of this process can be traced back to soon after deglaciation in the Outer Hebrides (Bennett *et al.*1990; Edwards, 1996) and in upland Perthshire (Tipping *et al.*, 1994) where *Calluna*-dominated heathland seems to have become a component of the landscape. There are many well established arguments for the inception and extension of blanket peat, whether the result of a mixture of climatic, pedogenic, hydrological or anthropogenic

processes (Moore 1975, 1993) remains uncertain. Despite these arguments, it is certain that blanket peat cloaked the land surface over many area of the the country.

The available dates for peat spread are not easy to evaluate because the general lack of sub-peat surveys make it impossible to assess the topographic origins of peat (Charman, 1995). Dates of initiation in Scotland vary widely (e.g. 9800-9200 BP at Carn Dubh, Perthshire (Tipping, 1995), 2415 BP at Starr, Loch Doon, Ayrshire (Edwards, 1996) and 4810 BP at Calanais, Isle of Lewis (Bohncke, 1988). A continuous process of peat inception and spread would probably have been in operation through these periods, and although intuitively it might seem reasonable that time of climatic deterioration would accelerate peat spread, in sufficient information is available to sbstantiate this (Edwards and Whittington 1993).

4.3   The extent of peat in Lewis and South Uist

A very large proportion of the Isle of Lewis is covered by peat. According to the Scottish Peat Surveys report, the peat deposits of Lewis were estimated in 1910-11 as covering approximately 595 km^2, averaging 1.5 m in depth. This figure was not easy to derive, and is less than precise, due to the south of the island having a very irregular topography where peat fills numerous hollows and depressions in the gneiss (Goode and Ratcliffe, 1977). In the north of the island however, the peat is much more continuous, blanketing all but the steepest slopes and covering most of the interior of the island. By using aerial photography it is estimated that in this northern plateau of Lewis, peat covers approximately 430 km^2, representing about 79% of the island, north of the main Stornoway to Calanais road (Goode and Lindsay, 1979).

In terms of the Uists, the coverage of peat has not been estimated. Its dominance is however clear, with peat covering the whole of the island except for the western coast, which is dominated by machair (see Figure 4.2).

4.3.1 The formation of peat in Lewis and South Uist

The following section provides a brief explanation of the initiation of peat deposits in the islands, illuminated by various pollen analyses from loch cores in Lewis. It serves to highlight that peat deposits were already widely established – and had so been for millennia - on the island at the time the settlement sites here considered were in active use.

The peatland of Lewis predominately consists of blanket mire developed as a result of the strongly oceanic, cool wet climate; the onset of peat development in Lewis occurred about 6500 years BP In areas of gentle relief, blanket peat has developed up to 5 m in depth masking small irregularities in the underlying bedrock and drift deposits. In the more irregular areas of ice moulded gneiss in the south of Lewis the formation of peat has been influenced to a considerable extent by topography. Valley mires, with a drainage axis, are well developed in this type of terrain, but there are also other intermediate types of mire which occupy the hollows within the gneiss. Such mires are like glaciers, filling shallow depressions and in due course expanding to merge into one another to form a complex of mires which often lead down slope into well defined valley mires (Goode and Ratcliffe, 1977).

The pollen record from Loch Lang, Siuth Uist (Bennett *al,* 1990), shows that the major spread of blanket peat vegetation as we know it today may have begun around 5500 BP. This started with a continuous curve of *Narthecium* pollen, shortly followed by a major increase in Cyperaceae pollen. Among other plants of blanket peat vegetation, *Drosera* occurs first at about 5250 BP. However, *Calluna* had been a prominent component of the vegetation from about 9500 BP, and Sphagnum spores appear consistently from around 9400 BP (Bennett *et al.* 1990). Additionally, radiocarbon dates from wood within blanket peat elsewhere in Uist and Lewis (Wilkins 1984) suggest that, at least locally, blanket peat was accumulating from 6500 BP. The varying times of increase of the elements of modern blanket peat vegetation in early post-glacial pollen spectra at Loch Lang, but also at Little Loch Roag (Birks and Madsen 1979) and Calanais (Bohncke 1988), suggests that the first

blanket peat communities may have had a different composition from those of today (Bennett *et al.* 1990).

In terms of South Uist, there have been no specific investigations on the formation of peat but it is generally considered that the initiation process began at around the same time as Lewis.

4.4   Peat: its formation

4.4.1 Definition of peat

Throughout the world, a variety of terms are used to describe peat soils and the areas they cover. In the United States, for example, 'peat', when used in a specific sense, refers to an organic soil or soil material containing identifiable plant remains, whilst 'muck' refers to an organic soil with no recognisable plant fragments (Soil Survey Staff 1951). However, the term 'peat' is also used in a general sense to describe all soils in which the content of organic matter is sufficiently high as to dominate soil properties and behaviour. In British terminology, a soil is defined as peat if it has an organic horizon (O-horizon) at least 40 cm thick starting at the surface, or at less than 30 cm depth (Fitzpatrick, 1984).

4.4.2 Peat initiation and forming factors

Sjors (1983) identified the two major paths of bog development as terrestrialisation and paludification. Terrestrialisation described the process by which a shallow lake becomes overgrown by fen vegetation, steadily infills with fen peat and is then overwhelmed by a rising mound or rain fed bog peat. On the other hand, paludification represents peat formation directly over a soil or rock surface under suitable climatic conditions, and may not involve any fen precursor prior to bog development.   From this definition of peat forming processes, it is clear that paludification is the major peat forming process for the peat on Lewis and South Uist.

The geographical distribution of peat shows clear climatic restrictions. Early research therefore proposed peat initiation as climatically driven phenomena (Godwin 1981). Knowledge of prehistoric climatic oscillations, coupled with artefactual evidence, led to the belief that peat formation took place in the oceanic conditions of the Sub-Boreal/Sub-Atlantic transition. Subsequent research concentrated upon Holocene vegetation change until the work of Simmons (1964) and Pennington (1965), who researched human impact upon peat formation in upland areas, and was supported by research by Moore (1975) These researchers established the importance of soil and vegetational changes upon peat formation. The belief emerged that in areas less sensitive to hydrological changes, topographical or biopedological processes may be important in peat formation (Smith and Taylor 1989). However, it is clear that in some areas at least, peat initiation is influenced by natural soil maturation. Researchers continue to emphasise the importance of climatic variation: however, the complexity of peat forming processes and their localisation are increasingly appreciated, as is the recognition of a 'regional, topographical and altitudinal metachroneity in peat development' (Moore and Price 1984).

4.4.3   Human impacts on blanket mire formation

The hydrological model developed by Moore (1975) was the first in which human impact on the development of blanket mire was postulated. This model building exercise, developing from the suggestions advanced by researchers in the 1970s to the effect that pre-historic human activity in the form of forest clearance and modifications of upland hydrology were of importance in blanket mire origins. In this model, the removal of tree cover, or even the thinning of the woodland canopy is considered to enhance the supply of ground water by reducing transpiration losses and by reducing interception and re-evaporation of precipitation. The model has subsequently been elaborated and modified. Figures 4.3 and 4.4 illustrate the complexity of the ecological and hydrological interactions potentially resulting from human intervention in the growth and development of upland peat (Moore 1993).

The model proposed by Moore (1993) also incorporates the concept of soil changes introduced by Taylor (1964). They proposed that podzolisation of the soil and the development of iron pan can further impede drainage and add to waterlogging within the soil. Malik and co-workers (1984) have also shown that the addition of charcoal to a soil following heathland fires alters the soil's drainage properties. This was illustrated in terms of the texture of the soil, where a sandy soil behaved like a clay loam from the point of water retention capabilities. The conclusion of these researchers considering this phenomenon was that fine, inert particles of carbon reduce the porosity of a soil, as charcoal absorbs the excess water. The charcoal would then swell, reducing pore space and hence the porosity or drainage capacity of the soil. It is thus apparent that woodland conflagrations and early agricultural practices can contribute to the creation of pedological and hydrological conditions that can lead to the onset of peat growth.

The hydrological model as originally developed (Moore 1975), linking human activity to peat development, demands that tree or shrub dominated vegetation existed before the onset of peat formation. The model also links the loss of this vegetation through human activity which resulted in hydrological changes that further reduced the regeneration potential of the woodland species (Moore 1993). The model presupposes therefore, that woodland was cleared by humans, and one of the major objections to it is that it is not applicable to areas where woodland may not have been developed because of adverse climatic conditions (Moore 1993). In the Hebridean islands and the far north of Scotland it has been proposed that woodland cover may not have been of sufficient density for its clearance to have produced significant hydrological impact. However, evidence is now emerging that tree growth might have occurred in the areas, this being documented in the previous chapter.

To summarise the issues following Moore's (1993) later reformulation of the model, the development of peat at a given location is ultimately dependent on the hydrological balance at that site. If the degree of microbial decomposition there is suppressed to such an extent that it is unable to keep pace with the rate of litter formation, then peat accumulation becomes possible. He continues by stating that

peat accumulation on water-shedding sites, a characteristic of blanket mires, is possible only under conditions of high precipitation/evaporation ratio. The evidence from the research discussed by Moore (1993) is that early human cultures were effective in forcing vegetation development across a tolerance threshold, leading to the development of peatlands over vast areas of the British Isles.

4.5   Characteristics of peat soils

The characteristics of the peaty soils are important as they can perhaps aid in the understanding of how the material would react as a flooring material and explain the characteristics such as compaction, that have been identified in the thin sections.

The great mass of peat that forms a bog is not simply a mantle of superficial deposits interspersed between bedrock and surface vegetation to a thickness determined largely by geomorphological processes (Lindsay *et al.*, 1988). Peat depth and shape are both products of biological processes directly comparable with organic growth. The factors determining this growth are climate, the nature of the immediate terrain and the rate of peat accumulation. Therefore, a peat body is not only of a biologically determined shape, but is normally also a continually growing feature in the landscape (Lindsay *et al.*1988). Further, because the components of peat soil are organic rather than inorganic, the natural drying of such material tends to produce physical changes resulting from aeration, shrinkage and decomposition of the organic matter. Such changes are irreversible, so a peat soil that has been affected by these changes can only recover by the fresh addition of organic material and subsequent accumulation of peat .

The water holding capabilities of peat are remarkable, with individual *Sphagnum* plants capable of absorbing their own weight in water (Moore, 1993). Three types of water are generally recognised as forming part of the peat matrix, though the boundaries between these states are not sharp (Hobbs, 1986). These water types include the following: intracellular, tightly bound intraparticle and loosely bound

interparticle, this latter type being the only source of mobile water in peatland under most natural conditions (Lindsay *et al.*, 1988).

Despite its high water content, peat has a significant sheer strength because of the fibrous nature even when highly decomposed (Lindsay *et al,.* 1988). It is perhaps for this reason, that peat was chosen as the suitable flooring material in the structure at Bostadh. However, the possibility that peat was the only natural resource suitable for flooring material and also as a fuel resource around the sites cannot be ruled out, but the sheer suitability as a flooring material is quite obvious. The suitability of peat as a flooring material and as a fuel resource is discussed in Chapter 6.

4.6   Overview

This section of the chapter has reviewed the distribution and extent of peat on the Scottish mainland and the Isles of Lewis and South Uist in the Outer Hebrides. The factors involved in the inception of peat, and the arguments based around the development of the material in the landscape have also been discussed.

From this discussion, it appears that there is varied thought regarding the anthropogenic input and the natural processes associated with the inception of the peat. These arguments especially revolve around the presence of woodland and the depletion of this vegetation, a notion particularly supported by Moore (1975, 1993), which has been discussed in Chapter Three.

4.7 The machair environment

The machair complexes are an important component of the Hebridean landscape, as the three settlement sites discussed in this thesis are situated within them. Bostadh Beach is situated in a machair complex on Great Berneradh, whilst the sites of Cladh Hallan and Bornais, are situated in the extensive systems on South Uist. It is therefore fundamental to the understanding of the environmental background of these sites that the machair system is considered in some detail.

4.7.1 The definition and distribution of machair

There are many variations on the definition of the machair landscape, and the term is thought to have derived from the Gaelic Magh, meaning plain or field, as typically occurs inland of the eroding or vegetated dune cordon by the shoreline (Crawford, 1966). In the academic literature, as well as in local usage, machair is often employed as a landscape term to describe dune pasture, often calcareous, on a coastal plain of sands which are subject to a shifting mosaic of spade cultivation, shallow ploughing, grazing and fallow (Angus, 1994).

Ritchie (1976) suggested that the lack of a precise description is ascribed to the different ways in which, for example, local inhabitants, botanists and geographers perceive the nature and distribution of the habitat. Ritchie (1979) attempted to construct a definition on the basis of a number of different criteria, and he listed the following as machair's important qualities:

- Shell-rich blown sand base
- Lime rich soil with a pH > 7.0
- a morphologically mature surface
- the absence of psammophilous grasses
- the effects of different biotic factors
- an oceanic climate

Curtis (1991) has elaborated on Ritchie's (1979) definition of machair and has suggested that Ritchie's 'machair plain' be replaced by the term 'machair grassland'. However, Owen *et al.* (1996) have elaborated further on this definition by stating that 'machair system' should be broadly applied, as this can be applied to the broad range of machair, including strandline; dune; machair grassland; coastal lochs and marshes, salt marshes and the transitional blackland area between the machair and moorland. These authors state that all of these systems are characteristic of the Western Isles, and were indeed shown on Ritchie's (1976) cross section diagram of the machair

landscape. Therefore, they state that this latter term is more appropriate for the landscape as it appears today.

The distribution of machair as illustrated in Figure 4.5 may be used as a means of identifying differences between island groups. In Barra and adjacent islands, machair is distributed widely but occurs as discrete bayhead units. In the Uists, the machair is almost continuous along the north and west coasts, where Cladh Hallan and Bornais are situated, and here the machair is almost 10% of the total land area of the island (Ritchie, 1994). In Harris, there are large areas of machair in the southwest of the island around the inner sheltered sea area, the Sound of Taransay. In Lewis, the island on which Bostadh Beach is located, machair occurs in a variety of forms, including small bayhead units; complex beaches, strands (in the southwest at Uig) and semi-continuous expanses have been identified between Barvas and Ness on the northwest coast (Ritchie, 1994).

4.7.2 The theories of machair formation

The machair as it occurs today is not representative of the landscape in which the three sites under consideration under this *thesis* will have occurred. Indeed, Gilbertson et al. (1996) state that coastal dunes and sand sheets are known from sites on Benbecula and North Uist to have begun to transgress on to what is now land from at least 7810 ± 140 radiocarbon years BP. Therefore, the machair will have been forming for around 5,000 years by the time that the settlement sites for this thesis will have been inhabited.

The origins of the machair and coastal dune sands along these Outer Hebridean shorelines have not yet been established unequivocally, and several large-scale geomorphological models have been proposed (Ritchie 1967, 1979; Whittington and Ritchie 1988; Mate, 1992; Gilbertson *et al.*, 1995; Whittington and Edwards 1997; Gilbertson *et al.,* 1996). These models are briefly reviewed in the following section, although the reader is directed to the individual papers for more extensive information.

The simplest and most general explanation is the 'continuous development, continuous sand supply model' (Mate 1992). This model proposed that the greater part of sands in the present machair landforms is biogenic. The machair is hypothesized to be the product of the continuous introduction and continuous re-working of carbonate sands which were driven inshore to form a beach, and the inland to form dunes which in turn deflated to create machair plains; all ultimately forced by sea level rise. Subsequent local topographical variations were attributed by Mate to the impacts of rainfall, and prehistoric agriculture which induced deflation. This model highlights constant progression and can be anticipated to have created, at the large scale, an on-lapping coastal sequence of deposits, consisting of near shore-beach-dune-machair sands (Mate, 1992).

However, the most widely known, and in this authors opinion the most complex model, was developed inductively from field studies in the machair of the west coast of the Uists by Ritchie (1967, 1979). The model can be characterised as 'founding events, finite or constant volume recycling' (Ritchie 1967, 1979). The model envisages the development of large sand dunes at about 8700 calibrated years BP, which were suspected to be the result of the re-working and shoreward transport of a large but essentially finite 'constant volume' of former glacial sands and early Holocene biogenic sands from the continental shelf. The dunes subsequent development was seen to have been profoundly influenced by a relative deficiency in the supply of sand to the shoreline, promoting a tendency to shoreline erosion. Repeated erosion and re-deposition of these initial sand dunes was believed to have led to the formation of further sand dunes and the 'low machair' plain, at approximately the elevation of both the winter groundwater table, together with a series of fossil soils, below which deflation could not readily take place. The repeated episodes of deflation and soil formation affected areas inland. Here an eastern 'high machair' accreted as a result of sand blowing from the eroding surfaces of the low machair plain. Features identified as palaeosols, often containing archaeological remains, were seen as layers of greater geomorphological strength to which deflation and re-working reached, but did not penetrate during gales, with the

result that significant 'stratigraphic gaps' might occur both above and below them (Ritchie, 1979).

A model by Gilbertson *et al.,* (1996) anticipates that the overall stratigraphy of the machair resembles a 'large scale layer cake'. The major episodes of sand deposition or soil formation implied might reflect distinct fluctuations in regional climate and oceanographic factors, rather than major hiatuses in an otherwise continuous development of sand dunes through time.

This author believes that an interpretative variant of the model by Gilbertson *et al.,* (1996) and Ritchie (1967, 1979), which relates dune stratigraphy to the ecological and geographical uniqueness of the machair in the Outer Hebrides, is the most appropriate for the formation of the machair. This model suggests that no matter what the geomorphological origins of the overall sequence, inland of any modern coastal dune cordon, the uppermost deposits are a continuous blanket of sand up to 4 m thick, which is characterised by the presence of machair stratification. This stratification is composed of 1-4 mm thick layers of blown sand and debris, alternating with thin topsoils, frequently reworked and bioturbated. These couplets are attributed to the result of reworking of surface shell-sands and organic materials by the gales of the autumn to spring period, followed by feeble and truncated soil development during the calmer summer months.

This author favours this later model exclusively over the earlier models of Ritchie (1967, 1979) and Mate (1992) because this later model takes account of the evidence for soil development, as evidenced in the micro-layers 1-4 mm thick, and also acknowledges the presence and effect of archaeological activity in the landscape, and the record of this activity that the machair stratification provides. Further, this author has identified these microlamminations of soil in the thin sections that were collected in the dune sequences around the three settlement sites under investigation. These microlamminations of soil shared the same or similar characteristics as the micromorphological descriptions of thin sections that were undertaken during the research of Gilbertson *et al.,* (1996).However, the thin sections collected in the sand

dune sequences during the excavations of Bostadh, Cladh Hallan and Bornais are not included in this thesis.

4.7.3 Overview

The machair landscape is most extensive in South Uist, as indicated in Figure 4.5, particularly along the western coast of these islands and it is here that the vast majority of the research into the systems has been conducted. This western coast of South Uist is also the area in which Cladh Hallan and Bornais are situated, along with further archaeological settlement sites. Localised pockets of machair dunes are located on the western coasts of Lewis and Harris, although these are not as extensive as the South Uist systems. Therefore in the literature of the formation of the machair, there is a notable bias to the Southern Hebridean islands.

There is an abundance of literature regarding the formation of the machair systems, and this has been succinctly reviewed in this section. However, there are several models postulating the formation of the machair, with the three prominent having been reviewed in this section. These models have described and illustrate the complexity of the systems, and the alternating theories that exist between researchers. However, this author tends to favour the model proposed by Gilbertson *et al.,* (1996) due to the basis of the model tending towards distinct stratigraphical evidence of soil formation and archaeological activity, which was evidenced through soil micromorphological analysis by that research team, and also evidence from thin section analysis of machair deposits collected during the excavation of Bostadh Beach.

4.7.4 Machair vegetation

4.7.4.1 Vegetation history

The vegetation history of the machair has been well documented (Bennett *et al.* 1990, Pankhurst and Mullin 1991; Kent *et al.,* 1994). Kent *et al.,* (1994) have distinguished that virtually all the species found in the various machair communities today are absent or poorly represented in most of the published pollen diagrams. This is largely due to the lack of suitable sites for the preservation of pollen within the machair. Also, the main machair species are low pollen producers, or are insect pollinated (e.g. orchids) which also contribute to the lack of representation in the diagrams.

4.7.4.2 Present vegetation composition of the machair

In their classic papers on the machair of the Uists, the Monach Isles and South Harris, Dickinson and Randall (1979) and Perring and Randall (1972) recognised a two fold division of the machair vegetation into generalised assemblages that they termed "dune type" and "grassland type". A number of factors have been hypothesised to be responsible for this dichotomy. Ritchie (1979) noted that, although the machair is ultimately dependent on the sand beach and coastal dune ridges for its origin, it is distinct from the dunes and should be regarded as the "non-dune part" of coastal systems. Development of the dunes relies on a sufficient supply of fresh dry sand that can be blown landward from the beach plain to be deposited above the high tide mark. In north-west Europe, vegetation plays a crucial role in the creation and maintenance of sand dune surfaces and speeding further accretion by reducing wind speed over the land surface. Certain plant species, most notably *Elymus farctus* and *Ammophilia arenaria* have the ability to withstand burial by accreting sand. *A. arenaria* is considered to be the main dune building species on Scottish dunes (Owen *et al.,* 1996). However, on the exposed machairs of the Western Isles, the dune building ability of the species is severely restricted by high average wind speeds, a limited sand supply and the effects of coastal erosion. The absence or reduced vigour of *A. arenaria* on the machair, combined with its

characteristic flat surface (<5°), is important in differentiating the plant communities of the machair plains from the vegetation of the dunes on its seaward side, and in distinguishing it from other dune and calcareous grasslands (Ritchie 1976).

Dickinson and Randall (1979) used phytosociological techniques to produce a map of the vegetation on South Uist. The data from their investigation describe the zonation of plant communities away from the sea, with an ordering of vegetation types from the beach through sand dunes and slacks to grassland, marsh and acid backland.

A number of authors have considered the importance of different biotic and environmental factors in creating and maintaining the classical ordering of vegetation types described by Dickinson and Randall (1979). These workers also demonstrated a steady increase in the organic matter content of the soil and a general decline in pH value on moving inland towards the zones of more mature vegetation. Average moisture content also increases through the vegetation types, and calcium carbonate content tends to progressively decrease. It is clear that the zonation of plant communities is related to differences in soil and other environmental factors, although biotic elements are also important. Randall (1973) agreed that the machair is a biotic plagioclimax that is held relatively stable by a combination of diverse biotic factors, including grazing by rabbit and sheep and the influences of past agricultural practices.

The category of environmental factors relates to the nature of the substrate, including both inherent and acquired characteristics of machair soil. The most important inherent characteristic is chemical composition (Dickinson and Randall 1979). The results of the analyses performed on the Monach Isles soils show that moisture content is low (<5%) in the unstable dunes, rising progressively through stable and flat dunes to 18% on the machair. This variable is much higher (53%) in *Carex aremaria* pasture and coastlands (89%) but fluctuates widely. Peatlands are markedly wetter (316%). Loss on ignition follows a similar pattern at much lower levels. Soil pH progressively decreases through the same series from pH 8.0 to pH 6.5 with

fluctuations on the coast and in the peatlands (Dickinson and Randall 1979). Conductivity of soil extracts is strongly correlated with humus content but is also related to distance from the sea. Thus there is a marked increase in conductance from the machair to the coastland and peatlands. Calcium carbonate content of the soils falls from 52% at to the coast to under 14% in the peatlands, a result of leaching. However, the machair has almost as high calcium carbonate content as unstable dunes, partly as a result of shell transport and partly reworking of the machair for agriculture in the 19th century (Randall 1973). These characteristics of the soils and the presence of carbonates in the soils is an important consideration for the components of the floors. As will be revealed later in the thesis (see Chapters 6 and 7), the floors have varying mineralogies, which is not only a consequence of the location of the sites, but also the material and its source used in the construction of the floors.

4.7.5   The soils of the machair landscape

The soils of the machair landscape were considered in Chapter Three section 3.6.

4.8   Overview

This section of the chapter has summarised the formation and location of machair in the landscape of the Outer Hebridean Islands. The machair landscape is most extensive in the southern Uists, particularly along the western coast of these islands and it is here that the vast majority of the research into the systems has been conducted. Localised pockets of machair dunes are located on the western coasts of Lewis and Harris, although the machair is by no means extensive in these locations and it has been relatively unexplored by research. Therefore in the descriptions of formation and vegetation composition of the machair, there is a notable bias to the Southern Hebridean islands.

Also within this chapter the three alternating views on the formation of the machair landscape have been discussed. These alternating views originated in 1975 from Ritchie's total volume theory, which was followed by the single event theory in 1985

by the same author. Mate, who has argued for the gradual development of the machair during the post-glacial period, contended this in 1992. There is still no set answer to the formation of the machair system, and 1996 saw the most recent investigation of the machair stratification through the islands by Gilbertson and co-workers.

Within the review, it has been established that the machair was a feature of the landscape for a long time before the construction and occupation of the sites within this thesis. The original inception for the formation of the machair is thought to be around 8500 BP, although this is still not fully ascertained.

The vegetation characteristics of the machair have been well documented, and a discussion of these characteristics has been provided in this chapter. Essentially, floristic studies of the machair vegetation of parts of South Uist and Barra have demonstrated the presence of eight main plant communities. These range from the mobile dunes closest to the sea and extend to the wet-slack and machair loch margin communities inland.

Finally, there has been extensive research into these systems, and the research is still on-going, through geological and geographical disciplines, but also through archaeological excavations. Here investigations of site formation processes, such as those encompassed in this thesis, are revealing the use of the immediate environment for the occupation of a site.

Chapter Five

Field and laboratory methodologies

5.1   Introduction

This chapter is concerned with the methodological strategies employed for the collection, production and analysis of the thin sections. The first two sections are concerned with the field methodology and sampling strategy employed. This is followed by a description of the micromorphological methods and problems encountered during the analysis of the thin sections. A summary of the methods employed in this chapter is provided at the end of the chapter.

5.2   Field methodology

The aim of any sampling exercise is to obtain a representative sub sample of the population being studied in order that meaningful statements and predictions about the properties of that population can be made. The ideal situation is to achieve a balance between the number of samples and the quality and reliability of the information about the underlying population that this sub-sample contains. For a sampling scheme to be successful therefore, it is necessary that close attention is paid to the research hypotheses, and that the sampling strategy is devised so that they can be tested. The result should be that the maximum amount of relevant information is retrieved.

5.2.1 Site selection

Three sites are undergoing research as part of this thesis, these being Bostadh Beach, Great Berneradh, Isle of Lewis, Cladh Hallan and Bornais, South Uist, Scotland. Bostadh Beach excavation was undertaken jointly by the Department of Archaeology, University of Edinburgh and the Centre for Field Archaeology, University of Edinburgh. The research was funded by Historic Scotland.

Cladh Hallan and Bornais are sites which fall under the Sheffield Environmental Research Campaign in the Hebrides (Department of Archaeology and Pre-History, University of Sheffield). Bornais is also excavated under the same campaign, with the Directors of excavation being from Cardiff University, Wales, and Bournemouth University, England. Again, the research was funded by Historic Scotland.

It is more feasible to describe the reasoning behind such site selection individually, as the latter two sites were incorporated in the later stages of the research. It should be noted that none of the sites were chosen by the author of this thesis with the aim of undertaking micromorphological analysis of the floors. Rather, excavation of the sites was undertaken and the use of micromorphological analysis was decided during these excavations.

5.2.1.1 Bostadh Beach

The initial objective of the fieldwork was the rescue excavation of drystone structures visible in the eroding dune face. The gathering of information relating to the date, sequence, method of construction and palaeoenvironmental potential of the site was an important research objective.

As it became clear from the initial week of test pitting, the site was much larger than originally anticipated, thus, the objectives evolved and a new timescale and strategy

were produced for the excavation. Two further seasons, totalling nine weeks were carried out with the purpose of achieving the following objectives:

- the excavation of a rectangular structure (Structure A) and midden sealing Houses 1 and 3,
- the complete excavation of the main building structure (House 3), including the dismantling of its walls,
- the characterisation of the two houses on the eastern side of the site 9Houses 1 and 2), away from the erosion face, by the excavation of internal features,
- testing for the presence/absence of further deposits or structures beneath the main eroding structure (House 3),
- placing the excavated remains within their immediate environmental, geomorphological and topographic contexts.

The objectives were further refined, when it became clear that coastal protection was to be erected.

The initial phase of the project involved the excavation of a series of test pits in March 1996 as an attempt to define the full extent of the site. Test-pitting demonstrated that structural elements were present between the 6m high erosion face to the west and the rock outcrop below the cemetery, c. 30m to the east. The north and south limits to the site were less clear and it remains likely that most of the areas occupied by the dune contains structural elements. However, the extent of the eroding face stretched c.35m north to south, and this was the sector prioritised in excavation.

Test-pitting was rapidly followed by three seasons of excavation, totalling 13 weeks in all. Initially the overburden of windblown shell sand was removed by machine under constant archaeological supervision, down to a spread midden. Most of the spoil was placed on the south-western portion of the site, spilling over the erosion face just to the south of any visible features.

Once the sand overburden had been removed, further excavation was carried out by hand. All features and deposits were recorded in plan and section, where appropriate. A composite section was drawn which ran eat to west across the site. The rooms of the houses were excavated by quadrants, once floor deposits had been reached. The intervening baulks were positioned so as to connect with entrances in such as way that one face ran through the entrance, whilst the other face ended at the wall to the side of the entrance.

5.2.2.2 Cladh Hallan and Bornais

These two sites form the basis of research for the Sheffield University Environmental Research Campaign in the Hebrides (SEARCH), in conjunction with the Universities of Cardiff and Bournemouth. Hence, different sampling strategies were employed than the one used at Bostadh Beach. The research in the SEARCH project has been developing a long term perspective on changes in settlement and house form from the Bronze Age to the 19th Century (Parker-Pearson and Sharples 1999). The sites of Cladh Hallan and Bornais were incorporated into the research of this thesis during its stages of the research, once it had been acknowledged that the floor samples from the sites could yield useful information regarding the use of the structure and information regarding the floors themselves. It is thought that the floors collected from these sites will provide a useful comparison with the floors from Boastadh which are putatively of the same period.

The soil micromorphology in this thesis is concerned primarily with structure 401, the central roundhouse, although samples were also taken from House 640 at Cladh Hallan. The samples at Bornais were collected from Mound 1, which contains the remains of one house, but given that the house was burnt down, it has been labelled House 1 prior to burning and House 2 post-burning.

Each of the house floors and any associated external deposits identified during excavation were sampled for geochemical analysis and flotation. This was completed on a grid basis, with samples for magnetics/geochemical analysis being taken at 0.5

m intersections. Bulk samples were collected from units measuring 0.5 m x 0.5 m across whole surfaces (for the collection of artefactual and ecofactual material). Where possible the complete depth of floor was sampled.

5.3 Field Sampling

At all excavations, the author of this thesis was not present for the collection of samples. At Bostadh Beach, the samples were collected during a rescue excavation and the PhD studentship was advertised after the collection of the samples. At Cladh Hallan and Bornais, the samples were collected by research teams from the Universitity of Sheffield and University of Wales, Cardiff. The sampling of these sites was undertaken during 1998, before the realisation that these samples could be used for this thesis.

5.3.1 Sampling strategies

A total interval sampling strategy (Jones 1991) was employed during the excavation at Bostadh, meaning a sample was taken from every excavated context where possible, and then processed through wet sieving on site. A normal sample consisted of 1 or 2 buckets of soil (14-28 litres by volume), though larger samples were taken when the excavator identified a rich or archaeologically important layer. This strategy was employed in order to gain a statistically representative assemblage for all ecofactual types which can be extracted using this method (carbonised plant macrofossils, fish bones, marine and terrestrial molluscs), as well as providing a control sample of smaller fragments for the larger mammal bones which might have been missed during normal excavation. Also, this sampling strategy was preferred to less time consuming strategies, owing to the extremely good preservation of bone, shell and plant ecofacts. A total of approximately 335 bulk samples were taken over the three seasons (Neighbour 2001).

The soil micromorphology samples were collected on a judgmental basis, and collected from floors within structures L, J and H from House 3. This house was the most extensively sampled in terms of micromorphology. Unfortunately, there were

no bulk samples of the contexts from which Kubiena tins were taken, this has hindered the soil physical and chemical analysis of these contexts. The author of this thesis was not present during the excavation and the archaeologist who collected the thin section samples, for reasons unknown, did not collect any bulk samples. Again, due to the author of this thesis not being present at the time of sample collection, I was unable to rectify this situation. Further, because the excavation at Bostadh was a rescue excavation, it was not possible to return to the site to collect samples due to House 3 having been destroyed and the site infilled.

The exact location of the Kubiena tin samples from Structures within House 3 are illustrated in Figures 2.9. 2.11 and 2.12.

At both Cladh Hallan and Bornais, each of the house floors and any associated external deposits identified during excavation were sampled for geochemical analysis and flotation. Using the site grid, samples for geochemical analysis were taken at 0.25 m intersections and bulk samples were collected from units measuring 0.5m x 0.5m across whole surfaces. Where possible the complete depth of floor from a quadrant was sampled. This was undertaken in the hope that these samples would be more likely to contain material representing consistent use of an area for an activity, rather than samples from the floor surface which might have been the result of a 'one-off' action (Smith *et al.*, 2001).

The use of relatively small high-resolution collection units for sample collection was preferred to two-dimensional recording of the large artefacts and quadrant frequency for seeds. This was due to the time saved in recording co-ordinate data of dubious validity and because data from collection units can provide a method of rapidly and accurately recording spatial information at a uniform level of precision (Smith *et al.*, 2001).

The geochemical and flotation samples were not analysed by this author, and at the time of writing, the samples had still not undergone analysis, which will be undertaken at the Department of Archaeology, University of Bournemouth. Due to

the late incorporation of the samples from Cladh Hallan and Bornais into the thesis, there was insufficient time for the analysis of these samples by this author.

5.3.1.1 Kubiena samples

All of the samples were collected on a judgmental basis, taking account of the thickness of the floor and any identifiable features within the floor. It must be noted here that in the field, the excavators state that the floor deposit represented one uniform deposit, and that micromorphology has been employed to investigate the constituents of these deposits, especially whether the contexts represented a single or accumulation of deposits.

Undisturbed blocks of soil were collected using Kubiena tins (8 x 6 x 5cm). These tins were carefully cut around and pressed into the exposed section. They were then marked with a sample number and orientation relative to the soil surface, before being cut out of the face, sealed and bound. The tins were then placed into polythene bags and stored in a cool, dry environment.

At Bostadh Beach, a total of 70 Kubiena samples were collected from the site, of which 21 are useful for research. Unfortunately, a detailed sampling strategy with floors in mind, was not investigated before the rescue excavation was undertaken. If more thought had been put into the initial sampling strategy, then perhaps it could have been designed to incorporate more efficient sampling of the occupational layers.

Murphy (1986) lists the points that need to be established before sampling as:

-What is the purpose of sampling?
-What orientation of the eventual samples is needed?
-What size of sample is needed and what replication is required to characterise the components or volume of material being investigated?

Two main sampling methods have been described by Courty *et al.*, (1989), selective and systematic. Selective sampling involves sampling to answer specific questions about context or composition of a particular stratigraphic unit. Systematic sampling involves sampling the entire vertical profile in order to look at profile dynamics.

It is suggested that a systematic strategy as defined by Courty *et al.*, (1989) would have been the preferred option for the investigation of the occupational layers at Bostadh Beach, as thorough and detailed analysis of a sequence could then have been achieved.

At both Cladh Hallan and Bornais excavations, a quadrant method of sampling was undertaken, with a total of 28 sections taken at Cladh Hallan and 4 from Bornais. These samples are representative of sequences of occupation layers, the method of sampling providing a thorough and adequate replication of samples.

Samples were taken from a number of deposits at Cladh Hallan, notably house floors, outside areas, ditches, middens and turf walls, to address specific questions regarding the origin and formation of these deposits. The Kubiena samples were collected from sections across house floors, usually on a judgmental basis within the transects. The position of the samples was marked on to sections and photographs and brief descriptions were taken in the field where possible. In later field seasons (Cladh Hallan 1999 and 2000) samples were spread as evenly as possible N-S and W-E sections, but were still collected on a judgmental basis in order to include specific contexts/deposits of interest, rather than being restricted to measured intervals (Smith, pers comm).

5.3.2.2 Reference slides

Whilst the description of thin sections has been well documented, there is a general lack of information regarding the interpretation of features within thin sections. As Fitzpatrick (1993) states, interpretation of features is still largely ' a combination of experience, intuition and guess-work'. Due to the analysis of domestic floors in the Western Isles being in its infancy, there is an absence of reference material for thin

sections from this locality. Therefore, reference slides were produced for a number of features that were thought to be included within the slides from Bostadh beach, and could be applied elsewhere.

Samples included are:

Well humified and peaty turf fire ash deposits
Beach sand from Bostadh beach
Peat thin sections collected during trial trenching near to Calanais Farm, Isle of Lewis

The fire ash deposits were collected during experiments using three replica hearths constructed on the basis of Late Iron Age three sided hearths which are commonly uncovered in the Western Isles of Scotland. Each hearth measured approximately 0.6 x 0.4 m, and was designed on the basis of the hearths excavated at the Late Iron Age site of Bostadh, Great Berneradh, Isle of Lewis. The hearth slabs consisted of Lewisian gneiss, the common local rock, and were placed into approximately 0.1 m of sand from the beach at Bostadh.

The peat was collected from two areas, the peat turf and fibrous upper peat from near Gearrannan (NGR NB 205 445) and the well-humified peat from near Gaerraidh na h-Aibhne (NGR NB 265 307). The peat was cut in the springtime and dried and stacked for the summer.

Generally, a single fuel type was burnt in each replica hearth for a 72 hour period, which allowed the construction, burning and sampling of a single hearth in one week. Following the burning, the hearths were allowed to cool before sampling. The colour of the ash produced was recorded using a Munsell colour chart.

Kubiena samples were collected from the full ash mound in each of the fires, allowing for a full sequence of the ash deposit to be collected. This was to enable the colour changes through the ash to be detected, which will prove useful for the

characterisation of ash residues in the thin sections at the description stage. The thin sections were produced following standard methods employed for other samples. They were manufactured at the University of Aberdeen.

The peat samples were taken through a section of peat that had been opened during trial trenching at Calanais Farm, Isle of Lewis. A whole sequence was collected from the trench which encompassed a range of peat types from well humified to the present surface accumulation. This was to enable comparison with the suspected peat deposits in the floors of the structures at Bostadh.

5.4 Micromorphological analysis

5.4.1 The theory of thin section micromorphological analysis

Micromorphology concerns the qualitative and quantitative description of undisturbed blocks of soil at microscopic levels. This allows soil to be viewed with the spatial characteristics of different soil constituents preserved. A wealth of previous research allows the identification of the features present within the soil and the same experience guides the interpretation of these features. The discipline of micromorphology revolves around the qualitative description of features in terms of the colour, size, shape, smoothness, optical characteristics, frequency and distribution, at a range of magnifications and illuminations. These properties characterise the micro-fabric of the soil, sediment and other material.

To undertake micromorphological analysis, a petrological polarising microscope is needed. This allows the observation of thin sections not only in plane polarised light (PPL) but also under crossed polarised light (XPL). In cross polars, the light is transmitted by the polariser and is fully absorbed by the 'analyser' (a polarising filter turned at 90°) unless it has first been refracted by any anisotropic material through which it has passed. This allows detailed observation of the optical characteristics of the materials in thin section and is especially used in the identification of mineralogy.

A further light source is to use Oblique incident light (OIL), which is generated by directing a suitable light source onto the upper surface of the thin section (Kemp, 1985).

Problems of the technique revolve around the quantification of slide characteristics, and the relationship between the two-dimensional thin section and the three dimensional, dynamic, soil unit that is assumed to be present. Taking a two dimensional slice through a three dimensional object can result in a two dimensional area which bears little logical relationship, both in shape and size, to the original 3D volume (Ringrose-Voase and Humphreys, 1994). As size and shape are two of the fundamental measures in micromorphology, the consequences of this effect are deep rooted. The Holmes effect is a further problem that leads to the overestimation of opaque and dark bodies in thin section, whilst wedging effects can lead to the underestimation of transparent particles such as quartz and void space (Bullock *et al.*, 1985).

Despite these problems, micromorphology is a powerful tool allowing *in situ* examination of soil particles and the relationships between the different soil elements, from which functional dynamics are extrapolated. For example, whilst filed examination of a soil profile may reveal horizons richer in clays, the process of clay illuviation can only be positively confirmed in thin section where the presence of clay void coatings indicates down profile movement. Spatial patterns may also elucidate the temporal sequence of pedological processes, where a feature is overlain or cut by another then the first must logically pre-date the latter.

The application of soil micromorphology to the question of occupational floor formation has a number of possibilities. Micromorphology allows the identification of trampling of the surface and the possible routes taken within a living space. The technique allows an insight into understanding into how a floor has been laid. Thirdly, microscopic analysis provides information on the type of material used in the construction of the floor. The technique is also being used to aid in the understanding of the use of space within a structure.

Finally, the micromorphological process involves four key stages:

1. manufacture of the thin sections
2. description and measurement of the soil/sediment microfabric at any 3. one of a number of possible levels of observation
4. interpretation of these microfabrics

5.4.2 The manufacture of soil thin sections

The thin sections from Bostadh Beach, Isle of Lewis were manufactured by Mr George MacLeod, Department of Environmental Science, University of Stirling, Scotland, whilst the sections for Cladh Hallan and Bornais, South Uist, were manufactured by Dr Ewart Adsil Fitzpatrick, Department of Plant and Soil Science, University of Aberdeen, Scotland.

Both laboratories followed the same preparation method (Murphy 1984), although Fitzpatrick (1984) has also devised a further methodology for the manufacture of sections. This was used at the acetone replacement stage of manufacture. The methods employed in this preparation of the sections were the slowest and the most appropriate given the high organic content of the samples. Fitzpatrick (1993) states that it is important that an understanding of the soil types in the samples is known, as this influences the method of preparation, as not all methods are suitable for all soil types.

Acetone replacement in the liquid phase was followed by impregnation in a polyester resin system applied under vacuum (Crystic 17449; MEKP, Accelorator 'G'; Scott Bador). After curing, blocks were bonded to polished glass slides (110 x 75 x 3 mm) with a standardised mass of epoxy resin (Epoxy 301, Logitech), then cut and lapped (CS10, LP40-Auto, PM2A; Logitech).

5.5   Protocols adopted for micromorphological description

As a descriptive and largely qualitative discipline, it was important that a systematic approach was adopted with the thin sections and the data they generated. The system devised, therefore, had to operate throughout the initial visual description, and the microscopic examination. The mass of information that is generated by a full description as proposed by Bullock *et al.,* (1985), where every property is described in detail is vast, and largely inappropriate for the highly organic sediments present in the research thin sections. Therefore, it was required that selectivity of description was employed, with each slide being described a number of times for varying characteristics.

The fist level of description collected the information necessary to characterise each of the archaeological materials, to outline the sample components and to highlight features of interest within the slide for the second level of description. This entailed basic mineralogical, organic, pedofeature (where present) and microstructure descriptions, and to highlight any obvious similarities and differences between thin sections within the same site.

The second level involved the detailed description of particular features and properties, which were selected as representative of the key features thought to be present in occupational sequences.

5.5.1 First level of description

The first stage in the analysis involved observing each slide on a light box, which allowed for the slide being divided into zones on the basis of colour change. The individual floors represented within the sections were clearly visible and the clarity and distinction allowed for each floor to be treated as a separate unit and described individually. The thickness and number of floors were also measured at this level.

5.5.2 Second level of description

Slides were microscopically described according to standard procedures (Bullock *et al.*, 1985), supported by Fitzpatrick (1984; 1993) and Courty and co-workers (1989). A Nikon (64136) polarising microscope at magnifications from x20 to x400 was used for the descriptions, using both Plane Polarised Light (PPL) and Cross Polarised Light (XPL). Oblique Incident Light (OIL) was used where deemed necessary. The size distinction between coarse and fine material was taken at 10 μm for all sections.

Written descriptions were undertaken for all of the slides, and have been summarised in standard summary tables, using a cross system to estimate abundances of features (e.g. Simpson 1996). Written descriptions are presented in Appendices 1 to 3, summary tables are presented in Chapters 6, 7 and 8.

The summary table written for each description contains information about mineralogy (type and abundance), fine material (organic and non-organic), microstructure (type) and groundmass relationships (coarse/fine ratios and distributions).

Microstructure is an important component in this research as this is the primary indication of trampling or other compaction activities associated with materials (Courty *et al.* 1989). In this research it is being used to detect trampling or materials, but also it is being used to determine whether planar voids (horizontal and vertical) are characteristic of compaction in ash or peat derived floors. Davidson and Carter (1989) and Matthews (1996, 1999 and 2001), Matthews *et al.*, (1996, 1997 and 1998) state that these microstructural forms are the primary indicator for compaction of materials.

It is hoped that the mineralogy of the floors will aid in the detection of the source of materials used in the construction of the floors. For example, if a floor has a high quartz grain content this could be indicative of the constructional material being sourced from a location outwith the immediate carbonate grain dominated

environment of the settlement. Further, mineral content aids in the discrimination between floors that have had sand deliberately incorporated into the organic matrix and those that have not. This is revealed from the percentage mineral abundance against the fine material abundance (c/f ratio).

Organic residues were described according to Fitzpatrick (1984) as this system was deemed more appropriate than Bullock *et al.,* (1985) for the description of peat represented in some of the thin sections. Along with the morphological description, the colour of the peat was also described, as it is thought that this would enable the detection of different peat types that were used in the construction of the floors. Further the aim of the detailed description of the organic residues was to determine whether well-humified peat was more favoured for the construction of floors than peaty turf. This method was particularly suitable for the description of the floors at the entrance to Structure L (Sample 178), House 3 at Bostadh Beach, Isle of Lewis, and the organic component of other floors was also described according to Fitzpatrick (1984).

Where the floors were not constructed from different types of peat, the main construction material used was peat ash. This was derived either from the burning of well-humified or peaty turf. The ashes in the floors were identified in the floors on the basis of colour differences, and the presence of fused siliceous material. When identified, detailed descriptions of the ash were undertaken, which included colour and structure. The fire hearth reference samples were particularly useful here as they enabled direct comparison of the ash characteristics with known fuel sources. This has enabled the identification of specific fuel sources. The microstructure descriptions of the ash floors follows Bullock *et al* (1985).

Boundary descriptions between floors was undertaken at x100 magnification and used the system of Fitzpatrick (1984). This system is divided into the following sections:

Term	Distance of change
Abrupt	< 100 μm
Sharp	100-500 μm
Clear	500-1000 μm
Diffuse	>1000 μm

As Fitzpatrick (1984) states, the nature of the boundary can appear very different depending on the magnification at which analysis is undertaken, and recommends that x100 magnification, as used in this research is satisfactory for most situations.

Boundary descriptions between each of the floors was used with the aim of determining the mode of formation of a floor. For example, if a diffuse boundary was identified, this could represent the gradual accumulation of a floor, whereas if a sharp or abrupt boundary was identified, this could represent a deliberate motion of laying the floor, rather than a gradual accumulation of material. Schwenninger (1999) used the boundary between floors at Dun Vulan, South Uist, to determine whether a floor had been compacted or not. He revealed that a diffuse boundary between two floors indicated that trampling had occurred on the sand-derived floors. The results from the analysis at the three sites in this research will be compared with those of Schwenninger to determine whether a diffuse boundary is representative for all floors.

Other features identified in the preliminary observation of the thin sections were the abundance of phytoliths and diatoms both intact and fused. Where these are abundant, and were able to be identified, the phytoliths were assigned to a morphotype based on the system of Powers *et al.* (1989). These features were not quantified due to the majority occurring in a fused state and bulk samples were not available for preparation of separate sample which would have allowed quantification of these components. No quantification was attempted with the

microscope as the organic components or ash residues would have masked the appearance of these features, and reliable estimates would not have been gained.

The identification of phytoliths to a morphotype, where possible, being included into this research due to their dominance in some of the thin sections. It is hoped that by determining the abundance of these features in each of the floors, that the type and source of peat used for that floor will be detected. The phytoliths are also useful for determining the presence of fire ash in the floor matrix, as these siliceous residues are frequently identified in a fused state, indicating that they have been subjected to high temperatures.

The species of phytoliths that are present can indicate the dominant vegetation that grew in the particular peat and this is hoped to be related to a specific peat type. The phytolith content will be compared with the other characteristics of the floors, notably the colour of peat, as this could also be an indicator of the type of peat used.

Phytoliths are microscopic silica particles which form in and around the individual cells of some plant species (Powers et al., 1989). The full breadth of phytolith distributions amongst members of the plant kingdom is unknown, but sufficient botanical studies have been performed to indicate that they are a common phenomenon amongst both species of monocotyledons and dicotyledons (Powers et al., 1989). The silica matrix of phytoliths confers a preservational resilience that makes these features a particular interest to archaeologists and vegetation historians. In particular, in circumstances where preservational circumstances are hostile to the survival and recovery of carbon based macrofossils and microfossils, silica fossils provide the only direct evidence of ancient plant growth and utilisation (Powers et al., 1989). In the Outer Hebrides, these fossils have been used successfully in the analysis of midden sites in the islands (Powers et al., 1989) and as an analytical tool in the investigation of site formation processes on a traditional Hebridean farmstead (Smith, 1996).

Throughout the descriptions abundacies of minerals and features have been calculated by visual estimation of the percentages of each class of components within single depositional units by area in the thin section and by visual comparison to area percentage charts (Fitzpatrick 1984). Computer aided image analysis was not used for quantification in this project as its application of heterogeneous components in thin sections of archaeological deposits is problematic, although studies are developing its application (Adderley *et al.* 2000, 2001). Some of the problems encountered in image analysis occur in the computer recognition and distinction between individual components of divers origin but with similar optical properties. Examples of these being black opaque minerals and charred plant remains. Other difficulties occur in recognition of only the are occupied by anatomical elements of plant fragments, rather than the total are which each area occupies within single depositional units (Matthews 2001).

5.6   Summary

This chapter has provided details on the various methodologies employed in the description and characterisation of floor layers from three different archaeological sites in the Outer Hebrides.

A brief summary of the methods employed in this chapter is provided below. For further detail regarding the problems and remedies to the problems are detailed at each stage of the analysis.

Field methodology:
- Site Selection

Field Sampling:
- Sampling strategy:
- Total sampling (Bostadh Beach)
- Total and gridded (Cladh Hallan and Bornais)

- **Sample collection:**
- Interval sampling (Jones, 1991) and judgemental
- Experimental Fire Hearths for ash reference material

- **Thin section manufacture** (Fitzpatrick, 1984 and McLeod 1997)
- Sample drying
- Impregnation
- Thin section production

- **Micromorphological Analysis:**
- Theory behind analysis
- Levels of description
- Level 1: Overview using lightbox
- Level 2: Description of features (Bullock *et al.*1985 and Fitzpatrick 1984, 1993, Courty *et al.* 1989, Powers *et al.* 1989).

Chapter Six

Case Study One: Bostadh beach

Results

The results tables and graphs for this Chapter are illustrated in Pages 370-380 and 398-412, behind the Appendices in this thesis.

6.1   Introduction

The micromorphological results from Bostadh beach are summarised in this chapter. All of the samples in structure L are reputed to date from the Late Iron Age phase of occupation within the house, and were collected from the same single floor deposit that was identified during excavation. Samples 128 and 133 collected from structures J and H, are considered to represent deposits from an earlier phase of occupation than that within structure L, but still within the Late Iron Age (Neighbour, 2001). The radiocarbon dates for the settlement indicate a period of occupation for the C7[th] to C9[th] cal. AD.

The largest number of samples, comprising the ten thin sections were collected from floor deposits in Structure L. The location of the samples is illustrated in Figures 2.10 – 2.11. Samples 160 and 178 were collected from the opposite ends of a north-south transect through the centre of Structure L, whilst Sample 120 was collected from the centre of the house, close to the central hearth. One sample was collected from suspected floor deposits in each of structures J and H.

6.2   Reference Thin sections

The descriptions of the reference slides are found in Appendix 1: however, these slides will be used for comparing the mineralogy of the floors, and also the ash content where this is present. The beach and dune reference slides will be useful in comparing the degree of sorting and content of carbonate grains within deposits that are organic but also have a high carbonate content. The peat reference slides will also be used for this in comparing the natural abundance of the minerals in natural peat with that in the floors. These will also prove useful in determining the of type of peat used for construction of the floors based on the colour and degree of decomposition between the reference materials and the floor materials.

6.2.1 Beach sand samples

The samples collected from the beach were naturally dominant in carbonate grains, which account for 80-90% of the total grains, accompanied by varying amounts of quartz and feldspar. The grains in the section were also well to perfectly sorted, based on the description of Bullock *et al.* (1985), containing no organic residues and had a single grain microstructure. Grains were medium to coarse sand sized with varying shapes, from sub angular to sub rounded or rounded. The grains were also randomly arranged and oriented. An example of the beach sand at Bostadh Beach is illustrated in Plate 30.

6.2.2 Fire ash residue samples

These fine residues differ according to the material from which they were obtained. Two residues, comprising well-humified peat (6.2.2.1below) and peaty turf (6.2.2.2) were distinguished.

6.2.2.1 Well humified peat

Four colours of fine, crystallitic (XPL) residues were identified in this sample:

- Black (PPL)/(OIL) Charcoal fragments, with some structure still visible
- Dark reddish brown (PPL)/Bright orange (OIL). Structureless and amorphous appearance
- Grey (PPL)/colourless (PPL)/dull orange (OIL) structureless, very fine residues.
- Brown (PPL)/Bright orange (OIL), same appearance as well decomposed organic material.

There is no stratification within the reference sample: all of the above colours are mixed and carbonate grains appear blackened for 1 cm below this material. The identification of this range of colours is interesting because the ash mound produced in the hearth recorded a single reddish yellow colour. Plate 16 illustrates the form of well humified peat ash. In XPL the dull and bright orange colouration of the ashes is illustrated.

6.2.2.2 Peaty Turf

In the fire hearth experiments, this fuel source produced an ash mound of 10 cm depth. The mound is clearly stratified in thin section with colour variations through the mound, with dark reddish brown (PPL) in the top 3 cm, followed by light grey brown (3-7 cm) and brown (PPL) for 7-10 cm. As in the well-humified peat, the mound remaining in the hearth after burning recorded a single red colour. Plate 23 illustrates the high charcoal content of the peaty turf ashes and the light grey-brown ashes that characterise the material.

Colours identified:

Dark reddish brown (PPL)/Bright red (OIL). structureless fragments that appear amorphous in PPL and would appear unburned if not in known ash residue

Light-grey brown (PPL)/Bright orange-brown (OIL). Very fine almost crystalline residues.

Brown (PPL)/Bright orange brown (OIL) Structureless and amorphous appearance.

Except for the light grey-brown residues, the ash residues above appear as though they are not derived from the combustion of material. Rather the ash has an appearance of natural organic residues, and if it was not known that the residues are ash derived they could be easily mistaken for organic fine residues.

6.3   House Three Structure L

A total of 46 individual floors have been identified in the ten thin sections collected from this structure. Each sequence of floors are constructed from different materials, according to the area in which the floor sample was located.

Due to the number of differences identified in each of the floors within a set of thin sections, the results for that particular floor sequence are described according to the area from which they were collected within the structure. These areas are:

Sample 160: Stepped area between Structures L and G (northern point of transect)
Sample 178: Entrance to Structure L (southern point of transect)
Sample 120: Centre of Structure L, close to the central hearth

It must be noted, that throughout the descriptions and in the graphs of the results, the lowest (i.e.: oldest) floor has been assigned number 1, with the highest number representing the highest deposit in the sequence. This method of describing the

results has been chosen as it represents the sequence in which the floors will have formed, and also enables easier description and understanding of the results.

For the microstructure and coarse/fine related distribution descriptions, full definitions are provided in Tables 6.11 and 6.12. These tables are also for use in the proceeding chapters (7 and 8) for the floors at Cladh Hallan and Bornais.

These definitions were tabulated to reduce repetition in the results as these characteristics were recorded and described for each of the floors analysed in this thesis.

6.3.1 North-South Transect through Structure L: Sample 160

The four thin sections that form this sample set were collected from the field identified floor deposit at the northern end of the transect through Structure L. These samples represent the floor in the stepped area between Structure L and G. The samples were collected from contexts 218 and 221, which are described respectively as beige brown windblown sand layer covering the interior (c. 218) and compacted dark, peaty layer (c. 221) (Neighbour, 1996).

6.3.2 Number and thickness of floors

These four thin sections have enabled the identification of five floors in the 34 cm thick deposit. Each of these floors varies in thickness, with the thickest being Floor 5/160 at 9.0 cm and the thinnest Floor 2/160 at 1.0 cm. The variation in thickness of each floor is represented in Graph 6.1. As the graph indicates, there is a trend of increasing thickness of the floors from the bottom Floor (1/160) to the accumulation represented by Floor 5. However, not all of the floors are organic material here, with only Floors 2/160 and 3/160 containing significant organic components. Other floors were dominantly composed of mineral grains.

6.3.3 Mineral characteristics

The mineral grain presence in each floor is summarised in Table 6.1, where it is seen that quartz grains derived from shell sand dominate the floors. The presence of these grains being 50 % in each floor, with low quantities of carbonate and the other grains at 5 to 15% each.

A change in the type of material used for the construction of Floors 2/160 and 3/160 is indicated by a dominance of quartz sand grains. The explanation for the <100% content of grains in Floor 2/160 that this floor is peat derived and records a very low presence of grains. Floor 3/160 has a dominance of quartz grains at 50%, with feldspar the second dominant grain at 20% content.

The beach sand floors have minerals that are perfectly sorted, in comparison with the reference thin sections for these materials. The grains in the reference samples are randomly arranged and oriented. The minerals in Floor 3/160 are moderately sorted, due to the presence of fine residues (discussed further below) between the grains.

6.3.4 Floor fabric: the fine residues

Fine residue content was identified in Floors 2/160 and 3/160, forming the matrix of the floor. The residues here are described as dark brown (PPL), and isotropic in cross-polarised light. Dark red colours are reflected in OIL, indicating that the material is ash residue in origin. These ashes are similar in comparison to the well-humified ashes from the fire hearth experiments. The type and colour of fine residues are summarised in Table 6.2.

Phytoliths and diatoms are present in Floor 3/160 but are fused, and appear as glassy residues, indicative that these siliceous particles have melted at high temperatures (Courty et al. 1989). Therefore these components are too fused to be described in detail, and occur mainly as localised patches within the dark brown (PPL) floor matrix. The abundance of phytoliths in the floor is summarised in Table 6.1.

Floor 2/160 was formed from well-humified peat, being dark brown (PPL)/isotropic (XPL) and showing no plant residue content.

6.3.5   Microstructural characteristics of the floors

The microstructure of the floors varies (see Table 6.1 for a summary of the micromorphological characteristics), with single grain microstructure dominating the three beach sand floors This microstructure consists of quartz grains loosely arranged with little or no fine material to provide aggregation (Bullock *et al.* 1985).

 Intergrain microaggregate structure is recorded in Floor 3/160, where the matrix is loosely arranged, and fragmented rather than dense. Finally, Floor 2/160 is the only floor that appears to have been constructed from a dense organic deposit, and records a massive with crack microstructure. The characteristics of this are no fully separated aggregates, with the material being dense except for a few planes and occasional other voids (Bullock *et al.* 1985).

6.3.6 Anthropogenic inclusions

The variation in charcoal content through the floors is illustrated in Graph 6.2. From this graph, it is apparent that Floor 3/160 has the highest charcoal content at 40%, with the remaining floors recording very low charcoal contents.

6.3.7 Summary of results

- *Five individual floors identified micromorphologically*
- *Increasing thickness of floors from floor 1 (bottom) to floor 5 (top)*
- *Quartz grains dominate in most of these floors*
- *Single grain microstructure dominant*
- *Organic residues largely absent, with only one organic derived floor (Floor 2)*
- *No diatoms or phytoliths identified in tact*

6.4   Entrance to Structure L: Sample 178

The three thin sections composing this floor sequence were collected from the southern point of the north-south transect through Structure L, in front of the entrance to the structure (see Figure 2.10). According to the site plans, the only context represented in these samples is c.276, described as brownish red clayey deposits forming a possible floor level. These samples are from a different context than the 160 samples, although the floor from which the 178 samples were collected is thought to be contemporary (Neighbour, 1996) with the s160 floor.

The location of the samples is provided in Figure 2.10.

6.4.1 Number of identified floors and their thickness

The variation in the thickness of the floors through this sequence is indicated in Graph 6.3, it should be noted that the lowest floor is labelled 1, the upper most floor being number 21.

A total of twenty-one floors have been identified in this 27 cm thick deposit. The thickest floor is Floor 3/178 at 3.5 cm, located towards the base of the sequence, with Floor 19/178 the thinnest at 0.4 cm. It is found near to the top of the sequence. On analysis of this graph, it is clearly seen that the thickness' of the floors varies from the bottom to the top, the lower floors being the thickest.

There are two gross trends apparent within the graph, where the floor thickness peaks in Floor 3/178, but decreases drastically in Floor 4/178, but then increases in Floor 5/178. From this floor to Floor 11/178 there is a gradual decrease, with the exception of Floor 8/178. However, from Floor 14/178 to the floors at the top of the sequence, there is a clear gradual decline in the thickness of the floor deposits.

6.4.2 Mineral characteristics

The mineral content of each floor is summarised in Table 6.3. As can be seen in the table, the most distinct trend is that quartz grains dominate in the majority of floors (12), compared to marine carbonate (shell sand), which dominates in seven floors.

The floors in this sequence have a high organic component in terms of fine residues, but also have high mineral contents. Two of the seven floors that are dominant in carbonate grains contain no organic fragments and are clearly beach sand. These two floors have the same mineralogy as the beach sand reference slides, with 50% carbonate grains and 20% other grains composed of quartz, feldspar and hornblende. The two floors in which this admixture occurs are 6/178 and 15/178.

6.4.3 Floor fabric: the fine organic residues

The colours identified in the sequence of these floors are illustrated in Table 6.4. The colours of the floors under the microscope appeared to be very different from the field description of the deposit as a red clayey material (Neighbour 1996).

As seen in the table, the most dominant colour of floors in plane polarised light is yellow, or a variation on yellow (light, dark or grey-yellow). In total, 15 of the floors record a dominant fine yellow matrix, this matrix is illsutrated in Plate 1, with three floors consisting of only beach sand, and one floor each of orange-brown and brown residues. The fine organic residues in eighteen of the floors are recorded as isotropic in cross-polarised light (XPL), this being where the material appears black and with an absence of interference colours on rotation of the slide (Fitzpatrick, 1984). This isotropism is a common characteristic of fine organic residues in thin section (Fitzpatrick, 1984). The three floors (1, 15 and 17) that do not record any isotropism are the beach sand floors, which contained low organic residues.

In addition to the dominant yellow fine residues in the floors, two of the Floors (8/178 and 10/178) recorded a second fine residue within the yellow matrix, these being dark reddish brown (PPL) residues in Floor 8/178 and brown (PPL) residues in Floor 10/178. Examples of these dark reddish brown tissues are illustrated in Plate 2.

The colour of the coarse organic residues is also illustrated in Table 6.4. Generally, these fragments display a dark reddish brown (PPL)/isotropic (XPL) colouration (see Plate 2), with the exception of the orange-brown fragments in Floor 14/178 which record a reddish brown colouration in XPL. A possible explanation of this is that these fragments are either a different form of organic material, or in a different stage of decomposition than the other residues. The size of the fragments ranges from 300 μm to 1 mm, with a greater concentration occurring in Floors 4/178 and 6/178, with 20% and 30% charcoal contents respectively.

Generally, all of the fine residues in each floor are described as being very well decomposed with little or no cellular structure, and dense in appearance. The coarse residues are embedded within the fine matrices and are likely to be at differing stages of decomposition: some of the fragments are seen to be decomposing into the fine yellow matrix. The coarse fragments were identified in Floors 4, 5, 7, 9, 11, 12, 14, 19 and 20/178. In the remaining floors there was no evidence for coarse organic fragments in the floor matrix.

6.4.4 Microstructural characteristics

Microstructure definitions are summarised in Table 6.12.

The dominant microstructure in the fine organic matrix was massive, the form of which is illustrated in Plates 1,2 and 3, with this occurring in 15 of the floors. This form of structure is described as material with no discrete peds and few, if any, voids. Associated with this microstructure is a dense yellow (PPL) matrix that appears to be completely decomposed with no visible plant or cell residues.

In those samples from floors where the microstructure was not massive, it can be characterised as being single grain or as chamber. A single grain structure being where quartz grains are loosely arranged with little or no fine material to provide aggregation, and there is much grain to grain contact. A chamber structure occurs where dominant voids appear as chambers and with no discrete aggregates.

The single grain structure was recorded in four floors (1, 2, 15 and 17/178), with the intergrain structure found only in Floor 3/178. In all of the single grain structure floors, there is a dominance of mineral grains and only a 10% organic content, this usually in a fragmented state. In the floor dominated by a chamber structure, the coarse to fine material ratio is 30/70, indicating that fine organic material dominates over the mineral content.

Finally, a crack structure was identified in Floor 6/178. This consists of organic material dominated floor, with a dull yellow organic matrix.

6.4.5 Anthropogenic inclusions

Generally associated with these reductions in thickness of the floors is a decrease in the content charcoal fragments within them. These results are illustrated in Graph 6.4. Clearly, charcoal fragments peak in Floor 2/178 at 40%, with the lowest content is recorded in Floor 8/178 at 3%. However, this decrease is not a constant curve of decline, with peaks also being recorded in Floors 6/178 and 9/178.

6.4.6 Inorganic residues: phytoliths and diatoms

These components are given a detailed consideration here as they were most evident and identifiable intact in these floors. These components have enabled the possible identification and source of flooring material. In all other floors the presence of these components is in a fused state, thereby hindering the characterisation and quantification of these features in the floors. The abundance of these components in the floors is indicated in Table 6.3.

Phytoliths and diatoms are abundant throughout the majority of the floors in this sequence. There appears to be two distinct clusters of these siliceous remains, these occurring within Floors 4 to 9/178 inclusive (with the exception of Floor 5/178 and 6/178) and Floors 16 and 17/178, which all record abundances of 50%. In most cases, the abundance is well above a 50% content, more closely resembling 100%. Both forms of siliceous particles are mainly intact. Those that are naturally fragmented, and do not appear to have undergone any form of firing, the absence of fire ash within the floors confirming this assertion. Intact examples of these particles are illustrated in Plate 5.

The abundance within Floors 4 and 7 to 9/178 is associated with light yellow (PPL) or variations on yellow (PPL) fine material, with Floors 16 and 17/178 having a orange-brown and dark yellow matrix respectively. Therefore, these materials are not specific to a particular composition.

The phytoliths identified are morphotypes of smooth rods, fine wavy rods, fine spiny rods, coarse spiny rods and trapezoids (Powers *et al.* 1989). These morphotypes were not found to be particular to a specific peat colouration and occurred in all of the floors at what appeared to be varying quantities. The phytoliths were not quantified however, as this was not in the realms of this research, further the phytoliths were mainly in tact, that is, they had not been melted or fused by the action of burning.

The origins and implications for the presence of these residues is discussed below.

6.4.7 Summary points of Sample 178

- *21 floors identified micromorphologically within a 27 cm field identified deposit*
- *Floor thickness decreases from the base to the top of the floor sequence*
- *Charcoal content decreases through the floor sequence*
- *Quartz grains dominate in the majority of floors*
- *Dominant massive microstructure*

- *Dominant yellow fine matrix*
- *Abundant phytoliths in many floors*

6.5   The centre samples of Structure L: Sample 120

The three thin sections forming this sample set were taken near to the central hearth in Structure L, and were collected from the same floor covering the interior of the structure as Samples 160 and 178.

According to the site plans the samples were collected from the same context (c.276) as Sample 178, therefore it is expected that the floors in these samples should reveal similar characteristics. However the analysis has revealed that the floors in both samples are constructed from different materials, therefore rendering them unlikely to be from the same context.   Examples of the floors and their compositions are illustrated in Plates 13, 14 and 15.

6.5.1   Number and thickness of floors

The three thin sections reveal a total of 17 individual floors, in a deposit 25 cm thick. However, the deposit in the field measured some 35 cm thickness, but it appears that the underlying and overlying sand were not sampled.

The variation in the thickness of each floor through the sequence is illustrated in Graph 6.5. As in the other graphs, 1 represents the lowest floor and 17 the highest floor. From this graph, it is evident that the first and final two floors are the thickest, at 4.8 cm (Floor 1/120) and 3.3 to 3.8 cm (Floors 16 and 17/120). The thinnest floors are in the middle of the sequence (Floors 7 and 11), which are respectively 0.5 cm and 0.4 cm thick. Floors generally decrease in thickness from the start to the middle of the sequence but the pattern thereafter recesses.

6.5.2 Mineral characteristics

The summary Tables (Table 6.5 A and B) indicates that as in Sample 178, quartz dominates the mineralogy of most floors (11 in total), compared to carbonate in five floors. Both quartz and carbonate grains are present in equal proportions in Floor 7/120. The proportion of quartz grains is at its highest (40%) in all floors except for 9 and 17.

Carbonate grains peak at 50% content in nine Floors (1, 7, 9, 11, 12-15 inclusive and 17), with the lowest content at 5% in Floors 4 and 6/120.

6.5.3 Floor fabric: the fine residues

Under observation by the naked eye, individual floors are easily recognisable in the thin sections, with alternating layers of brown and light brown material. Under the microscope the light brown floors become brown (PPL) fine material, appearing dense and amorphous, with the brown (naked eye) fine material appearing Dark brown (PPL) organic fine residues (see Plates 13 and 14). The brown (PPL) material forms nine Floors (2, 3, 9, 10, 12, 13, 14, 15 and 16) and the dark brown (PPL) material five Floors (4, 5, 6, 7, 8), with the remaining two Floors (1 and 17/120) being composed of beach sand, although Floor 17 contains dark brown residues. Floor 11/120 is the only floor composed of grey-brown residues.

A further fine residue was also identified within the dark brown (PPL) residue: this is a grey-brown (PPL) colour, but also appears as a colourless (PPL) material. These residues have a very fine crystallitic appearance in (XPL), and show similar characteristics to the peaty turf ash in the reference sample. In OIL these residues reflect a bright orange colouration, again a characteristic of the peaty turf ash. The fine residue has been incorporated into the dark brown matrix, and occurs in elongated patches within these residues. A brief note of the colours is shown in Table 6.6.

The colour of these ashes shows a remarkable resemblance to those of the reference samples, with the well-humified ashes appearing as dark-brown (PPL)/dark red (OIL). The peaty turves are dominated by a more dark reddish brown (PPL) residue, that reflects light as bright orange brown (OIL). The most striking difference between the two residues is the presence of grey or coloureless (PPL)/isotropic (XPL) patches that are exclusive to the well-humified ashes. These are patches of opal silica caused by the melting of phytoliths and diatomaceous material, identified by their non-birefringent residue and the vesicular fabric (Courty *et al.* 1989).

6.5.4 Microstructural characteristics

The microstructure of these floors varies between massive (see Plate 13) and chamber (see Plate 14), with chamber being dominant. This microstructure has been identified in eight of the floors whereas massive microstructure is recorded in three floors. A combination of massive and chamber was identified in two floors, with chamber and crack occurring together in two floors. One single grain microstructure was identified in the shell sand forming Floor 1. This microstructure is typical of beach or dune sand, as exemplified in the reference sections discussed above. A summary of the microstructural characteristics of each floor is provided in Tables 6.5 A and B.

The microstructures identified are not specific to one type of ash residue, and occur in both the peaty turf and the well-humified ashes. The implications and suggestions for this are discussed elsewhere in this thesis.

6.5.5 Anthropogenic inclusions

Graph 6.6 illustrates the charcoal content within each of the seventeen floors. The charcoal fragments appear as black (plane polarised light) and (cross-polarised light) isotropic fragments. They are randomly distributed in the floors, and of various sizes.

The greatest content of fragments was identified in Floor 3/120 at 60%, whilst the lowest was 10% recorded in Floors 9, 11 and 17/120. In association with the greatest content of fragments, Floor 3 also recorded the largest fragments, up to 0.5 cm in diameter. The cellular structure of many fragments was not visible, although the fragments do record some crack structure. This is likely to be a result of a burning process, trampling activities or swelling and shrinkage attributable to alternating wetting and drying as a post-deposition process (Matthews, 2001).

The charcoal fragments appear to be at higher proportions within the floors which are dominated by the dark brown (PPL) residues, these floors also having the higher concentration of residues that are characteristic of peaty turf ashes. Therefore the increased charcoal residues could be an indication of the use of the fuel used in the hearth and the burning temperature of the fire. This is discussed at the end of this chapter.

6.5.6 Summary points of S120 samples

- *17 individual floors identified micromorphologically*
- *Quartz dominates the most number of floors, followed by calcium carbonate then feldspar*
- *Fine residues are derived from both peaty turf and well-humified peat ash.*
- *General trend of decreasing charcoal content from the bottom floor to the top*
- *Chamber and massive microstructures dominant.*

6.6   Structure H: Sample 133

The floor in Structure H is thought to be of Late Iron Age construction, although earlier within that period than the floor of Structure L (Neighbour, 1996).

Upon excavation the floor was found to cover the interior of this structure, being 15 cm thick and represented by context 261. This context was described by the

excavator as a mixed orange clayey 'peat' with black charcoal flecks and lenses of beige sand. Unfortunately, only one Kubiena sample was collected representing the lower 8.5 cm of the deposit, therefore meaning that the upper 7.5 cm of the floor not being available for analysis.

6.6.1 Number and thickness of floors

Within the 8.5 cm of the thin section, five individual floors have been identified. Each of these floors show different micromorphological characteristics and composition.

The variation in thickness of the five floors is indicated in Graph 6.7, where Floor 3/133 is shown to be the thickest floor at 2.6 cm and Floor 2/133 the thinnest at 0.8 cm. The difference in thickness between the two thickest Floors (1 and 3/128) is minimal, at 2 mm, with a similar pattern occurring in the thinnest Floors (2, 4 and 5/133) which have a 1 mm difference between them.

6.6.2 Mineral characteristics

The mineral content and variation in the floors is summarised in Table 6.7, where it is seen that there is an increase in the quartz content of the floors from the bottom floor to the top. Here, the increase is from 20% quartz content in Floor 1/133 to 50% content in Floor 5/133. Contrastingly the carbonate content of the floors decreases from 30% in Floors 1-4, to 10% content in Floor 5/133, with the main decrease from floor 4 to 5, where there is a decrease of 20%. There is very little variation in the feldspar content of the floor, the lowest content for this mineral being 10% in Floor 3/133.

6.6.3 Floor fabrics: the fine residues

The fine matrix of each floor differs although all five are either of peaty turf or well-humified peat ash of differing colour in thin section. Floor 1/133 differs from the remaining floors in being derived from a glacial till. The colour of the fine matrix of this floor is brown (PPL) and very dark brown (XPL);as illustrated in Plate 11, there are no coarse organic residues. The fine matrix of the remaining Floors (2 to 5/133) is very mixed, with material displaying characteristics of both ash residue types forming the floors. These are summarised in Table 6.8.

Light grey or colourless (PPL)/isotropic (XPL) (illustrated in Plates 11 and 12)patches within the floors appear to be composed of fused phytoliths and diatoms, which have been identified by the occasional intact example of one of these components in the ash residue. The identification of these elements has been discussed earlier and will not be repeated here. However, the presence and implications of these residues incorporated in the ashes is discussed later in the thesis.

6.6.4 Anthropogenic inclusions

Charcoal variation and content through the floors is illustrated in Graph 6.8, where it is seen that there is a general decrease in charcoal content from Floor 2/133 through to Floor 5/133 (40% to 5%). Generally, from these observations, the floors in Structure H can be described as clean with evidence of only low proportions of charcoal fragments.

6.6.5 Summary of S133 samples

- *Five individual floors identified*
- *Quartz dominates the majority of the floors*
- *Charcoal content decreases through the sequence from bottom to top*
- *Glacial till used as base floor material, other floors are peat and ash residue derived*
- *Dominant chamber microstructure*
- *Phytoliths and diatoms, both fused an intact within patches of ash material.*

6.7 Structure J: Sample 128

The one sample collected from Structure J is thought to be earlier than the floor of Structure L, but it is thought to have been constructed around the same time as Structure H. Therefore, it is possible that both these floor sequences are contemporary, although this remains to be substantiated.

The sample for this structure was collected from context 244, which was described in the field as being a reddish brown sand floor layer (Neighbour 1996). The floor measured 20 cm thickness on excavation, but the floor sampled for this research is the bottom 8 cm of the field identified floor. Therefore the upper 12 cm of the floor is not available for analysis.

Photomicrographs of some of the floors and their fabrics are illustrated in Plates 6 to 10.

6.7.1 Number and thickness of floors

In total, 9 individual floors have been identified in the 8 cm of the thin section. Each of these floors is of varying thickness and composition. These variations are illustrated in Graph 6.9.

As revealed in the graph, there is a general trend for a decrease in floor thickness from the bottom of the floor sequence to the top (Floor 1 to 9/128). It is also noticed that every second floor is thinner than the floor previous to it Floors 2, 4, 6, 8 and 9/128 are the thinner floors. These five floors also show a decrease in thickness through the sequence.

In the graph, the thickest floor is shown to be Floor 1/128 at 2.0 cm, this being the sand derived floor at the base of the sequence. Floor 6/128 is the thinnest floor at 0.4 cm, this floor being a sand dominated layer.

6.7.2 Mineral characteristics

The variation in mineral contents through the floors is summarised in Table 6.9, where quartz and carbonate grains dominate the mineralogy of an equal number of floors. Quartz dominates in Floors 5, 7 and 8/128 at 40% content, but also co-dominates the mineralogy of Floor 2/128 with feldspar at 30% content each. Carbonate grains dominate the mineralogy of Floors 1, 4 and 9/128, with the content in Floor 1/128 recording 40%, but 50% each in the other two floors. This content is the highest recorded by any of the minerals in the floors. Floor 6/128 is co-dominated by both quartz and carbonate minerals, each occurring at 30% content. Feldspar grains dominate only one Floor (3) singularly, at a content of 40%.

6.7.3 The floor fabrics: Fine residues

The colour of the fine residues in each of the floors is summarised in Table 6.10

The fine residue components of the floors vary through the sequence, with Floor 7/128 being unique due to its composition of 80% black (PPL)/isotropic (XPL) charred fragments. The nature of these residues is illustrated in Plate 6. By eye, the remaining floors appear to be composed of similar material based on the colouration of the layer, with Floors 3, 5 and 8/128 appearing to have the same yellow colour.

Floors 2, 4 and 9/128 record the same colour, in this case reddish brown. Under the microscope, the colours of the floors are however very different. Table 6.10 provides a summary of the fine residue in each floor. From this table, it is seen that in cross-polarised light the majority of the fine residues appear as isotropic, with the notable exception of some light brown and brown residues (the form of which can be seen in Plate 10) in Floors 4, 6 and 9/128, which reflect dark reddish brown colours. These fine residues have been described and identified as peaty turf ash and well-humified peat ash residues. Plates 8 and 9 illustrate the difference between the ashes when viewed in PPL and XPL, with the ashes viewing as isotropic in XPL.

As in the floors of Structure H, light grey/colourless (PPL) patches occur throughout the floors in this sequence, and are illustrated in Plate 7. These have the same appearance as the fused phytoliths and diatoms identified in these and other floors within House 3. The implications for the presence of these materials are discussed later in the thesis.

6.7.4 Microstructural characteristics

Microstructure of the floors is a combination of chamber, crack and complex, with the complex structure being dominant, with four floors recording this microstructure (2, 3, 5 and 6/128). The massive structure was recorded in the last three Floors (7, 8 and 9/128). The microstructure of each floor is illustrated in Summary Table 6.9.

6.7.5 Anthropogenic inclusions

Graph 6.10 illustrates the charcoal content within each of the seventeen floors. The charcoal fragments are described as black (PPL) and (XPL), isotropic fragments, randomly distributed in the floors, and of various sizes. The greatest content of fragments were identified in Floor 3/128 at 60%, whilst the lowest content was 10% recorded in Floors 9, 11 and 17/128. In association with the greatest content of fragments, Floor 3/128 also recorded the largest fragments, being upto 0.5 cm in diameter. The cellular structure of many fragments was not visible, although the fragments do record some crack structure. This is likely to be a result of the burning process, trampling activities or a swelling and shrinking as a result of alternating wetting as a post-deposition process (Matthews, 2001).

The charcoal fragments appear to be at higher contents within the floors which are dominated by the dark brown (PPL) organic residues, these floors also having the higher concentration of residues that are characteristic of peaty turf ashes. The peaty turf ashes and the charcoal fragment content typical of these ashes are illustrated in Plate 8.

6.7.6 Summary of Sample 128

- *Nine individual floors identified in 8 cm field deposit*
- *Decrease in the thickness of floors through the sequence from bottom to top*
- *Pattern of alternating floor thickness, with every second floor being thinner than the previous (2, 4, 6, 8 and 9)*
- *Both quartz and calcium carbonate grains dominate the mineralogy of floors in equal numbers*
- *Floor 7 is composed entirely of in situ black charred fragments*
- *Floors are dominantly organic derived with high ash content*

- *Complex microstructure dominant (4 floors), massive structure (3 floors) and crack structure 1 floor, single grain 1 floor.*

6.8   Summary

The results that have been documented in this chapter for Structures L, J and H, House 3 at Bostadh Beach are discussed in Chapter 9, where all three settlement sites under consideration in this thesis are compared and conclusions raised.

Each of the structrures and samples within them have been summarised at the end of that particular sample within the chapter, hence they will not be repeated here.

Chapter Seven

Case Study Two: Cladh Hallan

Results

7.1   Introduction

This Chapter presents the results for the analysis of floors from Houses 640 and 401 at Cladh Hallan. The second part of the chapter contains the discussion of these results and conclusions regarding the floors in both houses.

As described in Chapter 5, at Cladh Hallan, House 401, the samples were collected along two transects in the house, north-south and east-west, which divided the internal space into four quadrants. In House 640 a single trench was opened down the length of the house (east-west) from which the samples were collected.

The aim of the sampling was to identify putative occupation levels, and to determine the construction materials and mode of formation for these floors, and where possible to infer the use of space within the structure.

On this basis, the results in House 401 are described according to the transect from which the samples were collected (north-south/east-west), whilst the results from House 640 are presented according to the single transect. The results tables and graphs for this site are found in Pages 381-390 and 398-412, behind the Appendices in this thesis.

The same reference slides of hearth residues and beach/dune systems are used here as those at Bostadh beach, although information regarding the mineralogy of the South Uist machair systems has been sought from Schwenninger (pers comm).

Plates 17 to 22 are characteristic of the sand floors of Houses 640 and 401 at Cladh Hallan, and are referred to throughout the following results section.

For Figures 2.14 to 2.22, where indicated on the illustrations, the context descriptions are detailed in Appendix Three.

7.2   Cladh Hallan Houses 640 and 401

7.2.1 House 640

7.2.2 Introduction

A trench was opened from east to west in the house, the eastern point lying at the entrance to the structure. The transect measured 4.6 m in length, with two samples (4664 and 4666) collected, the first of these (4664) taken from the north-facing section in the eastern room, 1.2 m into the structure, and 4666   3.8 m into the structure in the western room. Both samples represent context 632, which in the field varied from 0.2 to 0.4 cm thick. Sample 4666 was collected from the deeper portion of the floor. The point of sampling is illustrated in Figure 2.22.

Full micromorphological descriptions of these floors are provided in Appendix 2, and summarised in Table 7.1

7.2.3 Results: Samples 4664 and 4666

7.2.3.1 Number and thickness of floors

The thickness of the floors is illustrated in Graph 7.1. Both floors are represented by a single floor deposit 7.5 cm thick, dominated entirely by quartz and carbonate grains, both at 30% in Sample 4664. In Sample 4666 quartz dominates at 40%, with carbonate grains second dominant at 30%.

7.2.3.2 Microstructural characteristics

The coarse/fine (c/f) ratios of these floors varies, with a ratio of 80/20 in Sample 4664, due to the presence of fine organic residue, but no c/f ratio in Sample 4666 due to the absence of fine residue. Based on these figures, the c/f related distributions of the two samples is dominantly monic, but with gefuric areas in Sample 4664 where the fine residues are present. The definitions of these c/f related distributions are found in Table 6.12.

Based on these descriptions and the micromorphological analysis, the microstructure of both floors in the samples is compact grain structure, with bridged grain in Sample 4664 where the fine residue is present. The microstructure definitions are be found in Table 6.11. These definitions are not included here but are summarised in tabular form to avoid repetition within the results.

7.2.3.3 Floor fabric: the fine residues

The colour of the fine residues is summarised in Table 7.2

The fine residue in Sample 4664 has a 20% occurrence, appearing as patches of organic material rather than fragments. The patches have a dense structure and are light brown (PPL)/dark brown (XPL) with a crystallitic appearance, caused by the

fine calcite grains in the organic matrix. The residue is well decomposed and structureless, although not of amorphous appearance.

7.2.3.4 Anthropogenic inclusions

Abundant charcoal and rare bone fragments. Charred peat fragments have 30% abundance (see Graph 7.1) in Floor 4664, composed mainly of fragments in the top 2.5cm of the floor.

In the floor of Sample 4666, the charred fragments are randomly distributed and measure from <1 mm to 2 mm in diameter. However, the 2 mm fragments are rare, accounting for <2 % of the total charcoal content.

The bone fragments in each floor are rare (<2%), with 3 white (PPL) fragments in Floor 4666, all measuring approximately 1 cm in length and being horizontally aligned in the sand matrix. The location of these fragments is in the lower 3 cm of the floor. Four fragments were identified in Floor 4664, the first occurs immediately below the charcoal dominated top 2.5 cm of the floor, and is vertically aligned in the sand matrix. This fragment also measures 1 cm in length and is white (PPL) in colour. The remaining three fragments are clustered at 5 cm depth in the floor and are randomly aligned, being white (PPL) in colour and 0.3 to 0.7 mm in length.

7.3   Cladh Hallan: House 401

Two contexts were assigned to putative floor levels upon excavation, and these are discussed separately here. The location of the samples in the field sections is illustrated in Figures 2.13 to 2.19

The results for each of these floors are discussed separately, beginning with Floor 595, assigned to Phase IV of occupation, the first floor sampled. The results of Floor 655, Phase III occupation and the second floor sampled are presented in section 7.4.

7.3.1 Floor 595: Phase IV

This was the first floor of the structure sampled exclusively for micromorphological analysis. The samples were collected with the aim of reconstructing use of space within the structure, but the samples are also being used by this author to reveal micromorphological characteristics of floors from a different archaeological site and possible period.

The results in this section are presented in accordance to the transect from which the samples were collected, for example six Samples (4897, 4895, 4893, 4847, 4849 and 4851) were collected from the north-south transect, in the order of sequence noted. However, the east-west transect was not fully sampled due to the context representing Floor 595 not being found in the eastern area of the structure (towards the entrance), hence the three samples for this transect were collected from the western end of the transect.

Plates 20 to 22 illustrate the form of the floors in context 595. Plate 22 is typical in terms of mineralogy and single grain microstructure of all the floors indentified within context 595, and are referred to for the floors in this section as a whole. Plates 21 and 22 in particular, illustrate the peaty turf ash deposits that were used for the formation of the floor near to the central area of the house.

7.3.1. North-South transect

As previously stated, a total of six samples were collected to represent the floor at specific points along the transect. In the northern section of the transect, the first Sample (4897/595) was taken 25 cm from the base of the wall, with the second Sample (4895/595) taken 50 cm after the first and mid-way along the transect. The

final sample on this part of the transect was collected close to the centre point, 2.1 m from the northern wall.

In the southern section of the transect, three further samples were taken, the first (4847/595) being 45 cm from the central point of the structure, followed by the mid-transect Sample (4849/595) 1.4 m from this point, and the final Sample (4851/595) 2.0 m from the central point. Plates 20 and 21 illustrate the mineralogical and microstructural components of the floors in this area.

The exact location of the samples in the field sections is illustrated in Figure 2.17 to 2.19.

7.3.1.1 Thickness and number of floors

As shown in Graph 7.2, four of the samples have a single floor deposit (4893, 4895, 4849 and 4851/595), whilst two individual floors have been identified in sample 4897 and six floors in Sample 4847/595. The graph indicates the thickness of each floor along the transect, with the four single layer floors forming 7.5 cm thick deposits, whilst the thickness of the other samples varies.

In the six floors of Sample 4897/595, the lowest layer (Floor 1) is 2.1 cm thick, with the upper layer (Floor 2) being thicker at 2.8 cm. In this Sample, there is a trend for decreasing thickness from Floor 1, at 2.1 cm thickness, to 0.4 cm in Floor 4, the middle floor. The thickness then increases from the middle floor to Floor 6, the final floor, which is 0.8 cm thick. However, from these figures it is seen that there is very little variation in thickness between Floors 2 to 6.

7.3.1.2 Mineral characteristics

The mineralogical component of the floors varies throughout the samples in the transect, as summarised in Tables 7.3 A and B. Here it is seen that quartz grains

dominate all of the floors, mostly at 30-50% content, as illustrated in Plates 20 and 21.

The gefuric related distribution is only present in the floors where the fine residues are located, thus the monic related distribution is the more dominant in the floor samples as there is a higher occurrence of mineral grains than fine residue.

The six floors of Sample 4847/595 have varying ratios and related distributions, based on the fine residue and mineral content. The ratios are illustrated in Table 7.3 A and B, the summary table micromorphological characteristics for this Sample.

7.3.1.3 Microstructural characteristics

The microstructure of the floors in these samples is summarised in Tables 7.3 A and B. However, single grain microstructure, illustrated in Plate 22, with localised patches of bridged grain structure occurs in the samples dominated by sand grains and with gefuric and chitonic related distributions. This applies to Samples 4897 (Floor 1), 4895, 4893, 4848 and 4851/595.

Floor 2 (Sample 4897/595) and all six floors of Sample 4847/595 record a combination of both compact grain structure and intergrain microaggregate. In Sample 4897/595, Floor 2, the compact grain structure occurs in areas of the floor where there is very little or no organic residue. The organic residues of the floor occur as dense patches in areas within the floor matrix, hence the formation of the intergrain microaggregate structure.

The six floors in Sample 4847/595 have a microstructure that is dominated by compact grain structure, but this differs from the compact structure defined by Bullock and co-workers (1985), as each of the floors in the sample have a matrix dominant in fine residues. However, the compact grain structure is the closest descriptor in the Handbook that is suitable for a description of the microstructure in these floors.

7.3.1.4 Floor fabric: the fine residues

Fine residues are dominant in Floor 2 (Sample 4897/595) and all six floors in Sample 4847/595. The colour of these residues is summarised in Table 7.4

The fine residues in Floor 2 (Sample 4897/595) are well decomposed and amorphous, light brown (PPL)/dark brown (XPL) material. The material occurs as fragments and dense patches and shows no structure.

Greater detail of results is provided for sample 4847/595, as 6 individual floors with alternating residue types were identified in this sample. These residue types are brown (PPL)/isotropic (XPL) residue, as illustrated in Plates 20 and 21, where the structureless microstructure and abundant charcoal residues are also seen. This residue is characteristic of the peaty turf ash in the reference samples.

Floor 2 is composed of light brown (PPL)/isotropic and crystallitic (XPL) residue, abundant in phytoliths and diatoms, which appear to be fused, but some are also intact. These residues are characteristic of peaty turf ashes on comparison with the reference sample of this ash. Deposited within this fine matrix are orange-brown (PPL)/reddish brown (XPL) patches of decomposing, amorphous residue. The fine organic residues account for 20% of this floor, reflected in the c/f ratio of 80/20, and a related distribution described as close porphyric.

Floor 4 floor matrix is composed of grey-brown (PPL)/isotropic (XPL) very fine residues with no amorphous appearance. The fabric is crystallitic in XPL, tending to an organo-mineral origin, the crystallitic appearance being caused by the fine sand sized quartz grains. The fine residues are abundant in fused and intact phytoliths with diatoms, the matrix being structureless and dense. These residues are characteristic of the peaty turf ashes as identified in Floor 3 and in the reference samples.

Brown (PPL)/isotropic (XPL) fine residues form the composition of Floor 5, the material also has a crystallitic appearance in XPL, tending to an organo-mineral origin. As in Floor 4, the crystallitic appearance being caused by an abundance of fine sand sized quartz grains. The residues do not have an amorphous appearance, and are abundant in fused and intact phytoliths and diatoms. These are characteristic of fire hearth ashes, with the colouration and fabric characteristics of these residues appearing to resemble peaty turf fire residues.

Finally, Floor 6 is composed of three differing fine residues, with a dark brown (PPL)/isotropic and crystallitic (XPL) matrix. The second fabric within the floor is orange-brown (PPL)/isotropic (XPL), patches within the above matrix. These patches are structureless and dense. The third fabric is grey-brown (PPL)/isotropic and crystallitic (XPL) fine residue. There are abundant phytoliths and diatoms, which are mostly fused, composing this material.

This material is also structureless, and possibly of organo-mineral origin given the abundance of fine sand sized quartz grains embedded within the matrix. The micromorphological characteristics of these residues are in accordance with the well-humified peat ashes in the reference samples.

7.3.1.5 Anthropogenic inclusions

Together with the fine residue and microstructural characteristics identified in the floors, further anthropogenic indicators include charcoal and bone fragments. Graph 7.3 illustrates the charcoal abundance in each floor along the transect

Charred fragments were identified in all floors through the transect, being most abundant in the six central floors of Sample 4847. Of this sequence, Floor 1 (the lowest floor) contains the highest fragment content at 40%, with the remaining four floors each recording a 30% content, but the upper most Floor (6) records one of the lowest abundances in the transect at 2%.

In the northern transect, as illustrated in Graph 7.3, the charcoal content of the floors varies from 30% in the upper floor of sample 4897/595, decreasing to 10% in the following floor sample (4895/595) and finally increasing to 30% in floor sample 4893/595. As the graph illustrates, there is a marked decrease in the southern transect, where charcoal contents of 15% (sample 4849/595) and 5% (sample 4851/595).

The majority of the charcoal fragments are very fine, typically less than 1 mm diameter, structureless and fragmented. The most coarse fragments were identified in Floors 2 and 3 (Sample 4847), with fragment diameters of 3-4 mm and showing cellular structure.

Bone fragments are rare throughout the floors, with the greatest concentration occurring within the organic matrix of Floor 2 (Sample 4847/595). Here four fragments were identified, two measuring 4 mm in length, with the others at 1 and 2 mm. The fragments are yellow (PPL) and birefringent (XPL). All four are horizontally aligned in the matrix.

7.3.2 East-west Transect: Samples 4871, 4873 and 4875

Three samples were collected from the western area of the transect. No samples were collected from the eastern area due to an absence of a context representing the floor.

Sample 4871 was collected 55 cm from the central point of the transect, followed by Sample 4873, 55 cm further to the west (1.1 m from centre) and finally Sample 4875/595, 2.1 m further to the west from the centre, at the edge of the structure. All samples were taken from context 595.

7.3.2.1 Thickness and number of floors

The variation in thickness and number of floors identified in these samples is shown in Graph 7.4, where it is seen that the sample close to the central area has two individual floors, the lower floor being 2 cm thick and the upper 6 cm thick. The second Sample (4873/595) along the transect also had two individual floors identified, the lower measuring 4 cm and the upper slightly thicker at 4.1 cm. Finally, the floor represented in Sample 4875/595 is a single deposit of 7.5 cm thickness.

7.3.2.2 Mineral characteristics

The mineralogical composition of each floor is extremely varied, with quartz and feldspar grains being most abundant in both Floors 1 and 2 of the sample closest to the central area (sample 4871/595). The mineral abundance is summarised in Table 7.5.

However, in Sample 4873/595 floors, there is a change in dominance, with quartz grains dominating the lower floor at 40%, but carbonate grains dominating the upper floor mineralogy at 40%. These mineral grains are indicative of the beach sand collected for reference material from Bostadh Beach, this indicating either a beach or machair origin for the floor material.

Sample 4875/595 and Floor 1 of Sample 4873/595 both record a well to perfectly sorted mineralogy, with the other floors recording either a moderate or poorly sorted mineral content.

7.3.2.3 Microstructural characteristics

The microstructure of the floors in this transect vary, as illustrated in summary Table 7.5.

The lower floor of Sample 4871/595 has a complex structure where all three of bridged, intergrain microaggregate and compact grain structure were identified. The upper floor of this sample records a compact grain structure embedded in a dense

organic groundmass. In Samples 4873/595 (Floors 1 and 2) and 4871/595, the floors were identified as having dominantly single grain structures, although in both floors of Sample 4873/595, a bridged grain structure was recorded in the presence of fine organic residues.

7.3.2.4 Floor fabric: the fine residues

The fine residues in the floors are either organically or ash derived, occurring as either fragments or patches between mineral grains. The colour of the fine residues is summarised in Table 7.6.

The dominant residue is dark brown (PPL)/isotropic and crystallitic (XPL), that forms fragments and patches upto 0.5 cm diameter in both floors of Sample 4871/595, and Floor 1 (Sample 4873/595). This residue is organically derived, possibly organo-mineral, being well decomposed, amorphous and structureless. The crystallinity is caused by fine sand sized quartz grains embedded in the organic matrix.

Light brown (PPL)/isotropic and crystallitic (XPL) fragments were identified in Floor 2 (Sample 4873/595). These appear to be organically derived, given the well decomposed, amorphous appearance that is dense and structureless. No plant residues or phytoliths are visible.

Further residues were identified in Floor 1 (Sample 4873/595), which are ash derived, given the fine appearance of the material and the abundance of fused phytoliths in the matrix. The residue is grey-brown (PPL)/isotropic and crystallitic (XPL) but also reflecting bright orange (OIL), a characteristic of burned organic materials. The matrix of the residue shows very similar characteristics to the well-humified peat ash in the reference thin sections.

7.3.2.5 Anthropogenic inclusions

Further anthropogenic indicators in the floors include charred fragments and bone. The charcoal content of each floor is shown in Graph 7.5, where it is seen that all floors contained appreciable amounts of charred organic remains.

As seen in the graph, both floors in the central area (Sample 4871/595) record the highest content, with an increase from 30% in the lower floor to 40% in the upper floor. A similar increase is also shown in the floors of 4873/595, which are mid-transect floor samples. Here, the increase is from 20% in the lower floor to 30% in the upper. The sample at the far western end of the transect also recorded a high charred component of 30%. The majority of these fragments are in the size range of 1 mm diameter or lower, with the coarser fragments being easily quantified by eye. The very fine fragments (<1 mm) are dominantly structureless, whereas, the larger fragments (>2 mm) generally show a visible intact cellular structure. Both these size of fragments are randomly distributed throughout the floors

Bone fragments are rare in the floors, with only a rare (<2%) occurrence in Floor 2 (Sample 4873/595). Here, two white (PPL)/grey (XPL) fragments measuring 2 and 3 mm were embedded in the sand dominated matrix. Both fragments have a horizontal orientation.

7.3.3 House 401 Floor 655: Phase III

This was the second floor in the house sampled for micromorphological analysis. The floor is thought to represent phase III occupation, with samples collected to investigate the use of space and floor formation for that period. Radiocarbon dates for this phase reveal a period of use in the Bronze Age, but as always with dating, some reservation must be employed with regards to this date. However, if correct, then these floors are the earliest that have been analysed in this thesis.

The same transects were used for the sampling of Floor 655 as those for Floor 595, with many of the samples for 655 being located either directly below or to the below and side of the 595 samples. As in the previous floor, the full length of the north-south transect was sampled, together with the full length of the east-west transect.

The results are described according to the transect from which the samples were collected i.e.: north-south and east-west.

Plates 17 and 18 illustrate typical floor characteristics of all the floors identified within this context throughout House 401. All of the floors were composed of a dominant quartz content and a low fine residue content.

North-South transect

A total of six samples were collected from points along this transect, as illustrated in Figure 2.17 to 2.19. The first Sample (4898/655) was collected at the far northern point of the transect and is a base deposit of Floor 655. The following Sample (4896/655) was collected mid-transect from north to the central point, followed by 4894/655 in the central area.

The remaining three samples were collected from the central area southwards, starting with 4848/655 taken 45 cm from the centre, followed by 4850/655 mid-transect (1.3 m from the centre) and ending with 4852/655 at the southern point of the transect (approximately 2.0 m from the centre).

7.3.3.1 Thickness and number of floors

As shown in Graph 7.6, there is a distinct trend of the floors at both mid and end points of both sides of the transects recording one single floor deposit of 7.5 cm thickness, but with the more central samples recording a sequence of floors.

The floors of Sample 4848/655 in the southern half of the transect are generally of the same thickness, ranging from 1.8 cm in the lower floor to 1.6 cm in the upper floor. The middle Floor (2) is the thickest at 2 cm. In comparison, Sample 4894/655 on the northern side of the transect has three floors that are of differing thickness. Here, Floor 1 is the thinnest at 1.8 cm, with Floor 2 increasing to 5 cm thickness and the final Floor (3) being 2.4 cm thick.

7.3.3.2 Mineral characteristics

The mineralogical content of each floor is summarised in Tables 7.7 A and B, where it is shown that the floors in the central areas, Floors 1 to 3 in Samples 4849/655 and 4894/655, are dominated by an abundance of quartz grains. Each of the floors in Sample 4894 recording equal contents at 40%, whilst the middle Floor (2) of Sample 4848/655 records the highest abundance at 70%, with Floors 1 and 3 at 40% each.

The two northern Samples (4896 and 4898/655) are dominated by 40% quartz grains, with both feldspar and gneiss grains the second most abundant minerals. In the southern section Samples, 4852 and 4850/655, there is a notable difference in the mineralogy.

Sample 4850/655 is dominated by 40% quartz grains, a possible continuation of the central area floors, and Sample, 4852/655 by quartz grains at 50%. Also in the floor of this sample, carbonate grains are second most abundant at 20% content.

7.3.3.3 Floor fabric: the fine residues

The fine residues of the floors are either organically or fire ash derived, but varies in each of the floors through the transect. Based on the c/f ratios and observations under the microscope, the two samples from the central area of the house have the highest fine residue content. The results of each sample are discussed separately.

Sample 4848, Floors 1 to 3:

Floor 2 in this sample recorded the highest and most varied organic material, the colour of these residues is summarised in Table 7.8. Here, there are both dark brown (PPL) and light brown (PPL) residues, both having characteristics of peaty turf ash residues. The light brown material reflects as bright orange in OIL, a characteristic feature of ash residues in this light source.

Of the remaining two floors, Floor 1 is composed of fragments of residue from Floor 2, whilst Floor 1 is composed of reddish brown (PPL), amorphous residue. This appears to be well decomposed organic material, which occurs between the mineral grains.

Sample 4894/655, Floors 1 to 3:

Floor Fabric: the fine residues

The colour of the fine residues is summarised in Table 7.8.

The dominant residue in Floor 1, the lowest floor, is light brown (PPL)/isotropic (XPL)/orange (OIL). At low magnification, this material was thought to be stained ash, given the fine, silt like appearance and the orange reflectance (OIL). However, at higher magnification the residue is well decomposed and shows amorphous characteristics, indicating that the origin of the material is distinctly organic. Due to the dense organic composition and colouration, no phytolith or diatom residues were identified.

The middle floor is composed of two distinct fine residues, one being organically derived and the second fire ash residue. The yellow-brown (PPL)/isotropic (XPL)/isotropic (OIL) material is organic residue, well decomposed and structureless, with a dense appearance. At high magnification this residue has an amorphous appearance and is the dominant residue in the floor. The second residue shows very similar characteristics to fire ash reference material, with an origin of

well-humified peat. The patches of residue embedded within the organic matrix, are grey-brown (PPL)/isotropic (XPL)/ bright orange and red (OIL) in colour, and have a very fine structureless appearance. Abundant fused phytoliths were observed in patches that were not stained by organic acids.

The upper floor in the sequence has fine residue similar in appearance to Floor 1, although in cross-polars, the fine residue reflects a crystallitic birefringence fabric. This is composed of fine sand and silt sized grains of calcite, embedded within the light brown (PPL)/isotropic (XPL) organic matrix. This matrix is well decomposed and structureless, and does not form a continuous coverage in the floor, rather it forms fragments and patches between the mineral grains.

Of the remaining samples, there is a distinct divide in the composition of the fine residues between the two samples from the northern area and the two from the southern area of the transect.

In the two northern Samples (4898 and 4896/595) the fine residues are organically derived, with light yellow-brown (PPL)/isotropic (XPL), well decomposed and amorphous fragments and patches of material. The fragments are structureless, having a dense appearance and some intact phytoliths are visible, although these are largely masked by organic residue. Some of the fragments are lighter at the edges; possibly indicating that decomposition is still in process.

The two samples (4850 and 4852/655) at the opposite end of the transect each record differing fine residues. The fine residues in the floor of Sample 4850 are composed of light brown (PPL)/isotropic (XPL) fragments and dense patches, which are well decomposed and show no cellular structure. The origin is described as organic. Within the sand and fine residue matrix are 9 patches of 3-4 mm diameter, which have an orange-brown (PPL)/dark brown (XPL) matrix, with fine sand sized quartz grains embedded within. In cross-polars, the matrix of these fragments is also birefringent, indicating a high clay content. The fragments have no structure, appearing as dense and with the mineral grains in close contact. The matrix is

described as organo-mineral, with the fragments possibly originating from well humified peat. The characteristics of the fragments being very similar to the matrix of the well humified peat reference sections.

7.3.3.4 Anthropogenic inclusions

Anthropogenic inclusions in each of the floors take the form of abundant charred peat fragments. The abundance of fragments in each of the floors is shown in Graph 7.7, where it is seen that the content varies in each of the floors.

Both samples at either end of the transect, the northerly and southerly points, record two of the lowest abundances at 10% each. The upper and lower floors of the northern central area Sample (4897/595) have equal contents at 40%, with the middle floor recording 10% content.

Generally, the southern section floors have lower abundances of charred fragments, with the notable exception of the floor in Sample 4850/655, which has a 30% abundance. In comparison, the central area floors (Sample 4848/655) have varying contents, from 15% in the lower floor, dropping to 10% in the lower floor and increasing to 20% in the upper floor. The low content in sample has already been discussed.

7.3.4 House 401: Floor 655 East-West Transect

A total of six samples were collected along this transect from the entrance of the structure to the back wall in the west of the structure. Sample 4967 represents the floor at the entrance, followed by Samples 4965 and 64 in the central area of the structure. The central to western point of the transect is composed of Samples 4872 (centre), 4874 and 4876 at the end point of the transect. Figures 2.13 to 2.16 illustrate the location of samples.

Plates 17 and 18 are typical of the floors that have been identified within this context, and are used as reference for all of the floors in the east-west transect.

7.3.4.1 Thickness and number of floors

The thickness and number of floors in the samples varies at points along the transect, as shown in Graph 7.8.

Three individual floors have been identified within samples at two points along the transect. The first at the entrance (Sample 4967/655) of the structure, where the thickness of floors varies from 2.6 cm in the lower floor, to 1.4 cm in the middle floor and 3.1 cm in the upper floor. The second is in Sample 4872/655, from the central area of the house, where Floors 1 and 2 measure 1.8 and 1.6 cm thickness, and Floor 3, the upper floor the thickest at 5.6 cm. The four remaining floors, sampled in the mid to central section of the eastern transect, are single deposits measuring 7.5 cm, and the remaining two sections in the western section of the transect also being single deposits of 7.5 cm thickness.

7.3.4.2 Mineral characteristics

The three individual floors (Sample 4967/655) at the entrance of the structure have a varied mineralogy, as summarised in Tables 7.9 A and B. Here it is seen that two of the Floors (1 and 3) are dominated by an abundance of carbonate grains, 50% in Floor 1 and 40% in Floor 3.

The remaining two Samples (4965 and 4963/655) of this transect are both dominated by an abundance of quartz grains in their single floor deposits. The content in both floors is 40%.

In the central to western area samples (4872, 4874 and 4876/655) quartz grains are the most abundant minerals at 30-50% content. The floor samples along the whole east-west transect are dominated largely by sand grains, as illustrated by the c/f ratios

and the c/f related distributions. These are summarised for each sample in Tables 7.9A and B.

7.3.4.3 Microstructural characteristics

The microstructure of the floors is influenced by the content of fine residues, with the summary of microstructures for the floors provided in Tables 7.9 A and B. As seen in these tables, bridged grain, pellicular grain and compact grain structures are the dominant form, occurring singularly or as combinations within the floors. In the floors that are represented by single deposits (Samples 4965, 4963, 4874 and 4876/655) the microstructure is dominated by bridged grains, with the exception of Sample 4874/655 which also has areas of intergrain microaggregate within the floor. The microstructural definitions are summarised in Table 6.11.

In both of these definitions, the fine material is represented by fine organic residues that form the bridging material, this having been peat derived in most instances.

The sequence of floors in both Samples 4967 and 4872/655 at the far east and west sections of the transect, each show varying microstructures. The three floors at the entrance to the structure are sand dominated with very few organic components, being described as compact grain (Floors 1 and 3) and compact with bridged grain in the middle floor. A definition of bridged grain structure has been previously provided, with a compact grain structure being defined in Table 6.11.

7.3.4.4 Floor fabrics: the fine residues

The fine residues are of mixed origin and compositions through the floors, with the samples in the eastern section of the transect recording a greater variation in residue types than the floors of the western sections. The colour of these residues is summarised in Table 7.10.

Floor 4872/655 in the central area of the house has four different fine fabrics identified in the floors, with the middle floor containing two of these fabrics. The residues in Floor one are organically derived, being composed of dark brown (PPL)/isotropic (XPL), well decomposed, amorphous and dense fragments. These occurring mainly between the grains.

The matrix of the middle floor is composed of two different fine residues. The first being yellow (PPL)/isotropic and crystallitic (XPL)/isotropic (OIL), dense and structureless residue. This material forms a 4 x 1 cm patch in the middle of the floor. Phytoliths are abundant in the matrix of the material, with the crystallitic appearance being caused by fine sand sized quartz grains embedded in the matrix. The patch has possibly derived from a fragment of peat dropped in the floor matrix, which has subsequently undergone complete decomposition, hence the lack of identifiable plant residues and the fine nature of the matrix. The second and most abundant residue in this floor is composed of light brown (PPL)/isotropic (XPL, well decomposed, amorphous fragments. These are structureless with no visible plant residues, although the origin is thought to be organic.

The residue of the third floor is also organic in origin, the fragments in these floors sharing the same characteristics as those in floor 1, being dark brown (PPL)/isotropic (XPL), well decomposed and amorphous.

The single deposit floor in Sample 4963, taken from the central area of the house records the presence of two fine residues in the dominantly sand floor. The first and more abundant of these being light brown (PPL)/isotropic (XPL)/orange (OIL) residues. Due to the orange reflection in OIL, and the fabric characteristics of ash residues, then this material is representative of well-humified peat ash. The light brown material appears as dense patches within the dominantly sand matrix.

The second residue is yellow (PPL)/isotropic and crystallitic (XPL), patchy material. There are abundant intact phytoliths and diatoms within the matrix of the patches, which appears to be well decomposed and lacking any structure. The residue is similar to the patch in the middle layer of Sample 4872/655, which is in the same vicinity of this floor.

Three different residues were also identified in Sample 4965/655, the mid transect floor sample between the entrance and the central area of the house. The more dominant of the residues are light brown (PPL)/dark brown (XPL), well decomposed fragments. These are randomly distributed through the sand matrix, being structureless and undifferentiated. These fragments are organically derived, possibly being peat fragments in the floors.

The second fine residue is grey (PPL)/isotropic and crystallitic (XPL)/orange (OIL) very fine residue. At high magnification there are abundant fused phytoliths forming a dense matrix of this patchy material. There is no structure to the patches. These characteristics are similar to the grey residue identified in the ash residues of well humified peat in the reference samples. Hence, it is highly likely that these grey residues have a well-humified peat origin.

The third residue in this floor is very similar to the grey (PPL) material, with the exception that the colour is greyish-brown (PPL). Except for this, all other characteristics are the same, an explanation for the colour difference being that the organic acids that have leached from the light brown fragments have stained the ash residues.

In the remaining two samples in the western section of the transect (samples 4874 and 4876/655), the fine residue content is the same. Here, dark brown (PPL)/isotropic (XPL) fragments that have been identified in other floors along the transect were also identified here. These all possibly derived from the same well decomposed organic material that was windblown into the machair during its formation.

7.3.4.5 Anthropogenic inclusions

The anthropogenic inclusions of the floors are black (PPL)/isotropic (XPL) charred fragments that are derived from peat. These are abundant throughout the floors as illustrated in Graph 7.9. Here it is seen that the greatest abundance occurs in the two single floor deposits at the western end of the structure, where 40% content was

recorded in each floor (Samples 4874 and 4876/655). A 40% content has also been recorded in Floor 2 of Sample 4872/655 in the central area of the house. Both Floors 1 and 3 of this sequence record a 30% content.

For the floors in the eastern section towards the entrance of the house, the charcoal content is generally lower than the other samples. The greatest content occurs in the single deposit in Sample 4964/655 at 30%, matched by the middle floor of Sample 4967. In the remaining two floors of this sequence and that of Sample 4965/655, the charcoal content is recorded at 20% for each floor.

Generally the charcoal fragments are 1 mm sized or less, and record no structure. Coarser fragments are present in the floors, these usually showing some remnants of their original cellular structure. The greatest presence of coarse charred fragments occurs in the floor 2 of Sample 4872/655, with the size of the coarser fragments ranging from 2-5 mm. The fragments are generally horizontally aligned in the sand matrix.

In the remaining samples along the transect, the charred peat fragments are 1 mm in diameter of less, being randomly distributed in the sand matrix and structureless.

Bone fragments were identified only in the floor of Sample 4963/655, where the abundance is 5-15%; however, this accounts for only 4 fragments. These are white (PPL) and embedded in the sand matrix, being 3-5 mm in length. The fragments are randomly distributed in the sand matrix, and both vertically and horizontally aligned.

7.4 Summary

This results chapter has detailed the number, thickness, mineralogical compition, floor fabric and anthropogenic content of each floor within contexts 595 and 655 within House 401 at Cladh Hallan. House 640 has also revealed similar results, with the floors being derived from the same material as House 401.

Greater detail of the micromorphology is provided in Tables 7.X to 7.X, and with full micromorphological descriptions in Appendix 2. The implications of these results are discussed anc concluded in Chapter 9.

Briefly however, the summary of the floors is as follows:

House 640

- 2 floors

- Upper floor quartz and carbonate grain domianted

- Lower floor quartz grain dominated

- Floor fabric naturally derived

Context 595 and 655

- 17 individual floors in 595, 16 in 655,

- Quartz sand domined,

- Fine fabric naturally derived,

- Central area floors derived from peaty turf ash in both floor levels.

Chapter Eight

Case Study Three: Bornais

Results

8.1   Introduction

Four samples were collected from the floor of the house in Mound 1, all of which are abundant in charcoal residues, thought to be derived from roof collapse of the structure (Sharples 1999).

The charcoal abundant floor was subsequently covered with a sand deposit composed of red residue identified during excavation. This material has been captured in Sample 9159 as a layer over the charcoal residues.

The results tables and graphs for Bornais are found in Pages 391-393 and 427-429 behind the Appendices within this thesis. The thin section descriptions in Appendix Three.

8.2   Location of samples

The four samples were taken at various points along the east-west transect, with Samples 9158 and 9159 at the eastern end of the house, spaced 40 cm apart. Sample 9160 was collected from the most western point of the transect, with Sample 9161 taken 75 cm further eastwards from this. The exact location of the samples is illustrated in Figure 2.24.

Three contexts described in the field are present in the thin sections:

c. 457 (Sample 9158): Black sand with charcoal

c.397 (top of Sample 9159): Orange/black sand

c. 486 (Sample 9161): Yellow sand

c.484 (middle floor Sample 9160): Pale grey sand

8.3   Results

The results are described according to the floors or residues that have been identified within the thin sections from the east-west transect through the house. The floors identified have included a pre-charcoal layer floor, the charcoal layer and the post-charcoal floor. These floors were identified during the excavation of Mound 1, as detailed in the Data Structure Report for the site (Sharples 1999).

 Samples 9158 and 9159 were collected from the eastern area of the structure and Samples 9160 and 9161 from the western area.

The thin sections of these floors are illustrated in Plate 30, where a dominance of charcoal fragments and beach sand form the floors.

8.3.1 Pre-burning floor

The floor below the charcoal layer was evident only in Sample 9161 at the western end of the structure. Sample 9161 is composed of two layers, of varying thickness, the sand floor being 6 cm thick and the fine charcoal residue lying on top of this floor approximately 1 cm thick. The thickness of these floors is illustrated in Graph 8.1.

The lower sand floor is thought to represent the floor onto which the postulated collapsed roof has fallen. This sand floor is composed of quartz grains, with feldspar, gneiss and carbonate grains present in varying quantities (see Table 8.1). The sand is well-sorted, and composed of medium to coarse grains, with the sand dominance of the floor being illustrated through the 90/10 coarse/fine ratio.

The microstructure of this sand floor is described as compact bridged grain structure, the bridging material being the 10% fine residues that occur between the grains, bridging and holding the grains together.

The colour of the fine residues are summarised in Table 8.2.

The fine residues are organically derived being light and brown (PPL)/isotropic (XPL) fragments. Under high magnification the fragments are amorphous, and well decomposed, possibly representing peat fragments. There is no associated structure for the fragments and it is thought that they are naturally rather than anthropogenically derived.

The thin charcoal residue that overlies this sand floor is composed mainly of black (PPL)/isotropic (XPL) fine charcoal fragments. The abundance of these fragments is shown in Graph 8.2. These fragments have a dominantly cracked microstructure although some cellular structure is identifiable in a few of the fragments. Fragment size varies from <1 mm to 3 m diameter.

The boundary between this charcoal layer and the sand floor below is diffuse, the transition occurring over 1000 μm (Fitzpatrick 1984).

8.3.2 Charcoal layer

Sample 9158 was collected at the most easterly point of the transect, and is the only sample dominated by charred remains throughout its matrix. The sample is 7.5 cm in thickness (see Graph 8.1) with a mineral composition of 30%; the remaining 70% of the sample being charred material (c/f ratio 30/70), summarised in Table 8.1.

The mineral composition is quartz dominated, with varying contents of feldspar and carbonate grains. These are illustrated in summary Table 8.1. The mineral grains do not appear to have undergone rubification, and it is thought that these grains are representative of a quartz sand floor that was constructed prior to the collapse of the roof.

The black (PPL)/isotropic (XPL) charred remains (for abundance see Graph 8.2) in the samples are generally structureless with varying fragment sizes. These remains form a complex structure in the sample, with the fragments forming granules and chambers. The material does not appear to have been trampled.

The charcoal material also dominates (for abundance see Graph 8.2) Sample 9160 to the west of the structure, where two charcoal layers are identified within the thin section. These are separated by the presence of a coarse grained quartz sand.

The thickness of these layers is illustrated in Graph 8.1 Here it is seen that the middle layer is the thickest at 4cm, with the upper being 1 cm and the lower 2 cm thick.

For the expression of the mineral to charcoal content in each layer, the coarse/fine ratio descriptive criterion has been adopted. Even though the charcoal residues are coarse in occurrence, this ratio is thought to be the most appropriate criteria to use, as it efficiently allows the charcoal residue content in each layer to be estimated

The upper and lower layers of Sample 9160 have a greater content of charcoal remains (30/70), with the middle layer recording a dominance in sand grains (90/10).

In relation to these ratios, open porphyric related distribution is recorded for the layers with a greater fine material (layer 1 and 3 Sample 9160). These are described in Table 6.12, as defined by Bullock and co-workers (1985)

Microstructures of the layers are in accordance with the c/f related distribution and the presence of fine or charred material. The two charcoal dominated layers have complex structures, due to the charcoal forming chambers and granules within the black matrix.

The sand floor has a compact single grain microstructure, which is possibly evidence for compaction having taken place on the floor. There are no fine organic residues in this floor, only abundant fine charcoal fragments that have probably been translocated into the sand floor from the overlying charcoal layer. Water percolating through the material would be responsible for the translocation process.

The boundary between each of the floors is described as diffuse, indicating that the transition between floors occurs over 1000 μm (Fitzpatrick 1984). However, it is probable that this boundary has been altered by post-depositional processes, such as translocation of charcoal fragments and also compaction if the overlying floors have been trampled.

8.3.3 Post-burning floor

Sample 9159, 40 cm west of Sample 9158, is composed of two layers (for thickness see Graph 8.1), the lower is charcoal dominated, with the upper ash residue dominated.

The mineral to charcoal ratio in the lower layer is 30/70 with a coarse/fine ratio of 60/40 in the upper layer. This upper layer is composed of ash rather than charcoal, hence the use of the coarse/fine ratio rather than the coarse/charcoal ratio.

In Sample 9159 the upper layer is composed of grey-brown (PPL)/isotropic and crystallitic (XPL)/bright orange (OIL) dense ash residue. Within this matrix which forms the floor are abundant intact and fused phytoliths, although the fused phytoliths form grey (PPL)/isotropic (XPL) patches within the main grey-brown floor matrix.

The structure of this residue is massive, with no pores or cracks and appears to have been well compacted.

The boundary between this upper ahs layer and the lower charcoal layer is diffuse, occurring over an area of >1000 μm (Fitzpatrick 1984).

Chapter Nine

Discussion and Conclusions

The aim of this chapter is to discuss the findings that were apparent and common to each of the floors in the three settlement sites under consideration. The results have revealed that there are a number of microstructural characteristics of the floors that are dependant on the material used for the construction of that floor. A discussion into the mode of formation of the floors across the three settlement sites is then offered.

For ease of discussion, each of the characteristics will be discussed separately, with all of the settlement sites being discussed collectively where possible.

9.1 Composition of the floor matrices

The composition of the floor matrices has been shown to differ across all three of the settlement sites, with the floors in each of the structures within House 3 at Bostadh Beach being composed of either well humified peaty turf, machair turf, fire ash residues or beach derived sand. The chatracterictics of these floors is illustrated in Plates 1 to 15. Within Structure L of House 3, a variation in the type of material used according to a specific area within the house has been detected and this is described below. At Cladh Hallan, the individual floors that compose the field labelled contexts 595 and 655 are dominantly composed of quartz or shell sand, as illustrated in Plates 17 to 22, with fire ash residues derived from the burning of peaty turf or well-humified peat, the same practice as at Bostadh. The fine organic residues that were identified within the floors at Cladh Hallan are thought to have a natural origin, rather than an anthropogenic one, being the product of periodic episodes of soil formation on the sand dunes (Gilbertson *et al.,* 1996). However, the composing

materials of these floors is in stark contrast to the other two sites, especially Bostadh, as the organic material in the floors at Cladh Hallan is in the form of fragments rather than forming dense matrices.

The floors at Bornais were entirely different than those of the previous sites, as these floors were not deliberately formed for domestic purposes, but are thought to be formed from the collapse of the roof, with the deposits then being covered with beach sand and subsequently trampled. The deposits here are formed from charcoal and some ash residue.

9.1.1. Organic residues

As previously detailed in the results (Section 6.4), the greatest number of floors at Bostadh have been identified within the entrance to Structure L (Samples 178 A-C), where there is also a distinct variation in the material used for the lower two floors, compared to the remaining floors. The material used for the formation of these floors has been identified as two different types of organic material, notably well humified peat for the lower and upper sequences and machair turf for the middle three floors (11, 12 and 13/178). These organic residues for the floors of Sample 178 are illustrated in Plates 1 to 4.

Both the first and second floors of this structure showed different compositions than the remaining floors, as the first floor was composed of shell sand with little or no organic composition, whilst the second floor was composed of clean quartz sand. The origin of this quartz sand is discussed later in relation to the quartz sand floors that were identified at Cladh Hallan.

In the remaining floors (3 to 21), the constructional material used has been identified as peaty turf for the lower and upper sequences (see Plate 3), with three floors (11, 12 and 13/178) of machair turf in the middle of the sequence. The use of alternating types of peat for flooring was not identified elsewhere within the settlement sites, and is therefore unique to Structure L, House 3 at Bostadh Beach. The sequence of floors was seen to have a variable medium to coarse sand grain content, with the middle floors in the sequence recording both fine and medium to coarse sand grain

sizes, and at a higher presence than the lower and proceeding floors. Further, there is a clear divide in the colouration of the floors, where the upper and lower floor sequences recorded yellow or reddish brown colouration by naked eye, and variations in yellow (dark to light) under PPL. In these cases, colour is an indication of chemical change within the decaying plant tissues (Bullock *et al.*, 1985). Many living plant tissues are colourless, but in the early stages of decomposition of many of these tissues, pale yellow, brownish or sometimes reddish colours normally of high chroma appear (ibid.).

The floors in the upper and lower sequences at the entrance to the structure show similar characteristics with this colouration, and many of the coarse organic fragments within the floor layers are bright orange-red or reddish in colour. These fragments contain no cellular structure, and are possibly the phlobaphene and lignified tissues that are the most resistant parts of plants to decomposition (Fitzpatrick, 1984). The colouration of the different organic material types is also indicative of the environment in which they were formed. For example, the reddish colouration of the peaty turf material is a consequence of the low ferric iron (Fe^{3+}) reduction to ferrous iron (Fe^{2+}), which is an indication of poorly aerated soils (Brady, 1990).

The middle floors within the sequence, as stated earlier show a different composition than the other floors within the entrance area. As in the peaty turf floors, the material used in the formation of these middle three floors is unique to Structure L at Bostadh, and similar material has not been identified in the remaining two sites that were investigated.

The three floors not only differ in their organic composition, but also in the mineralogical composition. This could be a consequence of the organic material being derived from a different source than the other floors, or simply that more shell sand has naturally accumulated in the floors or had been trampled into the organic matrix over time. These three floors appear to be composed of a more minerogenic peat than the more decomposed peaty turf of the lower and upper floors. The structure of the organic material was also much more granular and not as densely compact as the other floors in this sequence.

Taking into account both the increased carbonate grain content relative to the other floors, and the different colouration of the organic matrix, it is postulated that the flooring material used in these three floors was derived from the shallow turf on the machair, rather than the turf from a surface of a peat deposit. These shallow calcareous brown earths have been discussed in Chapter 3.

This calcareous brown earth origin would also account for the strong colour differentiation from the yellow of a peaty turf. If the shallow turf material has been collected from the machair, characteristics revealed are a very low organic content, usually less than 10% and frequently less than 2%. This was evidenced through micromorphological examination, where the floor was found to have a higher mineral to organic ratio. Further characteristics of the machair turf are low phosphate, nitrate and potassium values, with a high pH (7.5 to 8.0) (Hudson, 1994). Estimates of shell fragments and hence the calcium carbonate content differ from one account to the other, although most authors agree that the carbonate content attains a maximum of 80 % (Boyd and Boyd, 1996). Due to the low organic content and the dominance of the coarse grained shell fragments, machair soils are subject to 'free percolation and aeration' (Boyd and Boyd, 1996). This free aeration accounts also for the low organic content, as microbial attack on plant residues is much faster given the freely available oxygen, hence the residues do not have the opportunity to accumulate as in the wetter, anaerobic peaty deposits. Ferric hydroxide and/or colloidal organic matter gives brown colours to the matrices and is common in a number of soils which have incorporated organic matter or are in a relatively early stage of weathering. Both of these substances are amorphous and cause the matrix to be isotropic when they are present in large amounts, singly or together (Fitzpatrick, 1983). The characteristics thus described for the calcareous brown earth's were largely identified within floors 11, 12 and 13/178, House 3 at Bostadh and it is unfortunate that bulk samples of these thin floor deposits could not have been taken for the physical and chemical analysis. However, given that these three thin floors were not identified in the field, due to forming three layers within what was thought to have been a single deposit, it would have been impossible to detect this short change in the material used for the floors.

There are a number of postulations that can be made regarding the second change in flooring material in this sequence of floors. It is possible that the machair turf was selected for its fine grained nature and possible finer matting effect over peaty turf. This change in flooring material was selected after eight peaty turf floors had been constructed and trampled. It is possible that the occupants of the house were experimenting with different flooring materials, in order to determine which was the most effective material to use for flooring. As the machair turf was only used for three floors, it is possible that this material was not deemed to be appropriate for flooring material in the entrance, or for any other area within the structure, hence the use of the peaty turf was reverted to.

Certainly the machair turf would have been drier when it was laid as a floor compared to the peaty turf that originated from a wetter environment. Owing to the machair turf being drier and with what appears to be a lower organic content in thin section, it was possibly more susceptible to compaction (as evidenced in Graph 6.3 for floors 11 to 13/178). Once dry, the turf would not have retained its structure compared to when damp or wet, and therefore would have been more susceptible to collapse. The peaty turf, due to its higher organic content, would possibly retain its structure for a greater length of time, and therefore required a lower level of maintenance or replacement than the machair turf. These factors could well have implications for the revision back to the use of the peaty material used in floors 3 to 11.

Together with the mineralogical differences between Bostadh Beach, on the Isle of Lewis and the two settlement sites on South Uist, there is also a difference between the sites regarding the organic composition of the floors. As previously discussed, the floors at Bostadh are composed from various forms of peat, or from ash residues formed from the combustion of peat. It was also discussed that the material used for the construction of the floors within House 3 at Bostadh varied according to the area within the house.

However, at Cladh Hallan a variation in the material used for the construction of the floors in the house does not occur, and the same material was used throughout Houses 401 and 640.

There is a notable difference in the type of organic material present in the floors between Bostadh Beach and Cladh Hallan, the derivation of the material at Bostadh has been previously discussed. However, at Cladh Hallan the floors are largely composed of sand with the organic residues present being a function of the area from which the sand was collected.

The derivation of these organic fragments (as illustrated in Plates 17 and 19) that are present in the floors of Contexts 595 and 655 at Cladh Hallan, has been postulated by Gilbertson *et al.*, (1996) in their research on the stratification of Holocene dune systems in the Uists. Here, two forms of organic materials were identified through the micromorphological analysis of the dune systems. The first form of materials occur in the zone of high stable machair, where there are 0.5 m thick layers of sand mixed with penecontemporaneous topsoil. The authors postulate that this topsoil will have blown onto the accumulating sand and been buried as the dune continues its formation, forming the organic residues that are present in the stratification of the machair today.

These organic residues also occur in the low machair systems that possess a characteristic vegetation of machair grassland. Within the machair stratification Schwenninger (1996) micromorphologically identified couplets of grey to brown shell sand and laminae of grey to black organic sand which he postulates was derived from this grassland vegetation.

The fine organic residues that have been identified within the floors of House 401 could have derived from either of these sources, and it is likely that the residues were transported into the floors at the same time as the sand. These organic sands might have been deliberately selected for use as a flooring material, due to the organic residues possibly providing a form of cohesiveness that rendered the sand more suitable for domestic purposes, as opposed to the coarser grained shell sand.

The possibility of the fine residues in the Cladh Hallan floors having been derived anthropogenically within the house remains difficult to ascertain. This is due to the residues being very well decomposed and with no preservation of cellular material, any plant identification is impossible through the microscope. Further, phytoliths or

diatoms are not identifiable due to the effect of organic masking, or simply that these siliceous particles were not formed within the material that has formed the residue. Therefore, due to the ubiquitous nature of the residue in all of the floors within the houses, it seems likely that the organic fragments were naturally derived, which together with the micromorphological evidence of Schwenninger (1996), appear to be an element of the landscape.

9.1.2. Mineral components

In comparison to House 3 at Bostadh Beach, the floors within Houses 640 and 401 at Cladh Hallan were formed of dominantly sand material, where carbonate grains sourced from the local beach or dune environment are present in low quantities, with quartz generally being the most dominant mineral. This dominance is shown in Plates 17 to 22, where quartz (white mineral grains) are seen to dominate the mineralogy. This is a possible indication that the shell sand immediate to the local environment of the settlement at Cladh Hallan was not the preferred flooring material.

Quartz sand is not abundant in the local environment around Cladh Hallan, and in the beach and dune or machair systems of the islands. Gilbertson *et al.*, (1996) have identified that the machair environments in the islands are formed predominantly of comminuted, white shell sands or conglomerates of well-rounded gneissose rocks, with or without a matrix of shell sand.

The presence of the quartz sand floor layers within Houses 401 and 640 at Cladh Hallan is similar to those identified by Schwenninger (1999) in his micromorphological analysis of two floors at Dun Vulan, South Uist. Here, he found that in these floors, the quartzose sand was present in a higher percentage in the absence of carbonate or gneiss grains. Schwenninger (1999) also postulated that the source of this quartz rich sand used in the formation of the floors at Dun Vulan was basal sands of aeolian origin that predate the widespread deposition of calcareous sand masses in the islands. This he identified during a stratigraphic survey of the Holocene coastal dune and machair sequences through the Uists.

Further, within the present dune systems around Cladh Hallan, Gilbertson *et al.,* (1996) identified Late-mid Holocene sand dunes, which may be upto 15 m thick and overlay beach conglomerates from previous shorelines. The mineralogy of these dunes was not identified, but it could be that the quartz sand used in the construction of the Cladh Hallan floors was sourced from these dunes. However, without further identification of the mineral components of these dunes it is difficult to ascertain this.

The presence of carbonate grains within these quartz dominated floors could be a result of a number of possible reasons.

The first and perhaps the most obvious is that the grains were deposited into the floors of the structure through movements into and out of the house. For example, carbonate grains would be easily carried into the house on the soles of the feet and shoes, as well as clinging onto other minerals and objects. A second possible explanation is the result of sand movements due to aeolian activities. The size of sand grains means that they are easily transported through saltation and other wind activities, and could easily be blown through the entrance or through cracks within the walls of the house.

As carbonate grains are not abundant in all of the floors at Cladh Hallan, their origin points to a more natural one than a deliberate incorporation of shell sand into the floors. Where carbonate grains are seen to dominate the mineralogy of the floors in the results tables, these are normally the lower or first floors in a sequence of floors. These deposits were incorporated as floor due to them representing the base onto which subsequent floors were constructed, and have in one form or another been trampled or used for domestic activity.

Further, carbonate dominated floors have been identified between field labelled Floors 595 and 655, and in fact possibly represent phases of abandonment between the use of the two floors, or they could represent levelling deposits between two successive floor constructions. However, their precise mode of formation remains speculative, as it is not possible to determine the deposits function or mode of deposition.

9.1.3. Fire ash residues

As revealed in the results, the second major component of the floors across all three settlement sites is ash residues, which are particularly evident within Structure L, J and H, House 3 at Bostadh, where sequences of floors were formed from this material. At Cladh Hallan ash residues were most abundant in the floor samples collected in the central areas of House 401, a similarity shared with House 3, Structure L at Bostadh Beach. At Bornais, ash residues were identified in the floor lying immediately above the collapsed burned roof layer, with the ashes thought to have been derived from the hearth within the structure, with the fuel used being well-humified peat.

At Bostadh, the same ash residue types were identified within sequences of floors within structures L (Sample 120), J (Sample 128) and H (Sample 133). However, the main difference between the samples and their associated structures and the floors that they form, is that the only stratified sequence of particular ash types was identified within Sample 120. The well-humified and peaty turf ashes that are characteristic of these floors are illustrated in Plates 13 to 15. In Samples 128 and 133, the ash residues forming the matrices of the floors were a combination of both peaty turf and well-humified peat ash (see Plates 6 to 12), whilst in Sample 120, the floors were composed of individual matrices of either peaty turves or well-humified peat ashes. This has particular assumptions regarding the formation of the floors and the possible use of the individual structures, which will be discussed further in this section.

The most extensive and significant sequence of floors has been identified within Sample 120, collected from the central area of Structure L, House 3 at Bostadh. These samples were collected approximately 20 cm east of the central hearth, thus perhaps the identification of these individual ash floors is as expected. Due to the similarity in the nature of the ash residues, i.e.: they are formed from the combustion of the same material type, in all three structures at Bostadh, the formation of the floors and the processes that have been undertaken for the presence and formation of the ashes within Sample 120 is discussed with direct relevance to the other ash

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residues that have been identified. The significance of the differences between samples and the floors in each structure at Bostadh is considered later.

However, the micromorphology has enabled the identification of floors that have been formed from the alternating use of well-humified peat and peaty turves in the hearth. The identification of individual floors and the material that composed these floors is particularly important, given that during the excavation the field assigned context (276) was associated with the floors at the entrance to the structure. However as revealed in the results, the contexts have been identified as being derived not only from different materials, but also consisting of a sequence of deposits.

The peaty turf floors are seen in Graph 6.6 to contain the higher abundances of charcoal fragments compared to the well-humified peat ashes. The most plausible explanation for the higher abundance here is that the peaty turf is composed of vegetation that has thicker or more woody stems. This vegetation has possibly not decopmosed or was living at the time of combustion and therefore these fragments were not fully combusted leaving behind partially reduced fragments as charcoal. The well-humified peats are the reverse of this, with the majority of the plant residues therein being well decomposed; thus all of the organic content in these samples is combusted, leaving behind very few reduced residues. This is also evidenced in the reference samples, as the peaty turves contain the higher abundance of charred residues over the well-humified material.

Alternatively, as evidenced by Boardman and Jones (1990) charred plant remains represent plants that have been subjected to low temperature burning or reducing conditions, generally between 200-400 ° C. This low burning temperature can be used to postulate the temperature at which the two fuel sources were burned, with the increased charcoal content in the peaty turves indicating a lower burning temperature than the well-humified peat.

The temperature at which each of the fuel types was combusted is also evident in the presence of grey (PPL), siliceous patches that are abundant, if not exclusive to the well-humified residues as opposed to the peaty turf residues. These grey patches contain fused and intact phytoliths, the fused phytoliths forming an opal, grass like

residue (Courty *et al.,* 1989). These phytoliths are indicative that the temperature of the fire must have been greater than 800 °C to allow the silica to melt (Matthews, 2001).

It is evident that alternating floors are different colours within the sequence of floors in Sample 120. These colours are further evidence for different fuel types causing these colour differences, and are also possible evidence for the use of the fuel for controlling the temperature of the fire. Grass ashes, as identified and described by Courty et al., (1989) are less homogenised and less grey than wood ashes for example, which is a result of the admixture of brownish (black to brown) charred grass residues. These brown to black residues are particularly abundant in the peaty turf residues.

It is also possible that the alternate layers of ash material could represent the use of the hearth for different purposes, with the well-humified peat being used for higher temperature fires and the peaty turves for low temperature fires. Th eresults produced by Boardman and Jones (1990) could also infer this alternating use of the hearth, although this also remains as postulation than an observation.

A further postulation for the alternate layering in Sample 120, Structure L at Bostadh, is that the ash residues are an indication of the use of peaty turf during the night time hours and the well-humified peat during the daylight hours as a fuel source for cooking and other high temperature activities. In ethnographic studies (Fenton, 1986) within the Outer Hebridean Islands, well-humified peat was the dominant fuel source used for cooking and other domestic activities, whilst peaty turf and fibrous upper peat is used if the fire was needed to be kept alight overnight.

As evidenced from the experimental hearths, the two types of peat burn differently, with the well-humified peat combusting quickly, a result of the well decomposed, easily combustible organic content. Whilst the peaty turf smouldered slowly, a by-product of the less well decomposed plant material. This is possible evidence for the use of well-decomposed peat to obtain high temperature fires, whilst the peaty turf could have been used to keep the fire alight, and to provide some warmth during the night. Also, as witnessed in the hearth experiments, less maintenance was required

for the peaty turf hearth in terms of the frequency at which fuel needed to be added, whilst the well-humified peat fire needed more frequent additions of fuel. Generally, peaty turves were only required after several hours of burning, whilst the well-humified hearths required a fresh addition of fuel every four hours.

However, if daytime and night-time activities are to be considered, then the 17 alternating layers of these ash residues are indicative that the hearth was used only 17 times. It is possible that these 17 layers are representative of 17 cleaning episodes of the hearth, and that ashes from subsequent cleaning episodes have been deposited elsewhere, either around the hearth, within another area of the house or outside the building. This is one of the limitations of micromorphology, in that the samples collected for analysis represent a specific point or area, and although information can be gleaned from that area, it is difficult to apply the results to other areas. If more samples had been taken from around the hearth, then it would have been easier to make postulations concerning the cleaning out of the hearth and to try to relate each layer to another. This would also have enabled further information concerning the formation of the ash floors to have been obtained, and to determine if other peat ashes had been used in the hearth, and then deposited elsewhere.

In terms of the accumulation of ash, it is unfortunate that the undergraduate student (Mitchell 1998) undertaking the hearth experiments did not record the amount of fuel put onto the fires. However the volumes of ash recorded after the burning episodes were 7 litres for well-humified peat and 3 litres for peaty turf (Mitchell 2000). These volume measurements take no account of compaction, so accurate differences are hard to quantify with the floors represented in the thin sections around the central hearth.

However it is obvious from the volume measurements and observation during the burning that peat and turf produced significant quantities of ash, with these hearths overflowing with ash at the end of 72 hours burning. This has a number of implications for Atlantic Scottish Archaeology. The large volume of ash that would have been produced from the continuous burning of peat fires creates a large amount

of material that can be curated throughout the settlement. The spread of ash would therefore be an important contributor to what is recognised as archaeological stratigraphy, trapping artefacts and ecofacts for recovery. Further, almost every later prehistoric domestic site in the Western Isles that has been excavated so far has significant ash components within the recorded stratigraphy.

The possible explanation for the use of well-humified peat and peaty turf over other fuel sources such as seaweed and straw that would have been found around the site is due to the nature of combustion of these materials. In the experimental hearths, seaweed and straw were used as fuels and on combustion were found to produced a lot of acrid unpleasant smoke. This feature of these materials thus renders them unsuitable for use within a domestic structure.

As previously stated, a sequence of ash derived floors were also identified within Structures J (Sample 128) and H (Sample 133). The ashes in these two samples share the same micrmomorphological characteristics as the ashes in Sample 120, and were probably derived from the same combustion activities as previously documented. A notable difference with these two sequences of floors is that the two ash types (peaty turves and well-humified peat) are mixed together, rather than occurring as distinctive, separate floors of a single ash type. However, the results indicate that in Sample 128 the peaty turf ashes are more dominant than well-humified peat ashes, which were largely identified as elongated patches of brownish-grey (PPL) or colourless residue within the brown (PPL) peaty turf matrix.

A particular feature of Sample 128 is the lower abundance of charcoal fragments in the floor matrices, compared to Samples 120, 133 and in floor 7/128 (see Plate 6), which is composed almost entirely of charcoal. There are a number of possibilities for the lower charcoal abundance in the floors of Sample 128, even though the floors are thought to have been derived from largely peaty-turf ashes. The first possibility is that the peaty turf used as the fuel in the fire, was totally combusted due to high temperature of burning, although this seems unlikely given that in the hearth experiments this fuel type smouldered rather than combusted. The second possibility

is that there was repeated burning of the ashes as the hearth was not cleared often, which would mean that the charcoal was repeatedly combusted and no longer identifiable.

A second notable feature in the floor sequence of Structure J is Floor 7 (see Plate 6), which is composed dominantly of a single charcoal layer. The insitu burning has been recognised by the lack of any fragmentation or break up of the charred layer, which would be expected had the material represented a 'dumping' of charred material.

There are a number of possibilities for the origin of this layer, the first and most obvious being that there has been a fir associated with the structure. Whether such a fire was deliberate or accidental is unknown, and for how long the fire lasted it is not possible to determine. Further, as the organic material that was the fuel source for this fire must have only smouldered rather than combusted at a high temperature, it is possible that a peaty turf material was used. However, it was not possible to determine the fuel type definitively, due to collapse of the material and also the lack of any phytolith evidence.

Although this charcoal layer has been identified it remains uncertain what the cause or effect of the fire has been. It is certain that the identification of the two ash floors overlying this floor did not discourage the use of the structure, and it is entirely possible that the fire was deliberately caused. Whether this was a cleaning act or to signify a new use of the structure remains at the interpretation of the archaeologist.

There is no associated hearth with Structure J, which indicates that the ash residues have been deposited in this structure from elsewhere. These ashes could have derived from the hearth in Structure H, as these two structures are thought to have had a longer history than the rest of House 3 (Neighbour, 1996). The history and construction of these structures has been discussed further in Chapter Two.

The charcoal layer in Structure J at Bostadh shares the same colour characteristic as the charcoal floor at Bornais, although the microstructure differs between the two features. However, the mode of formation of the two floors is different, with the

Bostadh floor possibly having been formed from the insitu burning of material and the Bornais floor representing roof collapse that was subsequently covered and used as a floor. These differing modes of formation for the floors would possibly account for the microstructural differences, although the colour similarity has been discussed previously in accordance with Boardman and Jones (1990).

As previously stated, there is comparison between the sites of Bostadh and Cladh Hallan and the floors within the central areas of the houses at these sites. At Bostadh, apart from at the entrance to the house, the greatest sequence of individual floors was identified in the central area. This was also found to be the case at Cladh Hallan, where as the results indicate, within samples 4848, 4894 and 4872 of context 655, three individual floors, one of which is composed of ash residues, were identified within each thin section. The upper and lower floors of each sample were formed from the naturally derived organic residues discussed earlier, although the middle floors (Floor 2) in each sample was derived from peaty turf ash. The ashes are not mixed with any other form of material, and possibly represent a single burning episode within the hearth which lies close to the source of the sample. It would appear that the ash has been used for the formation of a floor rather than a gradual accumulation of residues from the hearth.

This identification of only one ash layer in the floors around the central hearth could be indicative that the hearth was well maintained and cleaned of ash on a regular basis. However, in the floors above and below the ash floor there is no indication of any other ash residues. The presence of these would be expected, as ash would inevitably been blown from the hearth or ash residues spilled over from the hearth during cleaning or burning. The presence of charcoal fragments in the floors below the ash floor in each of the samples indicate that the hearth must have been used prior to the deposition of the middle floor.

In a similar vain to Context 655, six ash derived floors were identified within sample 4847, which are illustrated in Plates 20 and 21, showing the ash residues of floors 3 and 4, collected from the central area of Context 595 in House 401. These floors were different than the floors identified within the three samples of Context 655, as the six floors in Context 595 revealed a pattern of peaty turf ashes in floors 1, 3, 4,

and 6, with a combination of both peaty turf and well humified peat ashes in floors 2 and 5. The mixing of these two ash types shows similarity with the floors within Structures J and H at Bostadh Beach, although the floors at Bostadh are thicker than the floors at Cladh Hallan.

9.1.4. Phytolths and Diatoms as indictors of floor materials

Both phytoliths and diatoms feature in the organic and ash residue matrices from which the floors at Bostadh (Samples 120, 178, 128 and 133) and in the central, ash derived floors of contexts 655 and 595 at Cladh Hallan. The phytoliths and diatoms provide an insight into the origin of the materials used for either floor construction or as a fuel, and both feature in the matrices together.

Phytoliths are microscopic silica particles that form in and around the individual cells of some plant species (Powers *et al.*, 1989), whilst diatoms are one celled plants belonging to the plant class Bacilariophyceae of the division or phylum Bacilariophyta (Batarbee, 1986).

Diatoms are distributed throughout the world in aquatic, semi-aquatic and moist habitats. They are found in the sea, estuaries, freshwater lakes, ponds, streams and ditches. More rigorous habitats such as moist rocks or soils sometimes support lush growths of diatoms (Batarbee, 1986). The presence of diatoms in the peat derived floors at the entrance to Structure L, House 3 at Bostadh, has identified that the peaty turf was likely to have originated from a marshy area, and the peaty turf's used as a fuel were possibly derived from the same environment.

The identification of phytoliths has further aided in the identification of peat as a floor and fuel source at Bostadh, and as a fuel source for the ash derived material at Cladh Hallan. No phytolithic evidence was identified in the ash residues at Bornais. However, in this thesis, the evidence for phytoliths has mainly occurred in the peat ash residues, where phytoliths are fused, or where identified in tact, are difficult to distinguish. However, the peaty turf used in the entrance to Structure L is abundant with these siliceous particles, which have derived from the decay of the grass and other vegetation which would have formed the peat.

In comparison with the abundant phytoliths in the peaty turf material used at the entrance to Structure L at Bostadh (see Plate 5), the proposed machair turf floors in the same sequence, did not reveal any phytoliths. These results are in accordance with Powers *et al.*, (1989) who state that as the sand dune and machair vegetation decays, the phytoliths either do not enter the sediments, or do enter the sediments but are not preserved. This phenomenon to date remains unexplained, although this author suspects that because the sand matrix is well aerated, the organic residues in a sand environment are rapidly broken down. The phytoliths are then devoid of an organic matrix and it could be that the phytoliths are simply washed away when freely draining water filters through the sand.

As well as occurring in the peaty turf at the entrance to Structure L at Bostadh, these same morphotypes have also been identified in the peat ash residues in other floors of House 3, namely samples 120, 128 and 133. The phytoliths have occurred in patches within a dominant ash matrix, with the phytolith patches appearing as grey, isotropic material. In the majority of cases, the phytoliths are unidentifiable due to being fused and forming this glassy appearance (Courty *et al*, 1989). These same grey patches were also identified in ash derived floors within the central areas of House 401 at Cladh Hallan, and it is possible that the ash is derived from the burning of the same fuel type.

Even though the majority of phytoliths in the ash residues have not been identifiable, their presence has been useful in determining the type of fuel used for burning at both settlement sites, as well as providing useful information regarding the type of peat used for flooring at Bostadh. The use of phytoliths to determine the uses of peat and other materials has been successfully used elsewhere in the Hebrides. Smith (1996) was able to determine the use of straw as thatch which had collapsed forming the upper floor levels in a barn from lower floors which had been constructed from windblown sands and unvegetated deposits.

A similar method could also have been used at Bornais, which would have enabled the identification of the material used for roofing before the roof had caught fire and collapsed. However, due to the floor identified within the sample being charcoal, no

phytoliths were identified, possibly a result of masking of the phytoliths by the black colouration.

Although this thesis has not been concerned with the analysis of phytoliths, their usefulness in the determination and identification of different materials composing floors has been proved in this research. It is therefore foreseeable that their incorporation into future sampling strategies should be employed, especially in respect to identifying different components and construction materials within floors.

9.2. Microstructural characteristics of the floor components

As identified in the microstructure tables (6.1 to 8. 2), the microstructure for each of the different materials that have been used for the formation of the floors differs. Each of these materials will be discussed separately and in the same sequence as section 9.1.

9.2.1. Organic derived matrices

As the results indicate, only in Structure L, House 3 at Bostadh Beach were floors formed from the deposition of a two specific organic materials. This being at the entrance of the structure, where well humified peat and peaty turves were identified as flooring materials in Sample 178.

In terms of microstructural characteristics, both these resources used for the construction of the floors showed a dominantly massive structure (illustrated in Plates 1 to 4), with 14 of the 21 floors recording this structural type, as indicated in Tables 6.3 A and B. Therefore, there is no apparent difference between the microstructural characteristic of these two materials when used as flooring materials, and there appears to be no difference in effect of the peaty turves, which are thought to have derived from the turf line of shallow machair soils, recording a higher mineral content.

Given that the natural peat sequences, as inferred from the reference samples of peat, record a massive microstructure (illustrates in Plates 26, 27 and 28), then it is

perhaps expected that the floors would also record this microstructure type, especially since the floors will have undergone some compaction. The micromorphology of these floors has therefore indicated that the microstructure of peat does not change, and that the material becomes more dense and compacted with the increased compaction forces.

Unfortunately the original thickness of the peat used for the floors remains unknown, and therefore the determination of the amount of compaction through the reduction of this thickness will also remain unknown. However, the identification of horizontal decomposed plant residues and orientation of phytoliths and diatoms within the organic matrix (see Plate 2) of the peat have provided some insight into evidence for the detection of the compaction of floors.

Single grain microstructures were identified in floors 1 and 2, which were dominantly composed of sand (90%), and in two microlamminations of sand 1.5 cm and 0.8 cm thick (floors 15 and 17/178). The microstructure of these floors is not discussed here, as this is entered into in section 9.2.2.

9.2.2. Sand derived matrices

There is a distinct divide, as illustrated in the results, between the number of sand derived floors in the sites, with Cladh Hallan proving to record the most number of this floor type.

The dominant microstructure type at Cladh Hallan was compact single grained (illustrated in Plate 17), with both quartz derived and shell sand derived floors recording this microstructure. This was also reflected in the quartz and shell derived floors at Bostadh and Bornais, however a notable exception between the floors at Cladh Hallan and both Bostadh and Bornais, is that at Cladh Hallan, the sand floors have a fine organic component that is different than the remaining two sites. The evidence of these fine organic components was discussed in section 9.1.1, and a photomicrograph of the fine residues can be seen in Plate 19.

It would appear that the presence of the fine organic components in the Cladh Hallan has little effect on the microstructure, as evidenced in the single grain microstructure being recorded in the sand floors across the sites. However, the presence of compaction was determined from the comparison with samples collected from natural dune sequences with those collected from the floor deposits.

Micromorphological analysis has determined that in the floor samples across all of the sites, the mineral grains lie in closer proximity to each other and with a lower pore space than the naturally derived sand samples. It is possible that this was caused not only by compaction, but also where the fine residues are present in the floor, these act to bind and hold the mineral grains together, thereby reducing the loosening of the grains when compaction subsides. As the compact grain structure is not naturally derived, then this must have been formed from anthropogenic activity.

9.2.3. Ash derived matrices

As revealed in the results (Chapter 6), the floor sequences of Structures H, J and Sample 120, Structure L, at Bostadh were all constructed from the deposition of fire hearth residues. This was also the case in the central floor samples of both contexts 595 and 655, House 401 at Cladh Hallan.

At Bostadh, the results have shown that fire hearth residues record either chamber or massive microstructures, with some horizontal planar voids and cracks also being identified (Plates 6 to 15). The massive microstructure is possibly a result of the frequency that a floor was used or the depth of the floor in a particular sequence. For example in Structure J at Bostadh, the floors were found to be dominated by both chambers and horizontal cracks, forming a complex microstructure, whilst the upper three floors have a massive microstructure.

However, the occurrence of the chamber microstructure in all five floors of Structure H and Sample 120 at Bostadh, illustrate that the chamber microstructure can develop regardless of the floor position within the sequence.

On this basis, the more likely explanation for the formation of a massive microstructure could be either that the ash has been compacted for a longer period of time. Therefore more structure of the organic components lost, rendering the floor more susceptible to compaction. Alternatively, it could be assumed that the floors have been compacted over a long period of time and compacted more frequently, with the chamber microstructure representing floors that have undergone a lower frequency of compaction.

At Cladh Hallan and as revealed in the results, the ash residues are not in the same abundance within the floors of Houses 401 and 640 at Cladh Hallan, when compared to House Three at Bostadh Beach.

As previously discussed, the floors at Cladh Hallan are mineral grain dominated, with ash residues generally being present at 20-40% contents. This in turn affects the microstructure of the floors, where at Cladh Hallan, the dominant microstructure recorded is bridged grain, identified in samples 4873/595, 4848/655, 4963/655 and 4965/655. Also as revealed in Tables 7.3A, B and 7.7A and B, the bridged grain microstructure was more common in the well-humified peat ash derived floors, with compact grain being the dominant in peaty turf ash floors.

These microstructures are in comparison with chamber and massive microstructures that dominated the ash derived floors at Bostadh Beach. This is possibly a consequence of both the higher mineral content in the floors at Cladh Hallan, but also of the thickness of the floors. Due to the floors at Cladh Hallan being thinner, it is possible that upon impact from trampling for example, that the ash material did not compact as a thicker deposit would. Hence, there is more room for the material to disagrgate and not compress as a thicker floor would, meaning that the structure of the material would remain quite loose, and form the bridged grain microstructure as evidenced in these floors.

9.3. Conclusions

This section critically reviews the research findings and provides a discussion of the contribution and limitations of this research. It focuses on the problem of floor recognition, and takes into account interpretations put forward by archaeologists. It also considers the analysis of structures and settlements. The data presented in this thesis are the result of the first systematic study of archaeological floors to have been documented in the British Isles.

The overall aims of the research were to highlight the significance and importance of microscale analysis of floors initially recognised by conventional archaeological means during excavation. This was to be achieved by determining the composition, formation and possible uses of floors within houses. Finally, the intention was to establish microstructural criteria and characterisation of different materials for the construction of these floors.

In order to achieve these aims, three archaeological settlement sites in the Outer Hebridean Islands were selected for analysis. One, Bostadh Beach, had been fully excavated and selectively sampled prior to the start of this research, whilst the remaining two sites, Cladh Hallan and Bornais, were excavated and sampled during the later stages of the PhD.

9.3.1 The Micromorphological approach to archaeological problems

It is hoped that the data contained within this thesis will further strengthen the use of micromorphology in tackling archaeological problems. As was detailed in section 1.1.2, the application of micromorphology to archaeological investigation was first undertaken in the 1950's (Cornwall, 1953). In this pioneering phase, micromorphology was used to investigate buried soils. Since this period, the application of micromorphology to archaeological analysis has expanded greatly, and the wealth of knowledge derived from analysis at the microscale level through using this technique continues to grow.

Since the initial period of investigation in the 1950's, micromorphology has been used extensively in archaeology to investigate a wide range of problems and questions that have arisen during archaeological excavation. Many of these are unanswerable at the macroscale level of investigation, particularly those concerning the specific formation and composition of individual contexts.

At all three research sites, micromorphological analysis was used to investigate the composition and formation of the floors located in the excavated domestic structures. The questions posed during excavation would still be unanswered and any response would have been speculative if micromorphological analysis had not been undertaken. The composition of the floors could only be surmised from macroscopic inspection at the time of excavation: for instance at Bostadh beach, the floors at the entrance to House 3, Structure L, were postulated to have been composed of hearth material (Neighbour, 1996). The results of micromorphological examination have shown that this was not the case, with the individual floors in this area having been formed through the deposition of varying types of peat, notably alternating layers of well-humified peat and peaty turfs. If this form of microscale analysis had not been undertaken on these deposits, then the wealth of information that has been shown in the results could have been easily missed.

The success of this microscale analysis in answering archaeological problems and refining on-site observations has been particularly well documented in this thesis through the identification of individual floors within single contexts at all of the settlement sites. For example, in instances where a deposit has been assigned to a single context during excavation, micromorphology has determined that the context is composed of a stratified sequence of floors. This has been particularly important at Bostadh Beach, where within different sectors of the house up to 21 individual floors have been identified. At Cladh Hallan and Bornais, analysis has also been particularly successful in the identification of multiple floor sequences, where up to 6 individual floors were identified within House 401 at Cladh Hallan. During excavation, these floors were thought to have formed only a single context consisting

of wind blown sand, and therefore the microscale analysis has provided information not only on the number of floors present, but also that the single context contains more information than was originally thought.

The application of micromorphology to the analysis and interpretation of domestic dwellings has been most extensively documented in Near-Eastern archaeology. Here Matthews (1995, 1996, 2001) and Matthews *et al.,* 1996, 1997 and 1998) have demonstrated the suitability and successful use of micromorphology for the analysis of floor levels within domestic structures. The research undertaken in this thesis is in a similar vein to that of Matthews, although the environment in which the application was made is strikingly different. The Near-Eastern sites of Cataloyuk, Turkey and sites in Syria and Iraq in which Matthews has applied the technique, are in stark contrast to the higher latitude coastal environment of the three sites in this thesis. The sites on which Matthews has worked and is currently working are located in dry, dusty environments, and the buildings there are totally different in character from the subterranean buildings studied in the Hebrides.

However, despite these differences, the suitability of the technique and the results obtained from the micromorphological analysis are similar. At Cataloyuk, Turkey, Matthews *et al.,* (1997) identified 160 individual layers of plaster, which represented separate cleaning episodes of the floor within a structure, in a 3-cm thick deposit. This has similarities to the 21 individual floors which, as stated earlier, were identified within the 24 cm deposit of Structure L at Bostadh. The microstructural characteristics of plasters and floor levels that have been developed by Matthews' Near-Eastern work therefore have little direct relevance, although both sets of evidence imply that floor deposits can consist of evidence for far more episodes of activity than archaeologists would generally recognise.

The main explanation for the microstructural difference is the nature of the materials that have been used for the construction of the floors. In the Near-Eastern sites, the floor levels are usually constructed from micro-laminations of plaster. Matthews *et al.,* (1997), and Matthews (2001) states that these plasters are usually formed from

the mixing of silty clays which have been obtained from around the settlements. This was noted particularly at Cataloyuk. The sites considered in this thesis are located in sandy, machair environments within a geographical location which has an Atlantic climate. Therefore, there is a stark contrast between the environments surrounding the settlement sites. The results of the Hebridean work have revealed that the materials used in the construction of the floors is site dependant. For example, at Bostadh Beach, the materials used within Structure L depend on the position of that floor within the structure. At the entrance, the 21 individual floors were formed from alternating layers of well-humified peat and peaty turfs (Sample 178 A to C), which compares with 17 individual floors derived from the fire hearth material within the floor at the centre of the house (Sample 120 1 to 3). The microstructural characteristics of the fire hearth material within Structures H and J at Bostadh have been shown to be the same as those encountered in the floors found centrally in of Structure L. In turn, the microstructural characteristics of the fire hearth residues has been shown to be different, not only at this site, but with the descriptors that have been postulated by Matthews.

The identification of fire hearth material, particularly in the floors identified within the central area of Structure L, House 3 at Bostadh Beach, together with the ash material identified through various thin sections at Cladh Hallan, offer a contrast to the results obtained by Carter (1998). His paper was concerned with the use of peat and other organic sediments as fuel in Northern Scotland: his identifications were derived from soil thin sections. To date, this is the only contribution that describes the characteristics of burned materials in thin section, such as colour of ashes and form of charcoal fragments. However, the paper does not document the microstructural characteristics of the materials represented in the thin sections.

Carter (1998) states that most of the waste produced by burning under normal conditions will be oxidised, so that fuel residues should be dominated by ash rather than carbonised fuel. This was revealed not to be the case in all of the floors examined for this thesis. At both Cladh Hallan and Bornais, the floors were revealed to be composed predominantly of carbonised organic remains, with ash residue

largely absent. It would be expected that, given the high presence of carbonised remains in these floors, some ash remains would have been identified. Therefore, it would appear that Carter's assumption is incorrect and that oxidised materials can also dominantly consist of carbonised remains.

There was also a high carbonised fragment content in the floors of the central area of House 3 at Bostadh Beach. These results would also suggest that Carter's view is not incontrovertible and that the prevalence of ash or carbonised residue will be strongly influenced by the immediate environment in which the residue has been preserved and is also dependent on the type of material in which the ash or carbonised residue has been found.

Carter also states that the identification of fuel residues depends largely on the analysis of the components of the ash, rather than the fabric or microstructure of the material. This author disputes this, as some microstructural correlation is important, given that the subsequently different materials used for fuel will have different microstructures once burned, even if they are undisturbed after deposition. However, Carter does state that analysis of the microstructure will be relevant to an understanding of the formation of the sediment that contains the fuel residues. This perspective was particularly noted in this thesis, and useful comparison between the microstructure of the experimental hearth material and that of the ash in the floors enabled the identification of compaction.

Despite these differences in approach and interpretation between Carter's results and those in this thesis, there were some similarities between the mineral ash and carbonised remains within the floors that were examined. Carter (1998) states that mineral components in ash may include both mineral and biogenic silica (phytoliths and diatoms) and these were indeed identified in many of the ash residues of the floors, mainly in a fused condition and thus unidentifiable to species. The carbonised organic components identified in the floors, mainly at Cladh Hallan and Bornais, as well as at Bostadh, included plant tissues (stems, roots, fungal spores), which also fitted with Carter's interpretations.

9.3.2 Micromorphology and analysis of floors in Scottish archaeology: earlier work

The research encompassed within this thesis was the first detailed application of micromorphological analysis to floor levels in Scottish archaeology. A previous attempt at using the technique was undertaken by Schwenninger (1999) at the site of Dun Vulan, South Uist. However this attempt was not particularly successful, as the use of micromorphology for the identification and interpretation of the floors at the site had not fully been considered in the fieldwork stage. Due to this, insufficient samples were collected from the stratigraphy or the floor space within the structure, which in turn hindered the detailed analysis of the deposits. A similar problem was encountered at Bostadh Beach, although comparative material from Cladh Hallan and Bornais was obtained, in order to widen the investigation and to provide comparative data sets.

Even though floor levels were recognised through thin section analysis, Schwenninger (1999) made no attempt to characterise the floors that were recognised, and he based his conclusions that the floors had been anthropogenically formed on the presence of charcoal and bone fragments. There was very little attempt made at characterising the floors in terms of microstructure, nor were any hypotheses advanced concerning the formation processes or uses of the floors. The result being a lack of identifiable characteristics for compaction of sand based floors, which has made it difficult to employ these results as a direct comparison for the results collected from a similar environment in this thesis.

When this thesis was in preparation, the Dun Vulan floors were the only ones to have been documented by micromorphological analysis in Scotland. However, despite the similarity of the geographical location to that of the sites in this thesis, there was very little comparison that could be made between the floors at Dun Vulan, and those that had been identified at Bostadh, Cladh Hallan and Bornais. The analysis of the floors

by Schwenninger (1999) was essentially undertaken from a pedological viewpoint, rather than from an archaeological perspective, and this affected the nature of the interpretation and the comparisons that could be made.

Despite the research that has been undertaken for this thesis, and that of Schwenninger (1999) the application of micromorphology in Hebridean archaeology is still in its infancy. Elsewhere in Scotland, micromorphology has been used extensively for archaeological analysis, particularly in the Northern Isles (Simpson 1993, 1994, 1995, 1997; Simpson and Barrett, 1996; Simpson *et al.*, 1997, 1998a, 1998b, 1999), the application in this region however, had a different context than my application in the Western Isles, as the research in Orkney has been concentrated on plaggen soils and the recreation of the landscape during the period between the Bronze Age to more recent times. There is no reason why similar research could not be undertaken in the Western Isles, as there is a long history of plaggen manuring in the islands, in order to strengthen the machair soils for agricultural purposes. In a similar vein, there has been little documentation and analysis of floor levels to date in the Northern Isles, and therefore micromorphology could be used to investigate floors in future excavations of this area.

9.3.3 Future research

If thorough analysis of floor deposits in future excavations is to occur, then this author recommends that more intensive sampling strategies are employed when micromorphological analysis is to be used. The sampling strategy at Bostadh was not particularly successful for the complete interpretation of the floors throughout House 3, although the samples obtained enabled the identification of floor levels and also provided the micromorphological characteristics of floors constructed from peat and fire ash to be determined.

If in retrospect, a more rigorous sampling strategy had been employed at this site, as at Cladh Hallan, then much more information regarding the use of the structure could have been obtained. However, even though a rigorous strategy was employed at

Cladh Hallan, areas within the floor were still omitted, and this author believes that samples should be taken at regular intervals and be representative of the whole floor. For example, at Cladh Hallan, House 401, distinctive sectors within the building that were identified in the field were not examined in thin section, probably as a result of the samples being collected too far apart from each other; hence the distinctive areas were missed. Also, because the samples were collected along two horizontal lines through the structure, activities that occurred obliquely to this pattern may have been missed.

However, this will probably always remain a problem as the use of micromorphology as a tool in any analysis remains expensive and research into reducing production costs and time required for thin section manufacture should be undertaken. Mooney *et al.* (1998) have attempted to shorten the time that is required for thin section production, however, the authors detected that the actual soil sample began to peel away from the glass plate quite rapidly after production of the section, usually three months after bonding. Therefore, the more rapid method of production attempted by them appears to be less promising than originally thought, and particularly with regard to archaeological thin sections, which are archived and pose possible use in future analyses.

Sampling important stratification both spatially in the horizontal plane as well as vertically could represent a way forward. To date, this has not been documented if it has been attempted, such detailed sampling and analysis ought to provide a greater insight into microstructural relationships of floors.

In future excavations, particularly where floors are thought to be present, the use of a penetrometer in the field to guide the application of micromorphology might be employed to provide quantified data on the likelihood of a compacted surface. A penetrometer is a pointed steel rod with a gauge that records the pressure needed to penetrate the soil. It provides specific readings that are used to determine the degree of compaction and is an easily transferable technique and piece of equipment for use

in archaeology. The instrument is also very simple and rapid to use, permitting many results to be obtained in a short period of time.

For this approach to be successful, control samples would be needed. These could be determined by testing materials from the surrounding landscape. For example at the three sites in this thesis, the materials used in the construction of the floors were obtained from the immediate environment. The resistance to penetration down a profile of peat could have easily been determined, as has been successfully undertaken at Guinnerso, Isle of Lewis (Haston 1999). This technique could also be repeated to measure the resistivity of the beach and dune sand, although the resistivity to these materials is probably very low and hardly recordable. However, the difference between loosely arranged beach sand and compact sand, and a natural peat with an apparently compacted peat identified during excavation, could indicate whether compaction through anthropogenic or other activities has occurred.

More floors need to be sampled during excavation to enable more widespread comparison between materials and also to provide reference material. This author has collected samples from excavations undertaken on a range of sites in the Outer Hebrides, but there remains a lack of samples for other geographic areas in Scotland, where the materials used for flooring will very probably be different. In addition, there needs to be a greater range of reference samples available for micromorpholgists or a data base of workers' materials available that would enable direct comparisons of identified materials to be made. The easiest and most accessible format for this database could be a site on the internet, with each worker scanning the thin sections into a database, and providing a brief summary of the key features of the thin section together with a background of where the sample was collected and the interpretation of the features that the thin section contains.

The application of image analysis is currently still in its infancy with regard to archaeological contexts, although it is anticipated that the research currently being undertake at the University of Stirling will alleviate some of the problems. However, if the application of this technique is to be successful, then it needs to be applied to a

wide range of context types and archaeological situations, along with the greater application of micromorphological analysis.

Finally, it would be very helpful if all current researchers involved in applying micromorphology to archaeological analysis could form a database of the thin sections which they have worked on. This would be particularly helpful when an object is difficult to identify and would enable comparisons to be made between objects and features of materials.

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Appendix One: Index to Soil micromorphological descriptions of individual floors

House Three, Structure L:

House Three, Structure H:

Sample 133

House Three: Structure J:

Sample 128

Appendix One

Thin section Descriptions: Bostadh Beach, Isle of Lewis

House 3: Structure L

Sample 160.

Floor 1

Coarse fraction:

Carbonate (shell sand)
50% carbonate grains, 20% quartz grains, feldspar 10%, gneiss and hornblende 10% each. Perfectly sorted grains. Sub angular to sub-rounded. Loosely arranged. Medium to coarse sand sized.

Fine fabric:

None present.

Coarse organic residue:

None present.

Fine organic:

20% black (PPL)/isotropic (XPL) charred fragments. Dominant size <1 mm, randomly arranged in the sand matrix (between grains). Fragments have some cellular structure or are structureless.

Groundmass:

C/f ratio: 100/0
C/f related distribution: Monic
Fabric of coarse material: Random.

Microstructure:

Single grain

Pedofeatures:

2% 10-20 μm thick partial organic coatings around grains.

Floor 2

Coarse Fraction:

Quartz dominant 50%, feldspar 10%, hornblende 20%, carbonate 10%, gneiss 10%. Well sorted, fine to medium sized grains, with some coarse quartz grains. Loosely arranged within the organic matrix.

Fine fabric:

Dark reddish brown (PPL)/isotropic (XPL and OIL).Well decomposed, some cracks in the organic matrix.

Coarse organic residues:
None present.

Fine organic residues:

10% black (PPL)/isotropic (XPL) fine charcoal fragments (<1 mm). Embedded within organic matrix. Largely structureless.

Groundmass:

C/f ratio: 20/80
C/f related distribution: Open porphyric
Arrangement of coarse material: Random.

Microstructure:

Crack

Pedofeatures:
none present.

Floor 3

Coarse components:

Quartz sand.
Quartz 50%, feldspar 20%, carbonate 10%, gneiss 10%, hornblende 10%. Moderately sorted, medium to coarse grains. Loosely arranged. Sub angular to rounded.

Fine fabric:

20% well-humified peat ash residues. Dark and light brown (PPL)/isotropic and crystallitic (XPL)/dull orange (OIL). Fine minerals are calcite and quartz derived.

Coarse organic:

4 large fragments Black (PPL) charred fragments (2-4 mm diameter) within ash residue, randomly distributed. Larger fragments show some cellular structure.

Fine organic:

10% black (PPL)/isotropic (XPL) charcoal fragments, randomly distributed in the ash residue and between grains. Dominantly structureless.

Inorganic residues:

15% fused Phytolith and diatom patches. Grey (PPL)/isotropic (XPL). Some phytoliths still evident. Occur within ash residues.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Gefuric
Fabric of coarse material: random

Microstructure:

Intergrain microaggregate where ash lies between grains, otherwise compact grain.

Pedofeatures:

2% grains with brown coatings on grains, 10 μm thick. Result of ash residue in the sand matrix.

Floor 4

Coarse components:

Shell sand.
50% carbonate grains, quartz 20%, feldspar 10%, gneiss 10%, hornblende 10%. Well to perfect sorting. Medium to coarse grained sand, grains close together. Sub angular to sub rounded grains, randomly arranged.

Fine fabric:

10% dark brown (PPL)/isotropic and crystallitic (XPL) fragments. Occur between the grains and hold the grains together. Well decomposed organo-mineral material.

Coarse organic components:

40% charcoal fragments, upto 5 mm diameter, cellular structure visible. Randomly arranged between grains.

Fine organic:

Black charcoal grains, as a % of the coarse grains. Randomly distributed in the sand floor.

Groundmass:

C/f ratio: 90/10
C/f related distribution: gefuric
Arrangement of coarse material: random.

Microstructure:

Compact grain dominant in layer. Some areas of single grain.

Pedofeatures:
None

Floor 5

Coarse components:

Shell sand.
50% carbonate grains, 20% quartz, 20% feldspar, 5% gneiss and hornblende.
Single mineral grains, medium to coarse grains, well to perfectly sorted. Randomly arranged. Sub-angular to sub-rounded grains.

Fine fabric:

10% dark brown (PPL)/isotropic and crystallitic (XPL). Occurs as fragments between and around the grains. Well decomposed organo-mineral material.

Coarse organic:

10% Black (PPL)/Isotropic (XPL) charred grains, dominantly 1-3 mm diameter. Structureless and randomly arranged between the grains.

Fine organicmaterial:

None present.

Groundmass:

C/f ratio: 90/10
C/f related distribution: gefuric
Arrangement of coarse material: random

Microstructure:

Compact grain.

Pedofeatures:
2% 10-20 μm partial coatings of organic material on grains.

Sample 178: Entrance to the Structure

Floor 1

Coarse components:

Shell sand
50% carbonate grains, 20% quartz, 10% feldspar, 10% hornblende and gneiss. Well to perfectly sorted, sub angular and sub rounded, medium to coarse sand. Loosely arranged grains.

Fine fraction:

10% Brown (PPL)/dark brown and undifferentiated (XPL), well decomposed organic fragments.

Coarse organic:

10% black (PPL)/isotropic (XPL) charred fragments, randomly distributed between sand grains. Structureless and occur upto c. 3 mm diameter.

Fine organic:

< 1mm diameter charred fragments, randomly distributed throughout the floor. Occur between grains, black (PPL)/isotropic (XPL).

Groundmass:

C/f ratio: 90/10
C/F related distribution: dominantly monic with gefuric where fine residue is identified.
Arrangement of fine material: random

Microstructure:
Single grain, loosely arranged minerals.

Pedofeatures:

Thin 2-4 µm coatings of brown material around grains. Approx. 5% presence.

Floor 2

Coarse components:

Quartz sand
50% quartz grains, 30% feldspar, no carbonate grains. Well to perfect sorting, sub angular to rounded grains, loosely arranged. Dominantly medium sized grains with occasional coarse quartz grains.

Fine fabric:

10% brown (PPL)/isotropic and undifferentiated (XPL), well decomposed patches of material between the grains. Organic composition.

Coarse organic:

40% black (PPL)/isotropic (XPL) charred fragments, upto c. 2mm diameter, randomly arranged through the floor. Some cellular structures visible within fragments.

Fine organic:

Black (PPL)/isotropic (XPL) charcoal fragments throughout the floor. Random occurrence.

Groundmass:

C/f ratio: 90/10
C/f related distribution: Monic
Arrangement of coarse material: random

Microstructure:

Single grain. Loosely arranged.

Floor 3

Coarse fraction:

Quartz sand
50% quartz grains, 30% feldspar, hornblende 10%, gneiss 10%. Poorly sorted grains embedded within organic matrix. Sub angular to sub-rounded grains, medium to coarse sized, coarse grains dominantly quartzose.

Fine fabric:

Dominant dark yellow (PPL)/isotropic (XPL), well decomposed organic material. No cellular structure visible, forms dense patches and also fragments.. Undifferentiated b-fabric.

Coarse organic:

20% black (PPL)/isotropic (XPL) charred fragments randomly embedded within organic matrix. Some cellular structure still visible in fragments. Upto c. 4mm diameter (rare).

Fine organic:

Fine charcoal fragments embedded within yellow matrix. Random distribution, more abundant than coarse fragments

Inorganic residues:

10% fungal spores, randomly arranged in the matrix. Some appear fragmented.
30% intact phytoliths, abundant in the yellow matrix. Dominantly random arrangement, although some have parallel orientation within the matrix.
10% intact diatoms, randomly distributed within organic matrix.

Groundmass:

C/f ratio: 20/80
C/f related distribution: Open porphyric
Arrangement of coarse material: random

Microstructure:

Intergrain microaggregate

Pedofeatures:

5% partial organic coatings around mineral grains, 10-20 μm thickness

Floor 4

Coarse components:

Quartz sand
50% quartz grains, 40% feldspar, 10% gneiss, <5% hornblende. Poorly sorted minerals, medium to coarse grains. Sub angular and sub rounded. Embedded within organic matrix.

Fine fabric:

Dark yellow (PPL)/isotropic (XPL), well decomposed organic material forming a dense matrix. Undifferentiated b-fabric.

Coarse organic:

10% Dark reddish brown (PPL)/isotropic (XPL), amorphous fragments embedded within dark yellow matrix. Some fragments are changing colour at edges, decomposing into matrix. Randomly arranged. Upto 2mm diameter.

10% Black (PPL)/isotropic (XPL) charred fragments, randomly arranged and distributed in the organic matrix. Some structures, upto 2 mm diameter.

Fine organic:

Charcoal fragments embedded in organic matrix. Randomly distributed and arranged. Structureless fragments.

Inorganic residues:

10% fungal spores, intact and randomly distributed
100% intact phytoliths abundant throughout the floor. No particular orientation (see results for descriptions).
<5% diatoms, intact where identified.

Groundmass:

C/f ratio: 20/80
C/f related distribution: open porphyric

Microstructure:

Massive (no visible pores)

Pedofeatures:

2% thin coatings (10μm) around mineral grains, consisting of organic material.

Floor 5

Coarse components:

Quartz sand
50% quartz grains, 30% feldspar, <5% carbonate. Well to perfectly sorted grains, embedded in organic matrix. Medium to coarse sized grains.

Fine fabric:

Light yellow (PPL)/(isotropic) well decomposed and dense material forming complete coverage in the floor. Undifferentiated b-fabric

Coarse organic:

5% charcoal fragments, upto c.4 mm diameter (rare), embedded within matrix. Some cellular structure remaining in fragments.

10% Dark reddish brown (PPL)/isotropic (XPL), amorphous fragments, decomposing into the yellow matrix. Structureless fragments.

Inorganic residues:

15% intact fungal spores, randomly distributed through floor.
10% intact phytoliths within organic matrix.

Groundmass:

C/f ratio: 10/90
C/f related distribution: Open porphyric

Microstructure:

Massive

Floor 6

Coarse components:

Quartz sand
50% quartz grains, 30% feldspar, <5% hornblende, 10% carbonate grains. Medium to coarse grains, randomly distributed. Embedded within fine matrix. Poorly sorted minerals. Sub angular to rounded.

Fine fabric:

Dull yellow (PPL)/(isotropic), well decomposed organic material. Structureless and forms a dense floor matrix.Undifferentiated b-fabric.

Coarse organic:

20% black (PPL)/(isotropic), randomly distributed fragments. Upto 4 mm diameter, structure only in larger fragments.

Fine organic:

Black (PPL)/isotropic (XPL) charcoal fragments.

Inorganic residues:

Abundant intact phytoliths in fine organic matrix, 100% presence, randomly arranged.
<5% diatoms, intact where identified.
10% fungal spores, intact and embedded in fine matrix. Randomly distributed.

Groundmass:

C/f ratio: 30/70
C/f related distribution: open porphyric

Microstructure:

Crack (both horizontal and vertical) upto 5 mm length.

Pedofeatures:
None

Floor 7

Coarse components:

Shell sand
50% carbonate grains, quartz 20%, feldspar (10%), gneiss and hornblende (10%). Poorly sorted grains, medium to coarse sand sized. Sub angular to sub rounded grains.

Fine fabric:

Yellow (PPL)/isotropic (XPL) well decomposed organic material, dense floor matrix. Structureless. Undifferentiated b-fabric.

Coarse organic:

10% black (PPL)/isotropic (XPL) charred fragments, c.2mm diameter, both structureless and with structure. Randomly distributed.

5% Dark reddish brown (PPL)/isotropic (XPL) amorphous residues. Randomly distributed in fine fabric.

Inorganic residues:

15% intact phytoliths. Randomly distributed.

Groundmass:

C/f ratio: 30/70
C/f related distribution: Open porphyric

Microstructure:

Chamber (upto 2 mm diameter)

Floor 8

Coarse component:

Quartz sand
50% quartz grains, 20% feldspar, 20% carbonate grains. Well sorted, medium grains with occasional (<2%) coarse quartz grains. Randomly arranged. Sub rounded to rounded grains.

Fine fabric:

Light yellow (PPL)/isotropic and crystallitic (XPL) , well decomposed organic material. Crystallitic appearance caused by fine calcite and quartz grains.

Coarse organic:

2% charcoal fragments, Black (PPL)/(XPL), upto 2mm. Randomly distributed.

Fine organic:

Very rare fine charcoal fragments, <1 mm.

Inorganic residues:

<5% fungal spores
<5% phytoliths

Groundmass:

C/f ratio: 80/20
C/f related distribution: Open porphyric

Microstructure:

Massive

Floor 9

Coarse components:

Quartz sand
Mineralogy same as previous quartz sand floors.

Fine fabric:

Light yellow (PPL)/isotropic and crystallitic (XPL) well decomposed material. Organo-mineral origin. Crystallinity caused by fine calcite and quartz grains. Forms a dense matrix.

Coarse organic:

20% black charcoal fragments, randomly distributed, 2-3 mm, diameter.

5% Brown (PPL)/isotropic (XPL) organic fragments. Amorphous appearance, embedded in yellow matrix. Structureless.

Fine organic:

Very fine charcoal fragments, structureless.

Inorganic residues:

100% Phytoliths, intact and abundant in yellow matrix.
10% Diatoms.

Groundmass:

C/f ratio: 20/80
C/f related distribution: Open porphyric

Microstructure:

Massive

Floor 10

Coarse components:

Shell sand
50% carbonate grains, 10% each of quartz, feldspar, gneiss and hornblende. Well sorted material. Medium to coarse grains, randomly distributed. Loosely arranged.

Fine fabric:

Yellow (PPL)/isotropic (XPL) well decomposed organic material. Forms a dense matrix, but it appears that the material has been compacted into a sand floor from the overlying yellow floor. Undifferentiated b-fabric.

Brown (PPL)/dark brown (XPL) organic bands embedded within yellow matrix. These are horizontally aligned and are 20-40 μm thick.

Coarse organic:

10% black charred fragments between grains in the organic matrix. Dominant c. 1mm diameter. Mainly structureless.

Fine organic:

<1 mm charcoal fragments throughout the floor. Embedded within matrix.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Close porphyric

Microstructure:

Massive, but with a dominant mineral content. No pores present.

Floor 11

Coarse components:

Shell sand.
50% carbonate grains, 15% each of quartz and feldspar, 5% each of other grains.
Well sorted, medium to coarse grains, sub angular to sub rounded. Grains lie close together, and are randomly distributed.

Fine fabric:

Dark yellow (PPL)/ isotropic (XPL). Well decomposed organic material. No visible plant residues. Undifferentiated b-fabric.

Coarse organic:

10% black charcoal fragments embedded within fine matrix. Structureless and upto 2 mm diameter.

2% Dark reddish brown (PPL)/isotropic (XPL) organic fragments embedded into fine yellow matrix. Appear to be decomposing into the matrix, with colour differences at the edges.

Inorganic residues:

30% phytoliths embedded in fine yellow matrix.
<5% diatoms.
30% intact fungal spores randomly distributed.

Groundmass:

C/f ratio: 90/10
C/f related distribution: Close porphyric

Microstructure:

Massive, with an abundance of mineral grains.

Floor 12

Coarse components:

Quartz sand.
Lower mineral abundance than other floors in the sequence.
15% quartz and gneiss, with 5% content of other minerals. Well sorted. Dominantly medium sized grains, with occasional coarse quartz grains.

Fine fabric:

Yellow (PPL)/isotropic (XPL), well decomposed organic material. Forms a dense coverage in the floor. Undifferentiated b-fabric.

Coarse organic:

10% black charcoal fragments, upto 4 mm diameter. Some cellular structure in these coarse fragments.

5% Dark reddish brown (PPL)/isotropic (XPL) organic fragments, amorphous and structureless. Embedded within organic matrix. Upto 2 mm diameter, some decomposing into fine matrix.

Inorganic residues:

30% phytoliths, intact and embedded within light yellow matrix.
10% intact diatoms

Groundmass:

C/f ratio: 90/10
C/f related distribution: Close porphyric

Microstructure:

Massive with high mineral content (no pores)

Floor 13

Coarse components:

Quartz sand.
60% quartz sand, 30% feldspar, <5% each of gneiss, carbonate and hornblende. Medium to coarse grains dominant, Well sorted, randomly distributed.

Fine fabric:

Grey yellow (PPL)/isotropic (XPL) is the dominant residue. Well decomposed organic material, with brown (PPL)/dark brown (XPL) material forming patches within the floor. Undifferentiated b-fabric.

Coarse Organic:

10% charred, black organic fragments, c. 2-3 mm, structureless.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Close porphyric

Microstructure:

Massive with high mineral content.

Floor 14

Coarse component:

Shell sand
50% carbonate grains, 30% quartz, 10% feldspar, 10% other grains. Well sorted, medium to coarse grains, randomly distributed. Some weathering of carbonate grains.

Fine fabric:

Dark yellow (PPL)/isotropic (XPL) well decomposed, organic material.

Coarse organic:

5% Charcoal fragments, black and structureless. Fragments mainly 1 mm diameter randomly distributed and embedded in fine fabric.

10% Orange-brown (PPL)/reddish brown (XPL) organic fragments, varying size range from 2-4 mm (approx.)

Inorganic residues:

10% fungal spores, intact and randomly distributed through the floor.
10% phytoliths, intact, randomly distributed.
<5% diatoms.

Groundmass:

C/f ratio: 80/20
C/f related distribution: close porphyric

Microstructure:

Massive

Floor 15:

Coarse components:

Quartz sand.
Same mineralogy as previous quartz sand floors.

Fine fabric:

low content (10%). Dark yellow (PPL)/(XPL) well decomposed fragments, occur between grains.

Coarse organic:

5% black charcoal fragments, lying between grains. Grains dominantly c. 2 mm diameter and structureless.

Inorganic residues:

<5% each of fungal spores, phytoliths and diatoms.

Groundmass:

C/f ratio: 90/10

C/f related distribution: Monic

Microstructure:

Single grain, loosely arranged grains.

Floor 16

Coarse fraction:

Shell sand.
Same composition as previous shell sand floors.

Fine fabric:

Orange-brown (PPL)/isotropic (XPL) well decomposed organic residue, not as dominant as the mineral content. B-fabric undifferentiated.

Coarse organic:

2% charcoal fragments, randomly distributed, mainly 2 mm diameter. Very rare, lying between grains.

Inorganic residues:

Abundant phytoliths, over 50%, intact and distributed throughout the fine fabric of the floor.
10% diatoms

Groundmass:

C/f ratio: 90/10
C/f related distribution: Close porphyric

Microstructure:

Single grain

Floor 17

Coarse fraction:

Shell sand.
Same composition as Floor 16, with

Fine fabric:

Dark yellow (PPL)/isotropic (XPL) well decomposed organic material, appearing as fragments rather than a dense coverage. Undifferentiated b-fabric.

Coarse organic:

5% charcoal fragments, structureless and dominantly of 2 mm diameter. Randomly distributed in the floor.

Inorganic residues:

Abundant phytoliths, greater than 50%, embedded within fragments of fine residues. 10% fungal spores
<5% diatoms.

Groundmass:

C/f ratio: 90/10
C/f related distribution: Monic

Microstructure:

Single grains, loosely arranged in the floor.

Floor 18:

Coarse fraction:

Shell sand.
Mineral content as in previous sand based floors.

Fine fabric:

Yellow (PPL)/isotropic (XPL) well decomposed organic material. Undifferentiated b-fabric. Forms a dense floor fabric, with fine brown laminations, 20-40 μm thickness in horizontal orientation.

Coarse organic:

5% black, charcoal fragments, randomly distributed, upto 4 mm diameter (rare), mainly structureless with only larger fragments retaining some cellular structure.

Inorganic residues:

Abundant phytoliths, greater than 50%, embedded within the yellow matrix. Intact and randomly distributed.

Groundmass:

C/f ratio: 10/90
C/f related distribution: open porphyric

Microstructure:

Massive (no pores)

Floor 19

Coarse fraction:

Quartz sand,
50% quartz grains, 20% feldspar, <5% gneiss and hornblende. Poorly sorted, medium sized grains, few coarse quartz grains. Sub angular to rounded grains.

Fine fabric:

Dark yellow (PPL)/isotropic and crystallitic (XPL), well decomposed organic material. Possibly organo-mineral, with fine calcite and quartz grains causing the crystallinity.

Coarse organic:

<2% charcoal fragments, 1-2mm diameter, structureless and randomly distributed.
5% Orange-brown (PPL)/isotropic coarse organic fragments embedded in fine yellow matrix. Randomly distributed,.

Inorganic residues:

Abundant, > 50% intact phytoliths
<5% diatoms

Groundmass:

C/f ratio:10/90
C/f related distribution: Open porphyric

Microstructure:

Massive

Floor 20:

Coarse fraction:

Quartz sand floor, composition as previous quartz floors.

Fine fabric:

Dark yellow (PPL)/isotropic and crystallitic (XPL), well decomposed, organo-mineral material. Fine calcite and quartz grains cause the crystallinity, 30% abundance within fine material.

Coarse organic:

2% black, charred remains, c.2-3 mm diameter most abundant. Structureless fragments, embedded within fine residue and also between mineral grains.

5% Orange-brown (PPL)/isotropic (XPL) organic fragments, which have an amorphous appearance in a late stage of deposition.

Inorganic residues:

<5% fungal spores
10% phytolith abundance

Groundmass:

C/f ratio: 60/40
C/f related distribution: close porphyric

Microstructure:

Massive

Floor 21

Coarse fraction:

Quartz sand with same composition as Floor 20.

Fine fabric:

Orange-brown (PPL).isotropic and crystallitic (XPL), organo-mineral, well decomposed material. No visible plant remains. Forms a dense floor matrix.

Coarse organic:

Very low abundance of black, charred remains (5%), embedded within the organic fabric. Structureless fragments, 1-2 mm diameter most abundant.

Inorganic residues:

10% Fungal spores, intact and randomly distributed
<5% intact phytolith

Groundmass:

C/f ratio: 20/80
C/f related distribution: Open porphyric

Microstructure:

Massive

Structure L: Sample 120: Floors in the central area of the house

Floor 1

Coarse content:

Shell sand floor
50% carbonate grains, 30% quartz, 10% feldspar, 5% each of gneiss and hornblende grains. Medium to coarse size grains, well sorted with areas of perfect sorting. Sub angular to sub rounded grains.

Fine fabric:

10% Brown (PPL)/isotropic (XPL), well decomposed, structureless organic fragments. Undifferentiated b-fabric. Fragments occur between grains.

Coarse organic:

30% black, charcoal fragments, randomly distributed, upto c.2 mm diameter.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 90/10
C/f related distribution: monic

Microstructure:

Single grain

Floor 2:

Coarse content:

Quartz sand floor
50% quartz grains, 30 % feldspar, 10% gneiss 5% carbonate and 5% hornblende. Poorly sorted, medium sized grains dominant, with occasional coarse gneiss and quartz grains. Sub angular to sub rounded grains.

Fine fabric:

Dominant brown (PPL)/dark brown (XPL)/dark orange (OIL) well-humified peat ash residues. Undifferentiated fabric.

Yellow-brown (PPL)/isotropic (XPL)/orange (OIL) fine ash residue. Possibly stained from brown material. Undifferentiated fabric.

Grey (PPL)/isotropic(XPL) fused phytolith patches.

Coarse organic:

20% black charcoal fragments, upto 3 mm diameter, larger fragments with cellular structure visible. Embedded within ash residue. Some fragments are disintegrated and cracked.

Inorganic residues:

30% patches of grey fine material described above. Occasional intact or fragmented phytolith or diatom identified.

Groundmass:

C/f ratio: 30/70
C/f related distribution: open porphyric

Microstructure:

Massive

Floor 3

Coarse component:

Dominant quartz grains (40%), with 20% feldspar, 10% each hornblende and carbonate grains, <5% gneiss. Moderately sorted grains, sub angular to sub-rounded. Medium to coarse sized grains, some weathering of carbonate grains.

Fine fabric:

Brown (PPL)/dark brown (XPL)/dark orange (OIL) residue as floor 2. Except that the ashes are derived from Peaty-Turf.

Grey(PPL)/isotropic(XPL) residue as previous floor.

Coarse organic:

60% black, charcoal fragments abundant through the floor. Size upto 4 mm, with larger fragments retaining cellular structure. Some disintegration of fragments. Randomly distributed in the ash.

Inorganic residues:

Grey (PPL) patches of fused phytoliths and possibly diatoms mixed with the brown fabric. Abundance approx. 30% although difficult to quantify.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Dominantly massive, although 4 chambers of 100 μm diameter are present at various points in the floor.

Floor 4

Coarse fraction:

Quartz sand as in floor 3.

Fine fabric:

Dark brown (PPL)/black-isotropic (XPL)/dark red (OIL), derived from the burning of well-humified peat. Undifferentiated fabric.

Orange-brown (PPL)/isotropic (XPL)/bright dull-orange (OIL) ash residues. Undifferentiated fabric. Mixed with other residues.

Grey (PPL)/isotropic (XPL), fine fabric. Undifferentiated. Mixed with dark brown residue.

Coarse organic:

20% black charred fragments, randomly distributed, 2-3 mm diameter, mostly structureless fragments.

Inorganic residues:

Fused phytoliths identified in grey fine residue patches. Occasional intact of partly fragmented phytolith identified.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Chamber and crack. Chambers are the dominant form, 100-200 μm diameter. Cracks are both horizontal and vertical. Upto 1mm length.

Floor 5

Coarse fraction:

Quartz sand dominated, same as previous floor.

Fine fabric:

Three materials:

Dark brown (PPL)/dark reddish brown (XPL)/dark red (OIL) peaty turf residues. Undifferentiated fabric. Dominant residue. Dense structure.

Grey (PPL)/isotropic (XPL) undifferentiated patches, mixed with the other residues. Probable fused phytolith residues. Dense structure.

Grey-brown(PPL)/isotropic (XPL)/dull orange (OIL) fine ash, undifferentiated, dense structure. Possibly stained grey ash residue, as colour is not ubiquitous, and appears mainly at the edges of residue.

Coarse organic:

50% charred organic fragments. Upto 4 mm diameter, mostly structureless fragments, randomly distributed .

Inorganic residues:

Fused phytolith and diatom patches within main ash matrix.

Groundmass:

C/f ratio: 80/20
C/f related distribution: close porphyric

Microstructure:

Massive

Floor 6

Coarse fraction:

Quartz sand mineralogy as in previous floors.

Fine fabric:

Three residues as described in the previous floor, but derived from well-humified peat.

Coarse organic:
20% charred organic fragments, randomly distributed and largely structureless.

Inorganic residues:

Fused phytoliths in the grey ash patches as identified in the fine residues.

Groundmass:
C/f ratio: 20/80
C/f related distribution: Open porphyric.

Microstructure:

Massive

Floor 7

Coarse fraction:

Quartz grains 40%, carbonate grains 30%, feldspar 20%, , others 10%. Well sorted grains, sub-angular to sub rounded. Medium to coarse grains.

Fine fabric:

Three colours as identified same as Floor 6. Fuel source for floor 7 is peaty turf. Fine calcite grains in the grey-brown ash provide a slightly crystallitic fabric.

Coarse organic:

30% charred organic fragments, some cellular structure in larger grains. 2-4 mm diameter. Randomly distributed.

Inorganic residues:

Fused phytoliths in grey ash residue.

Groundmass:

C/f ratio: 60/40
C/f related distribution: Close porphyries

Microstructure:

Chamber, diameters 100-200 μm.

Floor 8

Coarse fraction:

Quartz sand dominated as previous floors.

Fine fabric:

Three ash types as previous floors, but the fuel source is well-humified peat.

Coarse organic:

40% charred organic fragments, randomly distributed. 1-3 mm size range. Mostly structureless.

Groundmass:

C/f ratio: 60/40
C/f related distribution: Close porphyric

Microstructure:

Massive and Chamber. Chambers are rare, 100 µm diameter. Random occurrence.

Floor 9

Coarse fraction:
Carbonate grains dominate, 50%, quartz, feldspar and gneiss 5-15% variation. Moderately sorted, medium to coarse sand grains. Randomly distributed.

Fine fabric:

Single ash type.
Brown (PPL)/dark brown (XPL)/dark orange (OIL) dense appearance. Undifferentiated fabric, although there are some fine calcite grains in the matrix, not abundant though. Derived from peaty turf.

Coarse organic:

10% charred fragments, randomly distributed, 1-2 mm diameters, some retain structure, others are fragmented.

Inorganic residues:

None identified due to masking by brown colour.

Groundmass:

C/f ratio: 60/40
C/f related distribution: open porphyric

Microstructure:

Chamber. Diameter upto 400µm

Floor 10

Coarse fraction:

Quartz sand dominated, similar to other floors.

Fine fabric:

Same as residue as previous Undifferentiated. Occurs as fine fragments of ash rather than a dense matrix.

Inorganic residues:

None identified due to masking by brown colour.

Groundmass:

C/f ratio: 90/10
C/f related distribution: monic

Microstructure:

Single grain.

Floor 11

Coarse fraction:

Shell sand.
Carbonate dominated at 50%, quartz 20%, sub rounded to sub angular grains, randomly distributed. Medium to coarse grains.

Fine fabric:

Three residues:
Grey-brown, grey and brown with the same characteristics as the peaty turf residues in other floors. Forms a dense floor layer.

Coarse organic:

10% charred organic fragments, 1-2 mm dominant, some cellular structure visible in 2% of fragments. Randomly distributed in the matrix.

Inorganic residues:

Evident only as fused phytoliths in the grey and grey-brown ash residues. Not always identified, and have a low abundance (5%) in these ashes.

Groundmass:

C/f ratio:30/70
C/f related distribution: open porphyric

Microstructure:

Massive dominantly, with occasional chambers (100 µm diameters). Chambers are randomly distributed.

Floor 12

Coarse fraction:

Quartz sand.
50% quartz grains (dominant), feldspar 20%, carbonate and hornblende 10% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Two residues:
As previous layer.

Coarse organic:

30% black charred fragments, upto c. 2 mm diameter, some cellular structure remaining. Mainly lying between grains, although also embedded in fine matrix.

Inorganic residues:

Some intact phytoliths and diatoms in Grey (PPL) fine residue, otherwise at high magnification appear as fused material in this same residue.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Chamber, upto 2 mm diameter, caused by sand grains.

Floor 13

Coarse fraction:

Quartz sand.
50% quartz grains (dominant), feldspar 20%, carbonate and hornblende 10% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Dominant brown (PPL)/isotropic (XPL)/dull orange (OIL) fine ash residue. Occurs as patches and fragments rather than firming a dense floor matrix. Undifferentiated.

Patches of reddish brown 9PPL)/dark reddish brown (XPL)/bright red (OIL) material. Also dense and structreless, c.5% abundance within the brown material. Undifferentiated.

Coarse organic:

20% black charred fragments, embedded within fine fabric but also in spaces between grains. Some disintegration occurring to larger grains (c. 1 mm diameter), mainly <1mm diameter.

Inorganic residues:

None identified, possibly due to masking by brown residue.

Groundmass:

C/f ratio: 80/20
C/f r.d: Close porphyric

Microstructure:
Chamber, some chambers are upto 2 mm diameter (c.1%)

Floor 14

Coarse fraction:

Quartz sand.
50% quartz grains (dominant), feldspar 20%, carbonate and hornblende 10% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Two forms:

Dominant brown (PPL)/isotropic (XPL)/orange (OIL) fine ash residue. Occurs as patches and fragments rather than firming a dense floor matrix. Undifferentiated.

Grey-brown (PPL)/isotropic (XPL), fine structureless residue. Occurs as patches within brown matrix, approx. 2% abundance. Staining possibly from brown ash residue.

Coarse fraction:

20% black charred fragments, embedded within fine fabric but also in spaces between grains. Some disintegration occurring to larger grains (c. 1 mm diameter), mainly <1mm diameter.

Inorganic residues:

Abundant fused phytoliths and possibly diatoms. in grey-brown residue. Identification of some intact components.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Close porphyric

Microstructure:

Chamber, various diameters.

Floor 15:

Coarse fraction:

Quartz sand.
50% quartz grains (dominant), feldspar 20%, carbonate and hornblende 10% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Two types:
Dominant brown (PPL)/isotropic (XPL)/orange (OIL) fine ash residue. Occurs as patches and fragments rather than firming a dense floor matrix. Undifferentiated.

Grey-brown (PPL)/isotropic (XPL)/dull orange (OIL), fine structureless residue. Occurs as patches within brown matrix, approx. 2% abundance. Staining possibly from brown ash residue.

Coarse components:

40% charred organic fragments, upto 3 mm diameter, mainly lying between grains, but also embedded into fine residue. Some disintegration occurring to fragments, mainly structureless.

Inorganic residues.:

Abundant fused phytoliths and possibly diatoms. in grey-brown residue. Identification of some intact components.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Dominantly massive, with rare chambers. Chambers occur where occasionally the grains are not compacted and there is a lower fine residue content. However, dominantly no pore space.

Floor 16:

Coarse fraction:

Dominantly quartz grains (30%) with equal feldspar and carbonate (20% each), gneiss and hornblende. Moderately sorted grains, medium to coarse sand sized grains, sub angular to rounded.

Fine fabric:

Two types:
Dominant brown (PPL)/isotropic (XPL)/orange (OIL) fine ash residue. Occurs as patches and fragments rather than firming a dense floor matrix. Undifferentiated.

Grey (PPL)/isotropic and crystallitic (XPL). Dense patches of material mixed with brown residue. Fine crystallinity caused by silt sized calcite and possibly quartz grains.

Coarse components:

20% black charred fragments, embedded within fine fabric but also in spaces between grains. Some disintegration occurring to larger grains (c. 1 mm diameter), mainly <1mm diameter.

Inorganic residues:

Abundant fused phytoliths in grey fine ash, as in other patches of this residue, there are partly fused and intact fragments that.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Chamber and crack, cracks are fine and rare in dominant horizontal orientation.

Floor 17:

Coarse components:

Shell sand.
50% or greater carbonate grains, with 30% feldspar and 10 % quartz. , Medium to coarse grains, these being dominant and caused by carbonates. Sub angular to rounded.

Fine fabric:

10% Dark brown (PPL)/isotropic and crystallitic (XPL)/dull red (OIL) fine ash residue. Occurs as patches of material between the grains.

Coarse components:

10% charred organic fragments, structureless and randomly distributed in the matrix. Commonly located between mineral grains.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 90/10
C/f related distribution: Bridged grain

Microstructure:

Gefuric

House 3: Structure H: Sample 133

Floor 1

Coarse components:
Dominant carbonate grains (30%), quartz and feldspar (20% each). Gneiss and hornblende. Medium to coarse sized grains, sub-angular and sub-rounded.

Fine fabric:

One reside:
Dark brown (PPL)/dark reddish brown (XPL)/red (OIL) fine ash residue. Undifferentiated, located in patches rather than forming continuous matrix.

Coarse components:

30% black, charred fragments. Randomly distributed between grains and in ash residue. Some disintegration and mainly structureless, frequently 2 mm diameter.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Chamber, upto 2 mm diameter

Floor 2:

Coarse components:

Dominant carbonate grains (30%), quartz and feldspar (20% each). Gneiss and hornblende. Medium to coarse sized grains, sub-angular and sub-rounded.

Fine fabric:

Two types:
Dominantly reddish brown (PPL)/dark reddish brown (XPL)/ deep red (OIL), fine ash reside. Forms patches with grains embedded in.

Light grey (PPL)/(XPL) dense but with very fine structure. Occurs as patches within above.

Coarse components:

40% charred fragments, upto 3 mm diameter. Larger fragments have some structure, otherwise structureless. Some disintegration occurring. Lying between grains and in ash.

Inorganic residues:

Abundant fused phytoliths and possibly diatoms in light grey residue. Rare intact partly fused fragments within residue.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Close porphyric

Microstructure:

Chamber

Floor 3

Coarse components:

Dominant carbonate grains (30%), quartz and feldspar (20% each). Gneiss and hornblende. Medium to coarse sized grains, sub-angular and sub-rounded.

Fine fabric:

Three types identified:
Dominantly light grey (PPL)/isotropic and undifferentiated. Forms the dominant matrix of the floor. Remaining residues appear mixed with this material.

Very light brown (PPL)/isotropic (XPL) fine ahs residue. Undifferentiated. Possibly stained from brown residues.

Brown (PPL)/orange-brown (XPL), fine material.

Coarse organic material:

20% charred organic fragments, structureless and randomly distributed in the matrix. Approx. 1-3 mm diameter.

Inorganic residues:

Fused phytoliths and diatoms in light grey fabric. Occasional intact fragments enable identification of phytoliths.

Groundmass:

C/f ratio:20/80
C/f related distribution: Open porphyric

Microstructure:

Chamber

Floor 4

Coarse fraction:

Dominantly quartz grains (30%) with equal feldspar and carbonate (20% each), gneiss and hornblende. Moderately sorted grains, medium to coarse sand sized grains, sub angular to rounded

Fine fabric:

Light grey (PPL)/isotropic and undifferentiated. Forms the dominant matrix of the floor. Remaining residues appear mixed with this material.

Brown (PPL)/orange-brown (XPL)/dull orange (OIL), fine ash material.

Coarse components:

10% charred organic fragments randomly distributed in dense floor matrix. Many with structure, <1 –2 mm diameter.

Inorganic residues:

Fused siliceous material in Light grey residue. 20% abundance.

Groundmass:

C/f ratio: 20/80
C/f related distribution: Open porphyric

Microstructure:

Chamber, upto 2 mm diameter

Floor 5

Coarse fraction:

Dominantly quartz grains (30%) with equal feldspar and carbonate (20% each), gneiss and hornblende. Moderately sorted grains, medium to coarse sand sized grains, sub angular to rounded

Fine fabric:

Three fabrics:
Yellowish brown (PPL)/isotropic or dark yellow-brown (XPL)/dull brown (OIL). Undifferentiated and dominant material.

Light grey (PPL)/isotropic and undifferentiated. Mixed with yellow brown dominant fabric, forming patches within that material.

Strong brown (PPL)/yellow-brown (XPL)/dull brown (OIL). Possibly same material as dominant matrix, with different stage of combustion. Forms patches within the dominant matrix. Undifferentiated.

Coarse organic:

5% charred organic fragments. Randomly distributed and dominantly < 1mm diameter.

Inorganic residues:

Fused siliceous material in the yellow matrix. 30% intact phytoliths are identified.

House 3: Structure J: Sample 128

Floor 1

Coarse fraction:

Shell sand.
5o% carbonate grains, 20% quartz grains, perfectly sorted, sub angular and sub rounded grains, loosely arranged and randomly distributed..

Fine fabric:

10% Brown (PPL)/isotropic (XPL) well decomposed organic residues, structureless and in between grains.

Coarse organic:

40% charcoal fragments, Randomly distributed and dominantly <1mm- 2mm diameter. Some disintegration of fragments.

Inorganic residues:

None present

Groundmass:

C/f ratio: 90/10
C/f related distribution: Open porphyries

Microstructure:

Single grain

Floor 2

Coarse fraction:

50% quartz grains (dominant), feldspar 20%, carbonate and hornblende 10% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Two fabrics:

Light brown (PPL)/dull reddish brown (XPL)/red (OIL). Dominant fabric in the floor, Crystallite appearance caused by fine calcite grains.

Grey (PPL)/isotropic and crystallite (XPL). Dense patches of material mixed with brown residue. Fine crystallinity caused by silt sized calcite and possibly quartz grains.

Coarse organic:

20% charred fragments, upto 3 mm diameter. Larger fragments have some structure, otherwise structureless. Some disintegration occurring. Embedded in the ash residue.

Inorganic residues:

Fused phytoliths in the grey (PPL) fine residue.

Groundmass:

C/f ratio:30/70
C/f related distribution: Open porphyric

Microstructure:

Chamber and crack.

Floor 3:

Coarse fraction:

Shell sand.
30% carbonate grains, 10% quartz grains, perfectly sorted, sub angular and sub rounded grains, loosely arranged and randomly distributed.

Fine fabric:

Two fabrics:

Yellow (PPL)/isotropic(XPL)/deep orange (OIL) Abundant material forming a dense matrix.
Colour possibly a function of post-deposition weathering of ash material.

Light yellow-brown (PPL)/isotropic (XPL)/deep orange (OIL) patches of material within the abundant matrix. Dense patches with no structure.

Coarse organic:

5% charred organic fragments, various size ranges, <1 mm to 2 mm. Fragments have some structure , but dominantly structureless and some disintegration.

Inorganic residues:

Abundant (50%) fused and intact phytoliths in the yellow matrix.

Groundmass:

C/f ratio:20/80
C/f related distribution: Open porphyric

Microstructure:

Chamber crack

Floor 4

Coarse fraction:

Shell sand.
30% carbonate grains, 10% quartz grains, perfectly sorted, sub angular and sub rounded grains, loosely arranged and randomly distributed.

Fine fabric:

Brown (PPL)/dark reddish brown (XPL)/deep orange (OIL) dense ash residue. Forms the fabric of the floor. Fine appearance.

Light grey (PPL)/isotropic (XPL) and undifferentiated. Mixed with brown dominant fabric, forming patches within that material. Crystallitic appearance caused by fine calcite grains.

Coarse fragments:

5% charred organic fragments, various size ranges, <1 mm to 2 mm. Fragments have some structure , but dominantly structureless and some disintegration.

Inorganic residues:

Fused siliceous material forming light grey residue. Some fragmented phytoliths and rare diatoms.

Groundmass:

C/f ratio: 20/80
C/f related distribution: Open porphyric

Microstructure:
Chamber and crack.

Floor 5:

Coarse fraction:

60% quartz grains (dominant), feldspar 0%, carbonate 5% hornblende 10% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Three fabrics:

Light brown (PPL)/dull reddish brown (XPL)/red (OIL). Dominant fabric in the floor, Crystallitic appearance caused by fine calcite grains.

Brown (PPL)/dark reddish brown (XPL)/deep orange (OIL) dense ash residue. Fine appearance. Undifferentiated.

Orange-brown (PPL)/isotropic/deep brown (OIL), patches of material within light brown fabric. Dense structure, amorphous appearance.

Coarse components:

10% charred organic fragments, larger (2mm) fragments with structure, although these fragments show the most disintegration.

Inorganic residues:

Fused siliceous material forming light grey residue. Some fragmented phytoliths and rare diatoms.

Groundmass:

C/f ratio: 20/80
C/f related distribution: Open porphyric

Microstructure: Chamber and crack

Floor 6

Coarse components:

30% quartz grains (dominant), feldspar 20%, carbonate and hornblende 10% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Three fabrics:

Dark brown (PPL)/dark reddish brown (XPL)/red (OIL) dominant material, dense structure, similar appearance to amorphous organic residues.

Light yellow-brown (PPL)/isotropic (XPL)/deep orange (OIL) patches of material within the abundant matrix. Dense patches with no structure.

Grey-brown (PPL)/isotropic (XPL) patches of material within dominant matrix. Lower occurrence than yellow-brown fabric.

Coarse organic:

40% charred fragments, sizes upto 3 mm diameter., located in the floor matrix and also between grains.

Inorganic residues:

Abundant fused and intact siliceous residue in both grey-brown and yellow-brown residues.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Chamber and crack

Floor 7

Coarse fraction:

50% quartz grains (dominant), feldspar 20%, carbonate and hornblende 10% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Floor composed entirely of black charred residue which is fragmented in places

Coarse organic:

As fine material.

Inorganic residues:

None identified

Groundmass:

C/f ratio: 20/80
C/f related distribution: open porphyric

Microstructure:

Chamber and crack

Floor 8

Coarse fraction:

 80% quartz grains (dominant), feldspar 10%, carbonate and hornblende 5% each, gneiss <5%. Medium sized grains, occasional coarse quartz grains. Sub-angular to sub-rounded grains. Moderately sorted.

Fine fabric:

Three fabrics:

Light brown (PPL)/dull reddish brown (XPL)/red (OIL). Dominant fabric in the floor, Crystallitic appearance caused by fine calcite grains.

Brown (PPL)/dark reddish brown (XPL)/deep orange (OIL) dense ash residue. Fine appearance. Undifferentiated.

Orange-brown (PPL)/isotropic/deep brown (OIL), patches of material within light brown fabric. Dense structure, amorphous appearance.

Coarse organic:

10% charred fragments, randomly distributed between grains and embedded within fine fabrics. Dominantly < 1mm diameter, some fragments 2 mm diameter.

Inorganic residues:

Fused and intact siliceous residue in both grey-brown and yellow-brown residues.

Groundmass:

C/f ratio: 40/60
C/f related distribution: Open porphyric

Microstructure:

Chamber and crack

Floor 9

Coarse fraction:

Dominant carbonate grains (80%), 10% quartz grains, 5% other. Moderately sorted medium to coarse grains. Sub angular to rounded grains.

Fine fabric:

Four fabrics:

Light brown (PPL)/dull reddish brown (XPL)/red (OIL). Dominant fabric in the floor. Dense structure. Undifferentiated.

Grey (PPL)/isotropic and Crystallitic (XPL). Dense patches of material mixed with brown residue. Fine crystallinity caused by silt sized calcite and possibly quartz grains. Undifferentiated.

Dark brown (PPL)/dark reddish brown (XPL)/red (OIL), dense structure, similar appearance to amorphous organic residues. Undifferentiated.

Yellow-brown (PPL)/isotropic (XPL)/deep orange (OIL) patches of material within the abundant matrix. Dense patches with no structure. Undifferentiated.

Inorganic residues:

Fused siliceous residues with 10% fragmented and rare intact phytoliths and diatoms in the light brown and grey residues.

Groundmass:

C/f ratio: 40/60
C/f related distribution: Open porphyric

Microstructure:
Chamber and crack.

Appendix Two: Index to Soil micromorphological descriptions of individual floors

Cladh Hallan

House 401

<u>Floor 655: North-South Transect</u>

Sample 4848

Index to Soil micromorphological descriptions of individual floors

Bornais, Mound 1

Appendix Two

Cladh Hallan, South Uist

House 640

Sample 4664 and 4666

Coarse fraction

Quartz and carbonate dominated, 40% and 30%, 10% feldspar, <5% gneiss, 10% hornblende. Medium to coarse grains, well sorted and randomly distributed.

Fine fabric:

20% Light Brown (PPL)/isotropic and crystallitic (XPL) well decomposed organic fragments, between the grains.

Coarse components:

5% (4664), 10% (4666), 1-2 mm charcoal fragments. Structureless and fragmented. Randomly arranged.

Inorganic residues:

None present.

Groundmass:

C/f ratio:80/20 and 100/0
C/f r.d.: Monic and gefuric

Microstructure:

Compact grain in both samples

House 401

Floor 595

East-West transect

4871

Floor 1

Coarse fraction:

Quartz sand,
50% quartz grains, 30% feldspar grains, well sorted, medium to coarse grain sized, randomly distributed throughout floor.

Fine fabric:

Dark brown (PPL)/Isotropic and crystallitic (XPL) well decomposed organic residues. Occur between grains. Structureless. Fine calcite grains embedded in fabric give crystallitic b-fabric.

Coarse components:

30% charred fragments, 1-2 mm diameter dominant, mainly structureless, randomly distributed between grains and in fine residue.

Inorganic residues: none identified

Groundmass:
C/f ratio: 70/30
C/f r.d.: gefuric/chitonic

Microstructure:
Complex

Floor 2

Coarse fraction:

Quartz sand,
50% quartz grains, 30% feldspar grains, well sorted, medium to coarse grain sized,
randomly distributed throughout floor.

Fine fabric:

Dark brown (PPL)/Isotropic and crystallitic (XPL) well decomposed organic
residues. Occur between grains. Structureless. Fine calcite grains embedded in fabric
give crystallitic b-fabric. 40% presence in the floor.

Coarse components:

40% charred fragments, 1-2 mm diameter dominant, mainly structureless, randomly
distributed between grains and in fine residue.

Inorganic residues: None evident

Groundmass:

C/f ratio: 60/40
C/f r.d.: Close porphyric

Microstructure: Compact grain.

Sample 4873

Floor 1

Coarse fraction:

50% quartz grains, 20% feldspar grains, 20% carbonate well sorted, medium to
coarse grain sized, randomly distributed throughout floor.

Fine fabric:

Brown (PPL)/crystallitic and isotropic (XPL), well decomposed organic residues. Occur between grains. Structureless. Fine calcite grains embedded in fabric give crystallitic b-fabric. 10% occurrence.

Coarse components:

20% charred fragments, 1-2 mm diameter dominant, mainly structureless, randomly distributed between grains. Some disintegration visible.

Inorganic residues: none identified.

Groundmass:

C/f ratio:90/10
C/f r.d.: Monic

Microstructure:

Single grain with bridged where fine residue occurs.

Pedofeatures:

2% 10-30 µm thick organic coatings to mineral grains.

Floor 2:

Coarse fraction:

Quartz sand,
50% quartz grains, 20% feldspar grains, well sorted, medium to coarse grain sized, randomly distributed throughout floor.

Fine fabric:

Three fabrics identified:

Dark brown (PPL)/isotropic and crystallitic (XPL) most abundant. Well decomposed amorphous patches of residue. Structureless.

Light brown (PPL)/isotropic and crystallitic (XPL) well decomposed organic material. Occurs as patches within dominant matrix and also isolated patches.

Grey brown (PPL)/isotropic and crystallitic (XPL), structureless fine ash residue. Fused phytoliths and diatoms. Few visible intact.

Coarse components:

30% charred fragments, upto 4 mm diameter with cellular structure. Otherwise disintegration and structureless dominates.

Inorganic residues:

Rare intact phytoliths in grey brown fine residue.

Groundmass:

C/f ratio: 70/30
C/f r.d.: Chitonic

Microstructure:

Bridged grain

Sample 4875:

Coarse fraction:

Quartz sand.

40% quartz grains, 30% feldspar, other grains vary. Medium to coarse sized, randomly distributed and perfectly sorted.

Fine fabric:

<5% light brown (PPL)/isotropic and crystallitic (XPL), well decomposed organic fragments. Occur between grains.

Coarse components:

30% charred fragments, upto 2 mm diameter with cellular structure. Otherwise disintegration and structureless dominates.

Groundmass:

C/f ratio: 95/5
C/f r.d.: Monic

Microstructure:

Bridged grain.

Soil Micromorphological Analysis: Cladh Hallan, House 401

Cladh Hallan
Floor 595

North-south transect

Sample 4897

Floor 1

Coarse fraction:

50% quartz, 30% Feldspar, 5% carbonate, gneiss and hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed.

Fine fabric:

10% light brown (PPL)/dark brown (XPL), well decomposed organic fragments. Undifferentiated. Lying between grains.

Coarse organic:

2% charred fragments. Dominantly 1-2 mm, structureless, randomly distributed.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 90/10
C/f related distribution: Monic

Microstructure:
Single grain with bridged grain where inorganic residue occurs between grains.

Floor 2

Coarse fraction:

50% quartz, 30% Feldspar, 5% carbonate, gneiss and hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed.

Fine fraction:

Brown (PPL)/isotropic and crystallitic (XPL), well decomposed organic fragments. Randomly distributed between grains. Organo-mineral, with fine silt size calcite and quartz grains embedded.

Coarse organic

30% charred fragments, 1-3 mm diameter, crack structure in larger fragments. Randomly distributed. Lying between grains and some embedded in fine fabric.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Bridged grain.

Sample 4895

Coarse fraction:

50% quartz, 30% Feldspar, 5% carbonate, gneiss and hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL), well decomposed organic residue. Organo-mineral, with fine silt size calcite and quartz grains embedded within fabric.

Coarse components:

10% charred fragments, dominantly 1 mm or smaller, mainly crack structure, some disintegration. Randomly distributed between grains.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 90/10
C/f related distribution: Monic/gefuric

Microstructure:

Single grain with bridged grain where fine fabric joins grains.

Sample 4893

Coarse fraction:

50% quartz, 20% Feldspar, 10% carbonate, 10% gneiss and 10% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL), well decomposed organic residue. Organo-mineral, with fine silt size calcite and quartz grains embedded within fabric.

Coarse components:

30% charred fragments, 1-2 mm diameter, crack structure in larger fragments. Randomly distributed. Lying between grains.

Groundmass:
C/f ratio: 90/10
C/f related distribution: Monic/gefuric

Microstructure:

Dominantly single grain with bridged grain where fine organics bridge grains together.

Sample 4847

Floor 1

Coarse fraction:

40% quartz, 30% Feldspar, 10% carbonate, 15% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic (XPL). Undifferentiated. well decomposed organic residue. Occurs as fragments between grains and also patches of residue.

Coarse components:

40% charred fragments, upto 3 mm diameter, Crack and cellular structure in larger fragments. Randomly distributed between grains.

Inorganic residues:

None present.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Gefuric/chitonic

Microstructure:

Compact grain with areas of intergrain microaggregate.

Floor 2

Coarse fraction:

40% quartz, 15% Feldspar, 10% carbonate, 30% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL), well decomposed organic residue, in patches and fragments between grains and also embedding some grains. Fine silt sized grains of calcite and quartz forming a crystallitic appearance.

Coarse components:

30% black charred fragments. 1-3 mm, lying between grains. Fragments are structureless and with structure. Randomly distributed.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Close porphyric.

Microstructure:

Compact grains and intergrain microaggregate.

Floor 3

Coarse fraction:

40% quartz, 15% Feldspar, 10% carbonate, 30% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Brown (PPL)/isotropic (XPL). Undifferentiated. well decomposed organic residue. Occurs as fragments between grains and also patches of residue.

Coarse components:

30% black charred fragments. 1-3 mm, lying between grains. Fragments are structureless and with structure. Randomly distributed.

Inorganic residues:

None identified

Groundmass:

C/f ratio: 80/20
C/f related distribution: Gefuric/chitonic

Microstructure:
Compact grain and intergrain microaggregate.

Floor 4

Coarse fraction:

40% quartz, 15% Feldspar, 10% carbonate, 30% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Grey-brown (PPL)/isotropic and undifferentiated (XPL), fine ash residue. No structure and forms patches between grains. Characteristics of peaty turf ash.

Coarse components:

30% black charred fragments. 1-3 mm, lying between grains. Fragments are structureless and with structure. Randomly distributed.

Groundmass:

C/f ratio: 60/40
C/f related distribution: Close porphyric

Microstructure:

Compact grain and intergrain microaggregate.

Floor 5

Coarse fraction:

40% quartz, 15% Feldspar, 10% carbonate, 5% gneiss and 30% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Brown (PPL)/(isotropic and crystallitic (XPL)

Coarse components:

40% quartz, 15% Feldspar, 30% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Inorganic residues:

None identified

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Compact grain and intergrain microaggregate.

Floor 6

Coarse fraction:

40% quartz, 15% Feldspar, 30% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Three types:

Dark brown (PPL)/isotropic and crystallitic (XPL)

Orange-brown (PPL)/isotropic and crystallitic (XPL)/deep orange (OIL), fine ash residue. Structureless and occurs in patches within the matrix.

Grey-brown (PPL)/isotropic and undifferentiated (XPL)/deep orange (OIL), fine ash residue. No structure and forms patches between grains. Characteristics of peaty turf ash.

Coarse components:

2% charcoal fragments, 1-2 mm, randomly distributed, largely structureless.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Close porphyric

Microstructure:

Compact grain and intergrain microaggregate.

Sample 4849

Coarse fraction:

40% quartz, 15% Feldspar, 30% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Brown (PPL)/isotropic (XPL). Undifferentiated. well decomposed organic residue. Occurs as fragments between grains and also patches of residue.

Coarse components:

20% charred fragments, randomly distributed <1mm to 2 mm, structureless and in between grains.

Inorganic residues:

None identified.

Groundmass:
C/f ratio: 90/10
C/f related distribution: Close porphyric

Microstructure:

Single grain/ bridged grain where fine fabric bridges grains together.

Sample 4851

Coarse fraction:

40% quartz, 30% Feldspar, 20% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Brown (PPL)/isotropic (XPL). Undifferentiated. well decomposed organic residue. Occurs as fragments between grains and also patches of residue.

Coarse components:

20% charred fragments, randomly distributed <1mm to 2 mm, structureless and in between grains.

Inorganic residues:

None identified.

Groundmass:
C/f ratio: 90/10
C/f related distribution: Close porphyric

Microstructure:

Single grain/ bridged grain where fine fabric bridges grains together.

FLOOR 655

north-south transect: House 401 Cladh Hallan.

Sample 4898

Coarse fraction:

40% quartz, 30% Feldspar, 20% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Light yellow – brown (PPL)/isotropic and undifferentiated (XPL), well decomposed organic residues. Occurs as patches in the thin section, embedding grains.

Coarse components:

10% black, charcoal fragments, randomly distributed. 1-3 mm diameter, some with structure and some without.

Inorganic residues:

Intact phytoliths embedded in fine fabric.

Groundmass:
C/f ratio: 60/40
C/f related distribution: Chitonic/gefuric

Microstructure:

Bridged grain

Sample 4896

Coarse fraction:

40% quartz, 30% Feldspar, 20% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Light yellow – brown (PPL)/isotropic and undifferentiated (XPL), well decomposed organic residues. Occurs as patches in the thin section, embedding grains.

Coarse components:

10% black, charcoal fragments, randomly distributed. 1-3 mm diameter, some with structure and some without.

Inorganic residues:

Intact phytoliths embedded in fine fabric.

Groundmass:
C/f ratio: 60/40
C/f related distribution: Chitonic/gefuric

Microstructure:

Bridged grain

Sample 4894

Floor 1

Coarse fraction:

40% quartz, 20% Feldspar, 30% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL), well decomposed organo-mineral residue. Embedded with fine calcite and quartz grains. Forms patches and fragments of material.

Coarse components:

40% black , charred fragments. Randomly distributed through matrix. 1-2 mm fragments, some with structure.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Chitonic

Microstructure:

Bridged grain with areas of compact grain.

Floor 2

Coarse fraction:

40% quartz, 20% Feldspar, 30% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Three fabrics:

Yellow – brown (PPL)/isotropic and undifferentiated (XPL)/deep orange (OIL), fine ash residue, structureless.. Occurs as patches in the thin section, embedding grains.

Coarse components:

40% black , charred fragments. Randomly distributed through matrix. 1-2 mm fragments, some with structure.

Inorganic residues:

Frequent patches of fused phytoliths in grey-brown residue. Some intact phytoliths identified.

Groundmass:

C/f ratio: 30/70
C/f related distribution: Chitonic

Microstructure:

Massive

Floor 3

Coarse fraction:

40% quartz, 30% Feldspar, 20% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Grey brown (PPL)/isotropic and undifferentiated (XPL)/deep orange (OIL) Structureless and dense fine ash residue.

Coarse components:

40% black , charred fragments. Randomly distributed through matrix. 1-2 mm fragments, some with structure.

Inorganic residues:

None identified.

Groundmass:
C/f ratio: 70/30
C/f related distribution: Chitonic

Microstructure:

Bridged and compact grain.

Sample 4848

Floor 1

Coarse fraction:

50% quartz, 5% Feldspar, 30% carbonate, 5% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Two forms:

Same appearance but different shades of colour.

Dark brown and light brown (PPL)/isotropic and crystallitic (XPL), well decomposed organic material. Organo-mineral with silt sized calcite and quartz grains. Occurs as fragments and patches.

Coarse components:

15% charred fragments, randomly distributed, 1-2 mm diameter, mainly structureless. Occur between grains and in some fine residue.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Chitonic

Microstructure:

Bridged grain and compact grain.

Floor 2

Coarse fraction:

60% quartz, 10% Feldspar, 5% carbonate, 10% gneiss and 10% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Same appearance but different shades of colour.

Dark brown and light brown (PPL)/isotropic and crystallitic (XPL), well decomposed organic material. Organo-mineral with silt sized calcite and quartz grains. Occurs as fragments and patches.

Coarse components:

10% black, charred fragments, randomly distributed through floor. Embedded in fine residue and also between grains. 1-3 mm diameter.

Inorganic residues:

None identified

Groundmass:

C/f ratio: 60/40
C/f related distribution: Enaulic

Microstructure:

Bridged and compact grain

Floor 3

Coarse fraction:

50% quartz, 20% Feldspar, 15% carbonate, 10% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Reddish brown (PPL)/isotropic and undifferentiated (XPL)/deep red (OIL) fine ash residue. Dense and structureless, occurs as patches in sand matrix.

Coarse components:

20% black, charred fragments. Structureless and randomly distributed. 1-2 mm.

Inorganic residues:

None identified

Groundmass:

C/f ratio: 80/20
C/f related distribution: Chitonic

Microstructure:

Compact grain.

Sample 4850

Coarse fraction:

50% quartz, 20% Feldspar, 15% carbonate, 10% gneiss and 5% hornblende. Perfectly sorted, medium to coarse grains. Sub angular to sub rounded, loosely arranged. Randomly distributed

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL), organo-mineral material. Forms patches in which grains are embedded. Silt sized grains of calcite and quartz form crystallinity.

Coarse components:

30% black, charred fragments, 1-3 mm, randomly distributed, larger fragments have some structure (cracked and cellular). Embedded in fine material and between grains.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 70/30
C/f related distribution: chitonic/ gefuric

Microstructure:

Bridged grain caused by fine residue.

Sample 4852

Coarse fraction:

50% quartz (dominant), 20% feldspar, 10 % hornblende, 15% carbonate, 5% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Orange brown (PPL)/isotropic (XPL), but highly birefringent fragments. Embedded with fine sized quartz and feldspar grains. Possibly patches of clay.

Coarse components:

10% charred organic fragments, randomly distributed, largely structureless, 1-2 mm sizes. Occur between grains.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 90/10
C/f related distribution: Monic

Microstructure:

Bridged grain.

FLOOR 655

EAST-WEST TRANSECT

Sample 4967

Coarse fraction:

50% carbonate grains, 20% quartz, 10% feldspar, 5% gneiss, perfectly sorted, medium to coarse grains, randomly distributed

Fine fabric:

5% Light brown (PPL)/ isotropic and crystallitic, well decomposed organo-mineral residue. Very rare in the section.

Coarse components:

20% charred organic fragments, randomly distributed, largely structureless, 1-2 mm sizes. Occur between grains.

Inorganic residues:

None identified.

Groundmass:

C/f ratio: 95/5
C/f related distribution: Monic

Microstructure:

Compact grain.

Floor 2

Coarse fraction:

50% quartz (dominant), 20% feldspar, 10 % hornblende, 10% carbonate, 10% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL), well decomposed organo-mineral material. Forms patches and fragments in the floor. Silt sized grains of calcite and quartz form crystallinity.

Coarse components:

30% black, charred fragments, <1-2 mm, randomly distributed, some with structure, larger fragments show signs of disintegration.

Inorganic fragments:

None identified.

Groundmass:

C/f ratio: 70/30

C/f related distribution: Enaulic

Microstructure:

Compact grain domiannt with areas of bridged grain were fine residue bridges grains together.

Floor 3

Coarse fraction:

50% carbonate grains, 20% quartz, 10% feldspar, 5% gneiss, perfectly sorted, medium to coarse grains, randomly distributed.

Fine fabric:

10% Brown (PPL)/(isotropic and crystallitic) well decomposed organo-mineral material. Occurs as fragments in the floor. Silt sized grains of calcite and quartz form crystallinity.

Coarse components:

20% charcoal fragments distributed through the sand matrix. <1-2 mm, randomly distributed, some with structure, larger fragments show signs of disintegration.

Inorganic residues:

None identified

Groundmass:

C/f ratio: 90/10
C/f related distribution: Monic

Microstructure:

Compact grain

Sample 4965

Coarse fraction:

50% carbonate, 10% feldspar, 5% gneiss, 30% quartz, 5% hornblende, moderately sorted, medium to coarse grains, randomly distributed. Coarse grains are dominantly quartz.

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL) well decomposed, organo-mineral material. Forms patches and fragments within sand floor.

Coarse components:

20% black, charred organic fragments, randomly distributed. <1-3 mm, coarse fragments show some cellular structure with cracks. Some fragments highly disintegrated. Embedded in fabric and between grains.

Inorganic residues:

Few intact phytoliths and rare diatoms in fine fabric. Random distribution and orientation.

Groundmass:

C/f ratio: 70/30
C/f related distribution: Chitonic

Microstructure:

Bridged grain

Sample 4963

Coarse fraction:

50% quartz (dominant), 25% feldspar, 5 % hornblende, 15% carbonate, 5% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL) well decomposed, organo-mineral material. Forms patches and fragments within sand floor.

Coarse components:

20% black, charred organic fragments, randomly distributed. <1-3 mm, coarse fragments show some cellular structure with cracks.

Inorganic residues:

None identified

Groundmass:

C/f ratio: 70/30
C/f related distribution: chitonic

Microstructure:

Bridged grain.

Sample 4872

Floor 1

Coarse fraction:

40% quartz (dominant), 20% feldspar, 5 % hornblende, 20% carbonate, 15% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Dark brown (PPL)/isotropic and undifferentiated (XPL), well decomposed organic reside. structureless. Forms patches into which grains are embedded.

Coarse components:

None identified.

Inorganic residues:

Rare (4) bone fragments clustered in the bottom of the floor. Unburned, yellow-white (PPL)/strong birefringence (XPL).

Groundmass:

C/f ratio:70/30
C/f related distribution: Enaulic and chitonic

Microstructure:

Compact grain

Floor 2

Coarse fraction:

40% quartz (dominant), 20% feldspar, 10 % hornblende, 15% carbonate, 15% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL)/deep orange (OIL), fine ash residue. Forms a dense floor, into which grains are embedded. Well humified peat ash.

Coarse components:

40% charred organic fragments, <1 –2 mm, some with structure visible, although mostly cracked and showing signs of disintegration.

Inorganic residues:

Rare bone fragments (2) randomly distributed in matrix. Appear unburned, yellow-white (PPL)/highly birefringent (XPL). Vertically and horizontally aligned. Embedded in ash residue. 1 fragment 5 mm length, 1 bone fragment 9 mm.

Groundmass:

C/f ratio: 50/50
C/f related distribution: Close porphyric

Microstructure:

Compact grain

Floor 3

Coarse components:

40% quartz (dominant), 30% feldspar, 5 % hornblende, 20% carbonate, 5% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Dark brown (PPL)/isotropic and crystallitic (XPL)/orange (OIL), fine ash residue. Forms matrix to the floor, structureless material with mineral grains embedded into it.

Coarse components:

30% charred organic fragments, <1 −2 mm, some with structure visible, although mostly cracked and showing signs of disintegration.

Inorganic residues:

1 bone fragment, 3 cm in length, vertically aligned at the top of the floor. Yellow-white (PPL)/high birefringence (XPL). Unburned.

Groundmass:

C/f ratio: 60/40
C/f related distribution: Gefuric/chitonic

Microstructure:

Compact grain.

Sample 4874

Coarse fraction:

40% quartz (dominant), 30% feldspar, 5 % hornblende, 20% carbonate, 5% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Dark brown (PPL)/ isotropic and crystallitic (XPL) fragments of fine ash material similar to floor 3 in 4874.

Coarse components:

40% charred organic fragments, <1 −2 mm, some with structure visible, although mostly cracked and showing signs of disintegration.

Inorganic residues:

None evident

Groundmass:

C/f ratio: 80/20
C/f related distribution: Gefuric

Microstructure:

Bridged grain and intergrain microaggregate.

Sample 4876

Coarse fraction:

40% quartz (dominant), 20% feldspar, 5 % hornblende, 30% carbonate, 5% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic (XPL) well decomposed organic material. Undifferentiated. Occurs as fragments in the floor.

Coarse components:

40% charred organic fragments, <1 –2 mm, some with structure visible, although mostly cracked and showing signs of disintegration.

Inorganic residues:

None evident.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Gefuric

Microstructure:

Bridged grain where fine fabric occurs, otherwise single grain.

Soil micromorphological descriptions: Bornais, Mound 1, Cladh Hallan.

Sample 9158

Coarse fraction:

40% quartz (dominant), 20% feldspar, 5 % hornblende, 15% carbonate, 15% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

100% black organic charred material. Cellular structure and cracks in material. Material is disintegrated and very fragmented.

Coarse material:

Charcoal as above.

Inorganic residues:

None evident

Groundmass:

C/f ratio: 30/70
C/f related distribution: Open porphyric

Microstructure:

Granular and chamber, although cracks also abundant

Sample 9159

Floor 1

Coarse fraction:

40% quartz (dominant), 20% feldspar, 5 % hornblende, 30% carbonate, 5% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Fine charcoal fragments, black (PPL)/isotropic (XPL), abundant through floor. Mainly structureless.<1 mm, few 1-2 mm fragments.

Coarse components:

90% charcoal fragments, upto 1 cm diameter, cracked and cellular structures, many appear to have been compacted.

Inorganic residues:

None evident

Groundmass:

C/f ratio: 30/70
C/f related distribution: Open porphyric

Microstructure:

Massive

Floor 2

Coarse fraction:

40% quartz (dominant), 20% feldspar, 10 % hornblende, 10% carbonate, 20% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Grey brown (PPL)/ isotropic and crystallitic (XPL), fine ash residue. Dense material forming the matrix to the floor.

Coarse components:

20% charred organic fragments, randomly distributed in the fine fabric.<1-2 mm, dominantly structureless.

Inorganic residues:

Abundant patches of fused siliceous material in the grey-brown fabric. Few intact and fragmented phytoliths.

Groundmass:

C/f ratio: 20/80
C/f related distribution: Open porphyric

Microstructure:

Massive

Sample 9160

Floor 1

Coarse fraction:

40% quartz (dominant), 20% feldspar, 5 % hornblende, 30% carbonate, 5% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Fine charcoal residues, forming matrix to the floor. Structureless and dense.

Coarse components:

70% charcoal fragments, up 2 cm diameter, randomly distributed and oriented, many fragments with structure, others disintegrated and cracked.

Inorganic residues:

None evident

Groundmass:

C/f ratio: 30/70
C/f related distribution: Open porphyric

Microstructure:

Complex.

Floor 2

Coarse fraction:

40% quartz, 30% feldspar, 5% hornblende, 10% carbonate, 15% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed.

Fine fabric:

Light brown (PPL)/isotropic and crystallitic (XPL) well decomposed organo-mineral material. Forms dense patches between grains, structureless material.

Coarse components:

10% charred organic fragments, randomly distributed and embedded between grains. < 1-2 mm size range. Dominantly structureless, with some retaining cellular structure.

Inorganic residues:

None evident

Groundmass:

C/f ratio: 90/10
C/f related distribution: gefuric

Microstructure: Compact grain

Floor 3

Coarse fraction:

40% quartz, 20% feldspar, 5 % hornblende, 20% carbonate, 15% gneiss. Medium to coarse grains, sun angular to sub rounded grains, randomly distributed. Loosely arranged.

Fine fabric:

Fine charcoal residues, forming matrix to the floor. Structureless and dense.

Coarse components:

100% charcoal floor. Charred remains are disintegrated and fragmented in places.

Inorganic residues:

None evident

Groundmass:

C/f ratio: 30/70
C/f related distribution: Open porphyric

Microstructure:

Complex

Sample 9161

Floor 1

Coarse fraction:

40% quartz grains, 30% carbonate, 20% feldspar, 5% gneiss and hornblende. Medium to coarse sized grains. Moderately sorted, sub angular to sub rounded dominantly, with some rounded quartz grains.

Fine fabric:

Black (PPL)/isotropic (XPL), fine charcoal forming the matrix to the floor.

Coarse components:

Dense black (PPL)/(isotropic) charcoal fragments. Mainly structureless and fragmented. Many grains also disintegrated.

Inorganic residues:

None evident

Groundmass:

C/f ratio: 20/80
C/f related distribution: open porphyric

Microstructure:

Massive

Floor 2

Coarse components:

40% quartz grains, 20% carbonate, 15% feldspar, 5% gneiss and 20% hornblende. Medium to coarse sized grains. Moderately sorted, sub angular to sub rounded dominantly, with some rounded quartz grains.

Fine fabric:

Brown (PPL)/isotropic and crystallitic (XPL) well decomposed, organo-mineral material. Forms patches and fragments between grains. Structureless residue.

Coarse components:

70% charred organic fragments, randomly distributed between grains. <1 mm-2 mm size range, many without structure and appearing disintegrated.

Inorganic residues:

None evident.

Groundmass:

C/f ratio: 80/20
C/f related distribution: Gefuric

Microstructure:

Bridged grain.

Appendix Three

Context descriptions for Bostadh Beach and Cladh Hallan. Please note that there were field descriptions and not undertaken by the author of this thesis, but bu field excavators.

Bostadh Beach (After Neighbour 1996)

Figure 2.10

Context Number	Description
174	Isolated midden deposit
218	Beige windblown sand
221	Compacted, dark peaty layer
276	Brownish, red clayey deposit
316	Isolated spread of greyish brown clay

Figure 2.11

171	No recorded information
172	Dark brown peaty layer
300	White sand
338	Sand infill
339	Sand infill
358	Sand infill

Cladh Hallan (After Parker-Pearson *et al.,* 2000)

Figure 2.14

| 595 | White wind blown sand with organic flecks |
| 655 | White/beige wind blown sand |

Figure 2.15

655	Yellow wind blown sand
659	Wind blown sand layer
1290	Wind blown sand layer

Figure 2.16

| 655 | Yellow wind blown sand |
| 1290 | Wind blown sand layer |

Figure 2.17

| 595 | White wind blown sand |
| 655 | Yellow wind blown sand |

Figure 2.18

655	Beige wind blown sand
659	Wind blown sand layer
792	Beige wind blown sand
808	Yellow/beige wind blown sand
866	Wind blown sand
864	Beige wind blown sand

<u>Figure 2.19</u>

655	White wind blown sand
659	White wind blown sand
782	Wind blown sand

<u>Figure 2.22</u>

| 632 | Wind blown sand |

Figure 2.1: Location map of Lewis and the Bhaltos Penninsula
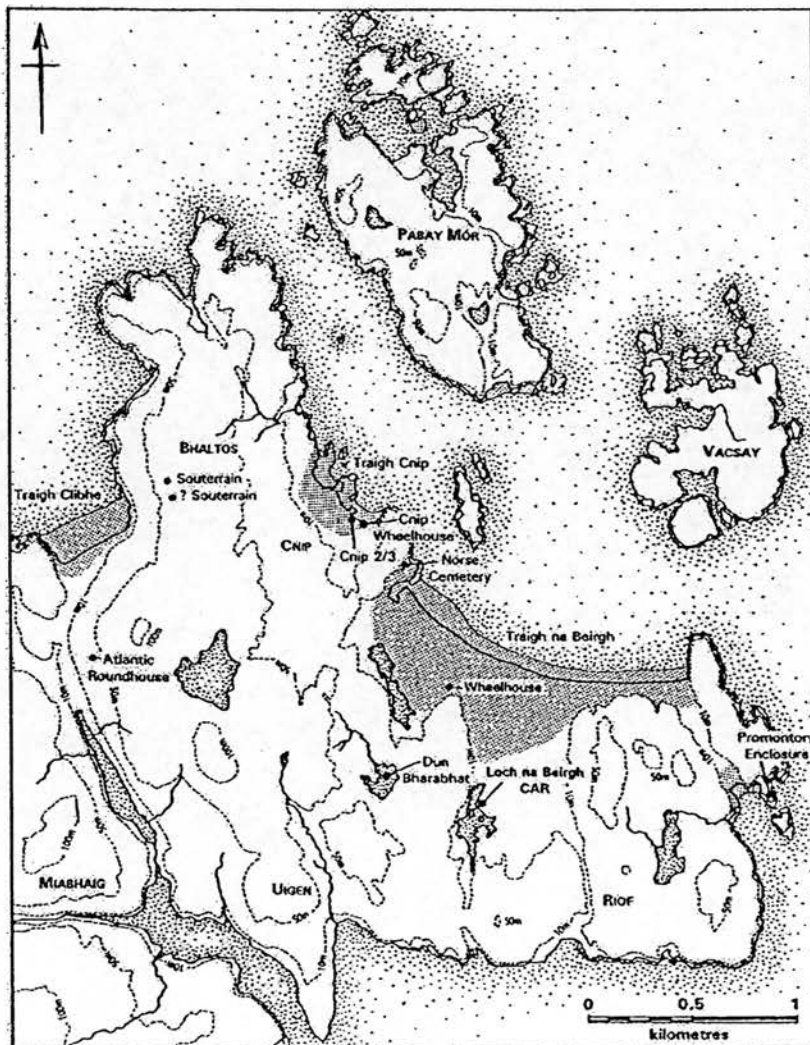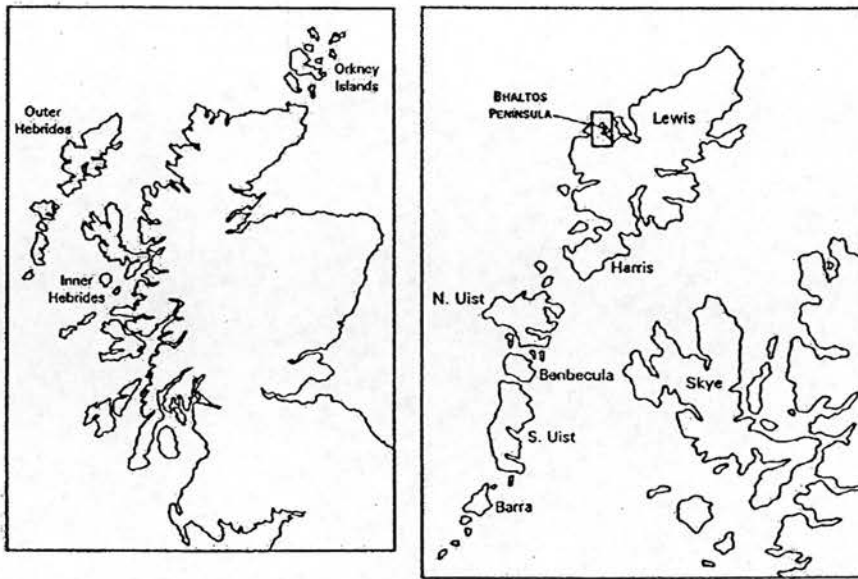
(After Harding and Gilmour 2000)
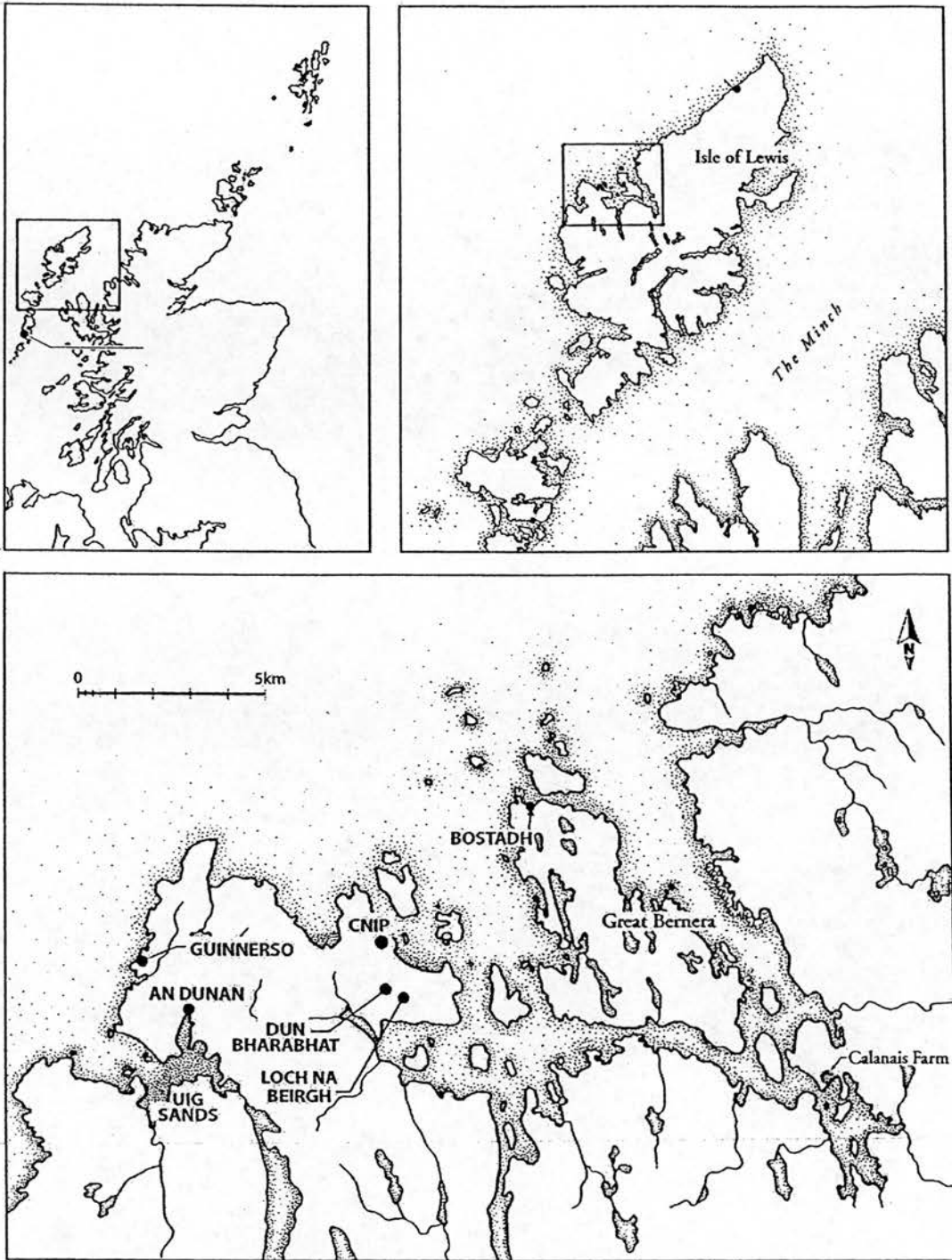
Figure 2.2: Location of the Settlement sites on the Uig Peninsula, Isle of Lewis, Scotland

Labels on map:

HARRIS

The Udal
Olabhat
Sollas
Clettraval
NORTH UIST

Baleshare

BENBECULA

Hornish Point

Dun Mor
A'Cheardach Mhor
A'Cheardach Bheag
Bornais
Dun Vulan
Cill Donnain
Usinish
SOUTH UIST

Cladh Hallan
Kilpheder

Dun Cuier
Allasdale

BARRA

N

0   20
km
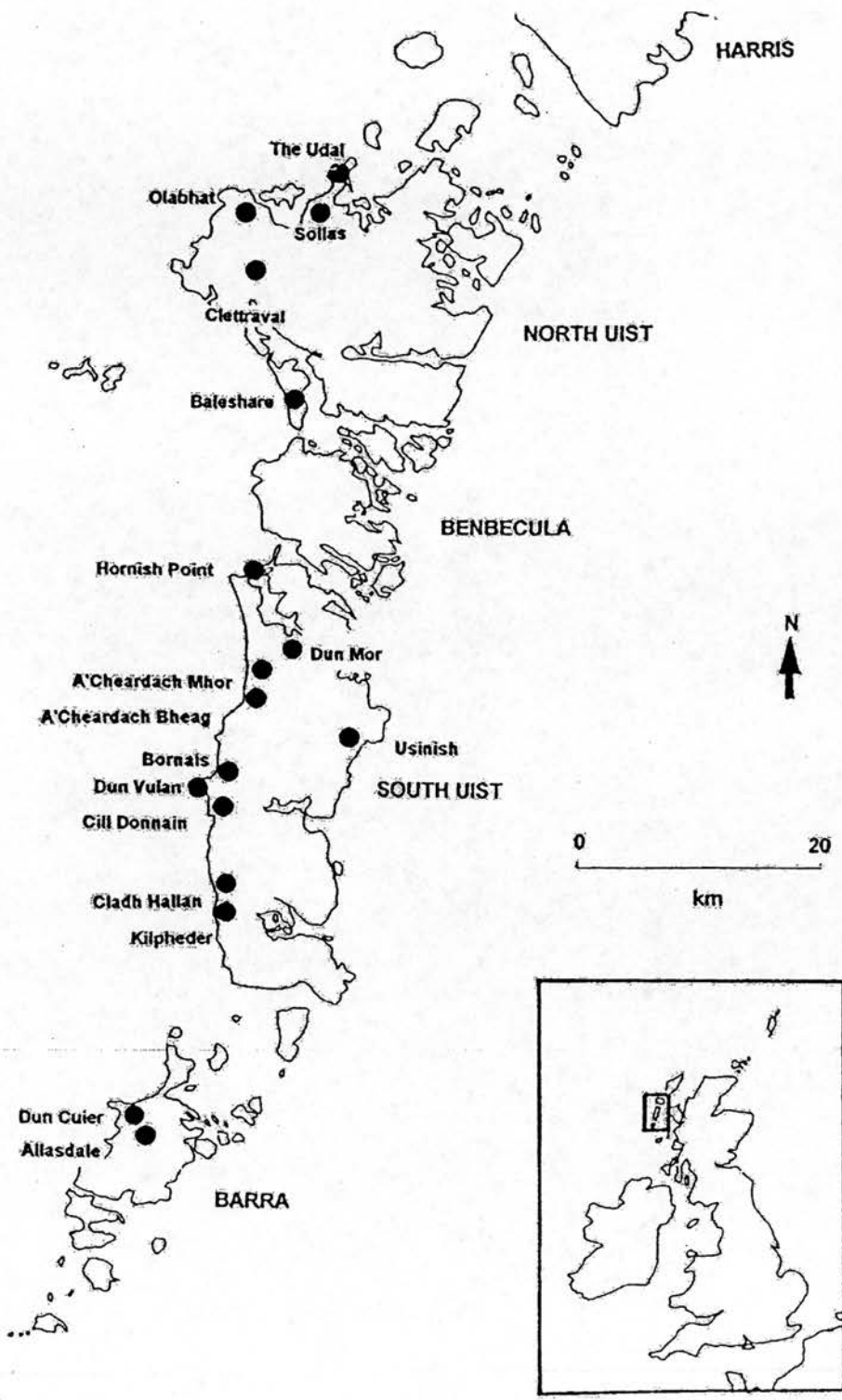
(After Parker-Pearson and co-workers 1999)

Figure 2.3: Distribution map of Iron Age settlements on South Uist

Dun Carloway

Loch na Berie

Dun Bharabhat , Cnip

Rudh an Duin

Dun Flodigarry

Dun Vulan

Dun Ardtreck

Dun Cuier

0   50 Km
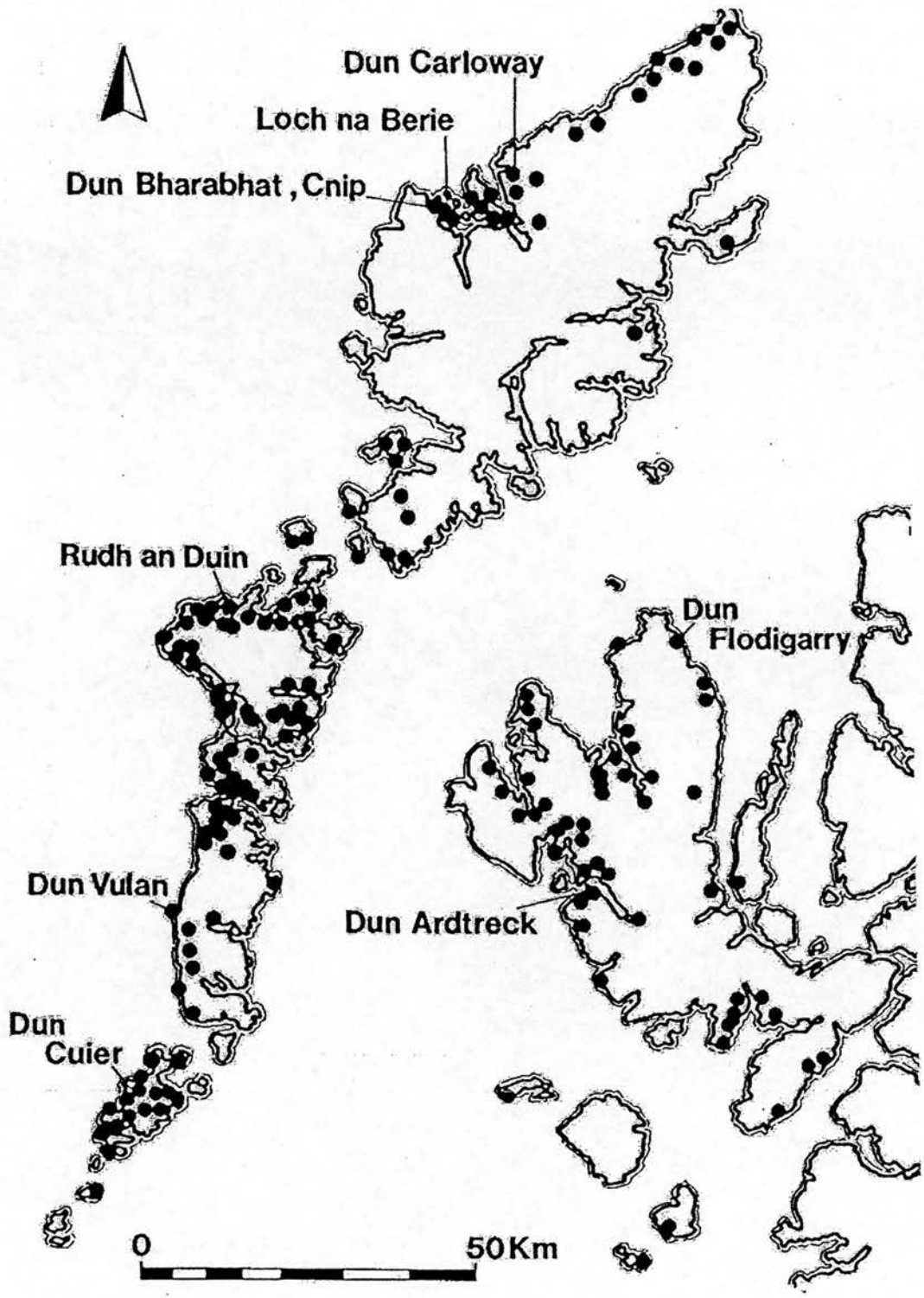
(After Armit 1996)

Figure 2.4: Distribution of Atlantic Roundhouses in the Outer Hebridean Islands
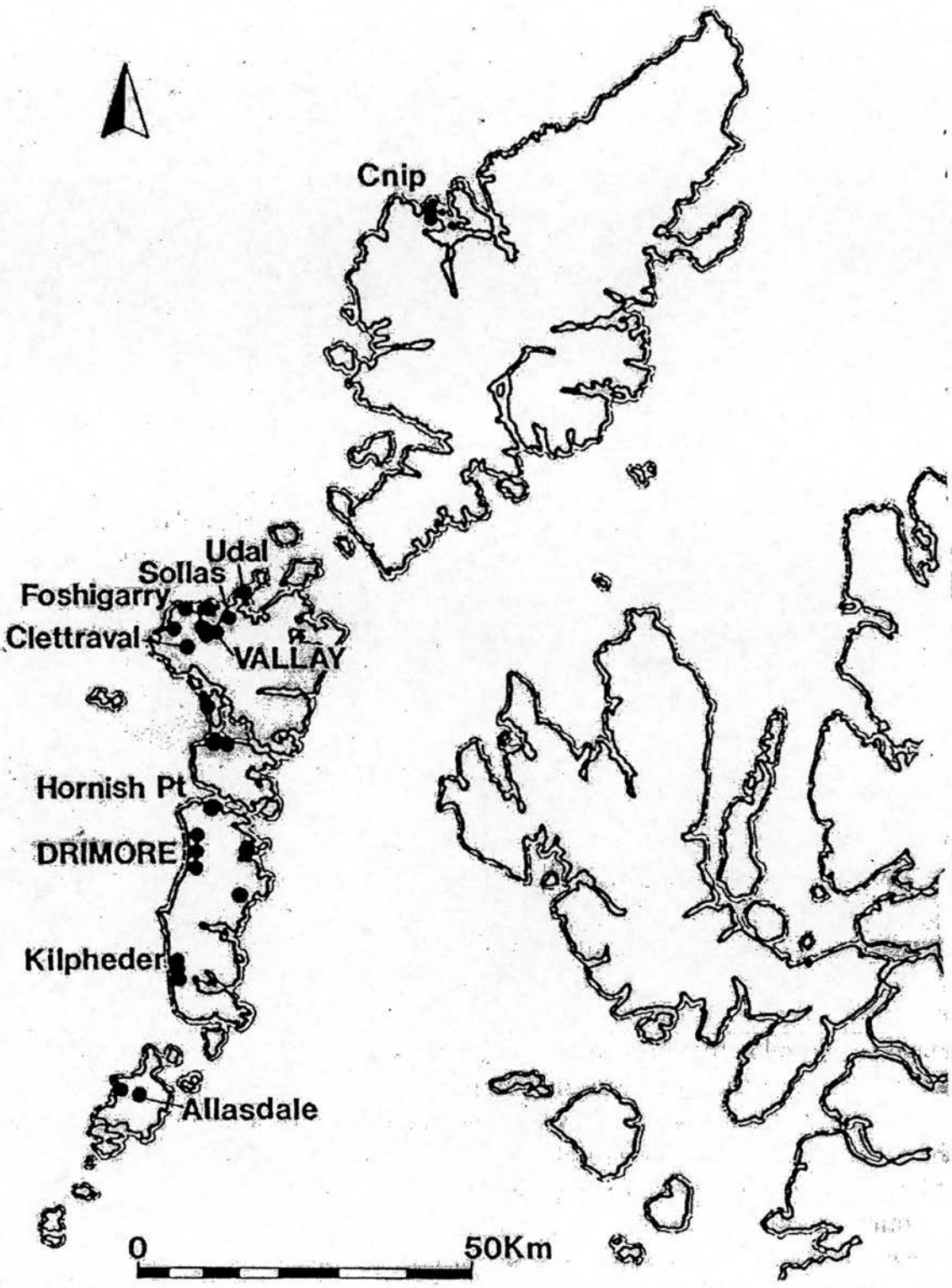
Figure 2.5: Distribution of Wheelhouses in the Outer Hebrides (After Armit 1996)
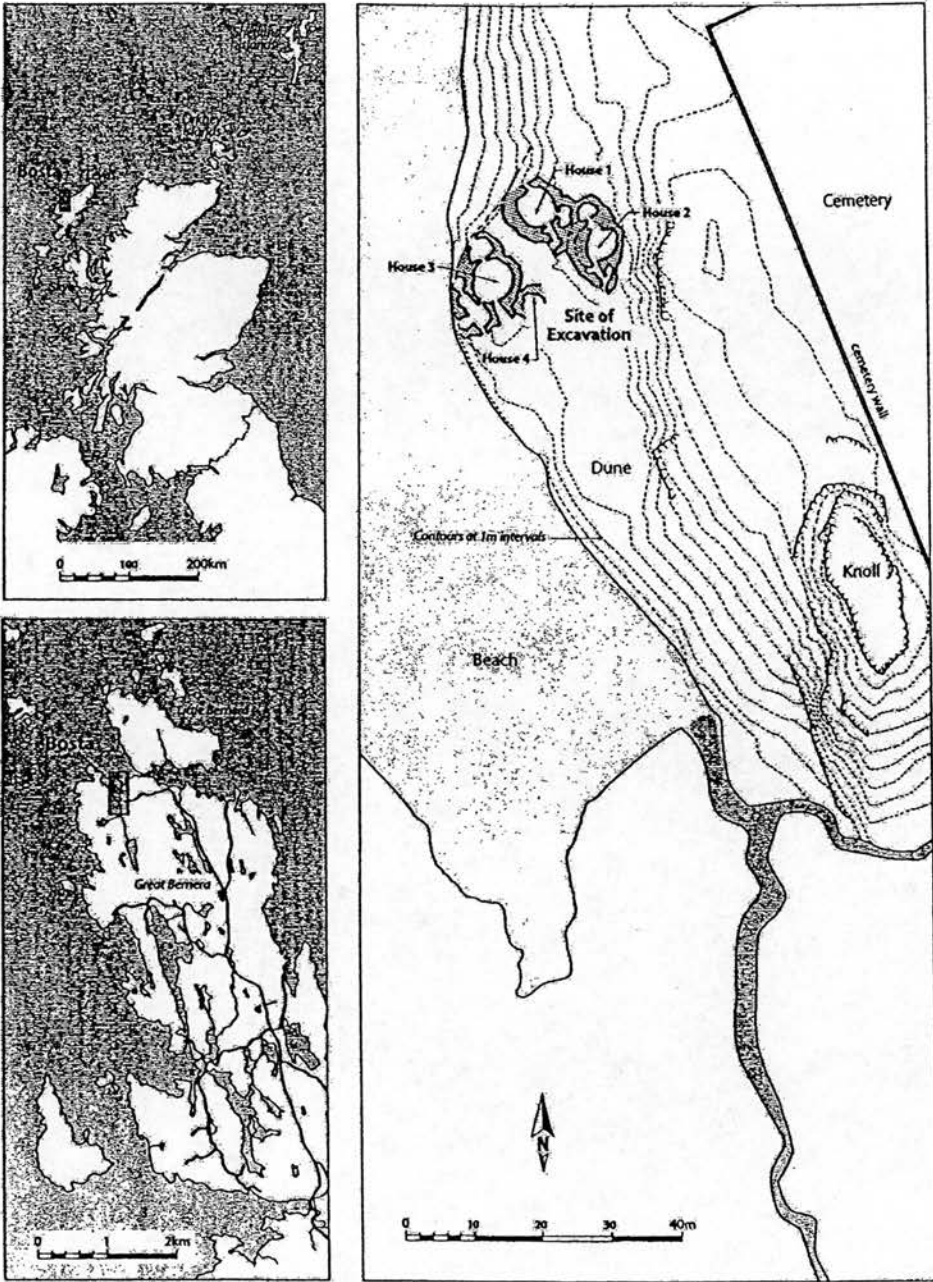
(After Nieghbour 2001)

Figure 2.6: Location map of Bostadh Beach, Great Berneradh, Isle of Lewis

Cnip Phase 3 structures (after
Armit 1990), for comparison with
Early (1 & 2)
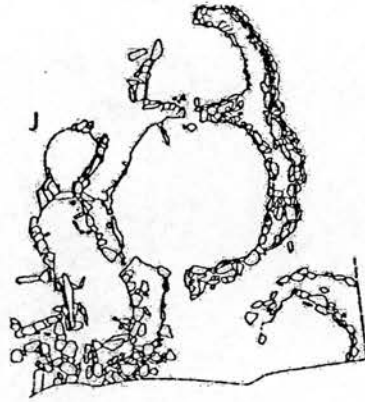
Early (1): Structure J
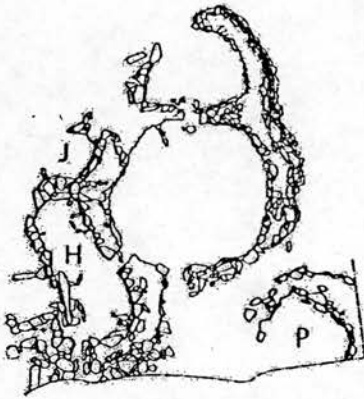
Early (2): Structures J, H and P

Ventral: House 3 (I)

0   10m
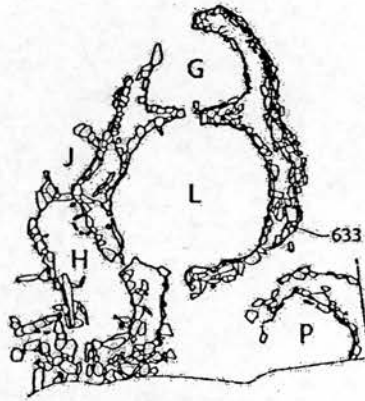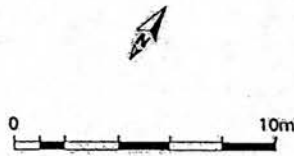
(After Neighbour 2001)

Figure 2.7A: Settlement sequence of Bostadh Beach, Great Berneradh, Isle
of Lewis

Figure 2.7B: Settlement sequence of Bostadh Beach, Great Berneradh, Isle of Lewis
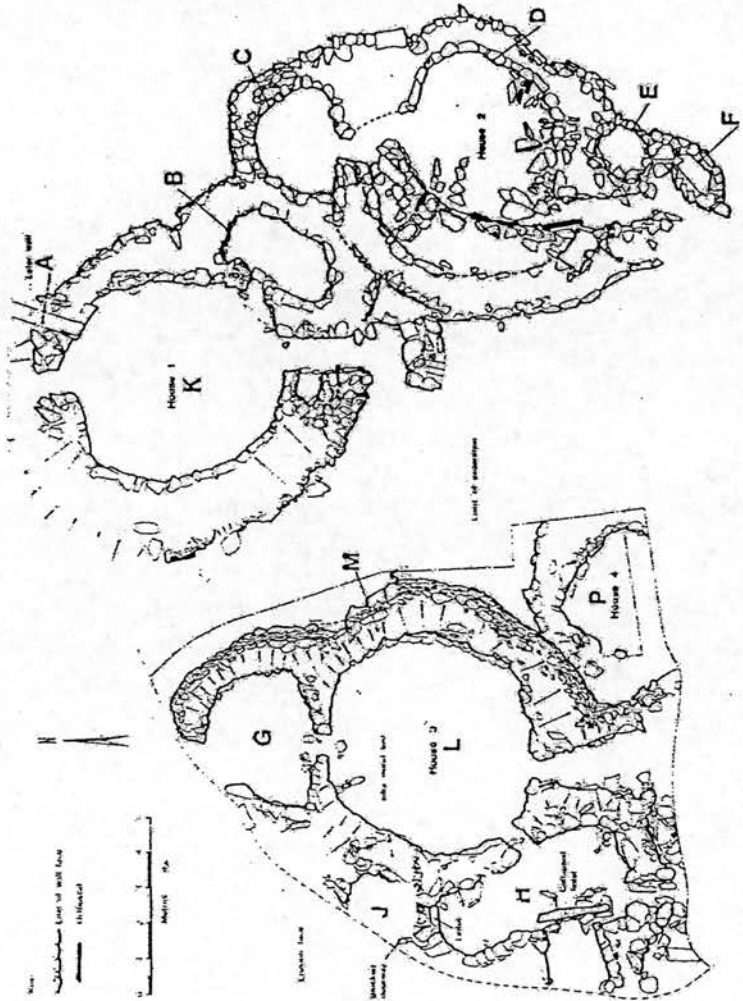
(After Neighbour 1996)

Figure 2.8: Plan of Settlement at Bostadh Beach, Great Berneradh, Isle of Lewis
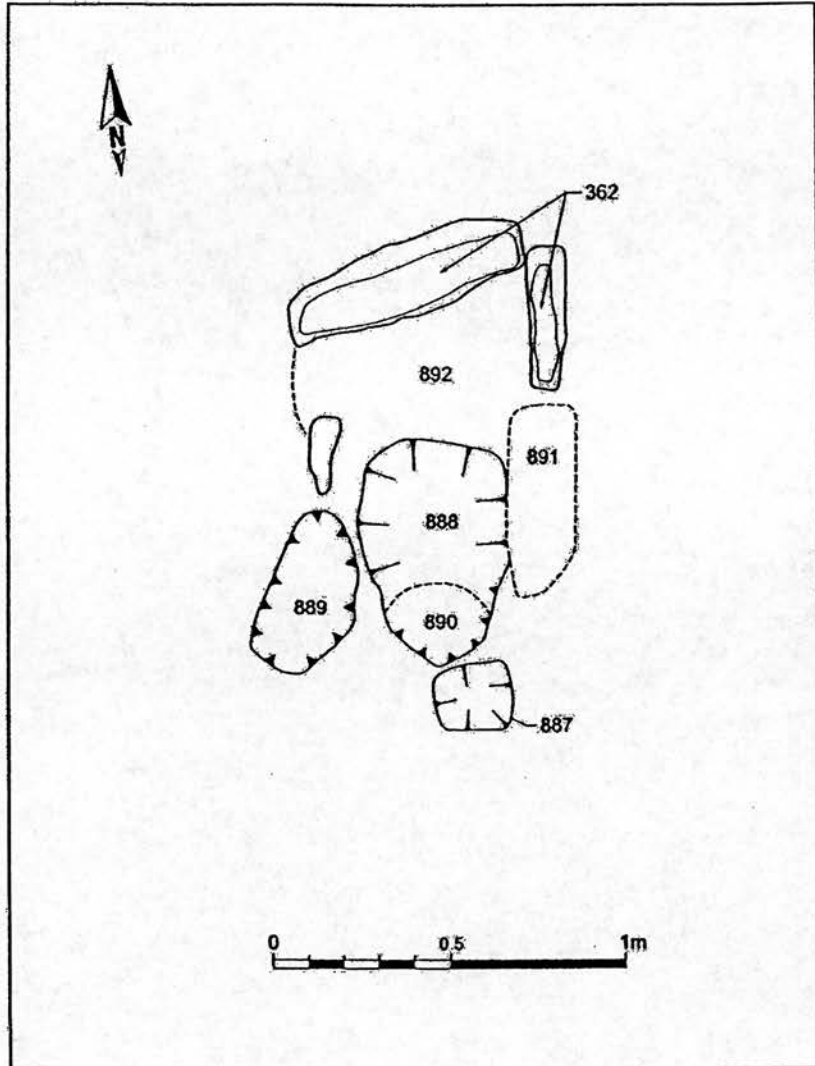
(After Neighbour 1996)

Figure 2.9: Central hearth, Structure L, Bostadh Beach, Great Berneradh, Isle of Lewis
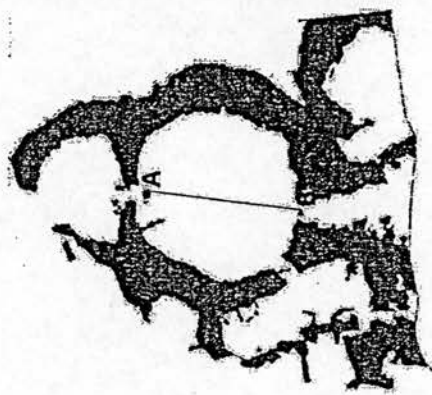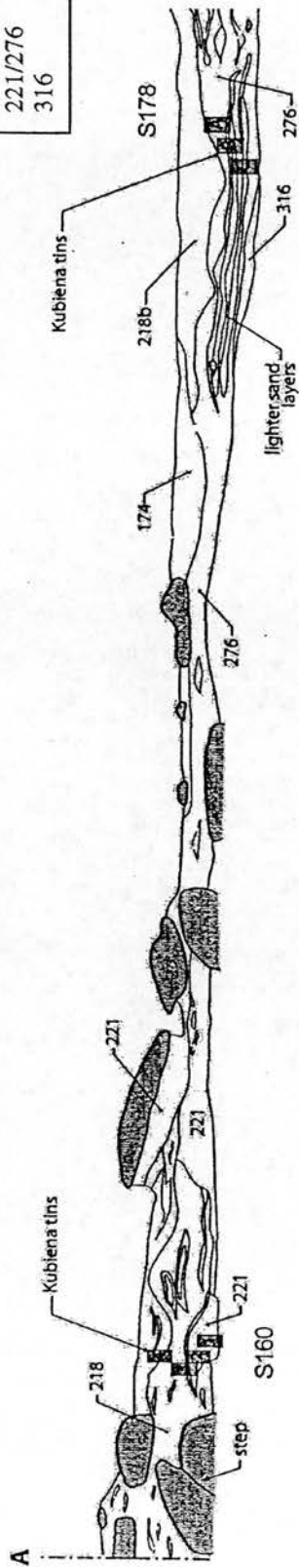
Figure 2.10: Location of Samples 160 and 178 in Structure L, House Three, Bostadh Beach

Key:
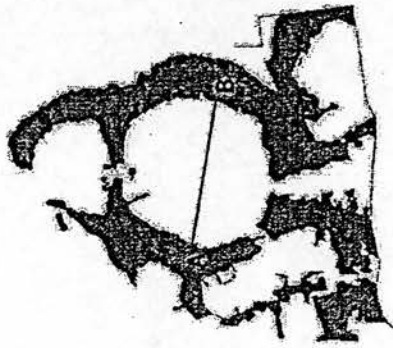
Stones/boulders

171/173 Context numbers
174/218
276/300
338/338
339/358

House 3

219

300

322

339

358

cut-337

218

276

cut-338

S120

Kubiena tins

276

322

218b

173/171

218

174

174

(After Neighbour 1996)

0   1m
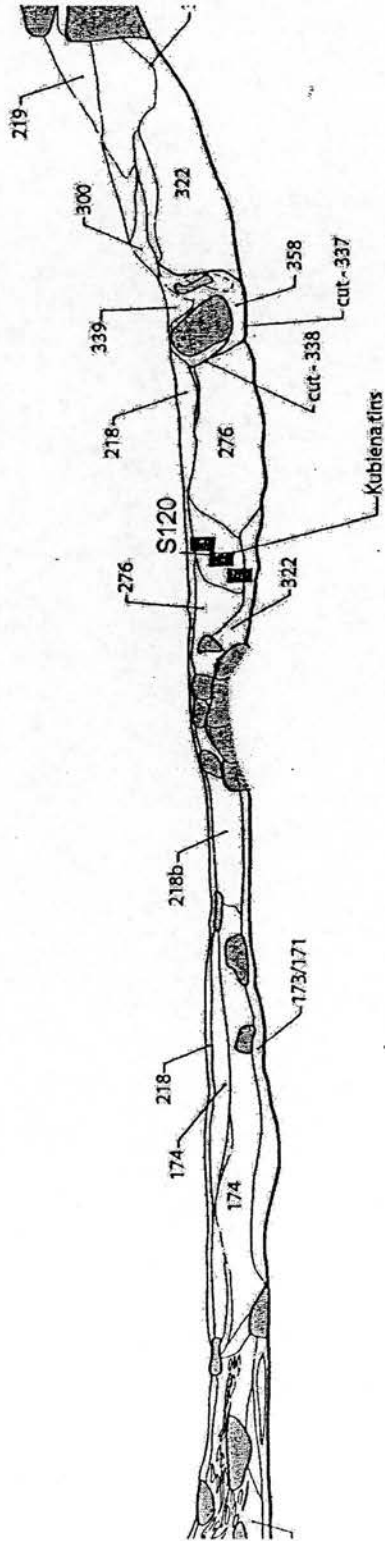
Figure 2.11: Location of Sample 120 in Structure L, House Three, Bostadh Beach

E100/N130

E110/N130

House 640

House 1370

0 ⎯⎯⎯⎯⎯⎯⎯⎯⎯ 5
metres

House 401

Forecourt
1300

N

House 801

E100/N100

E110/N100
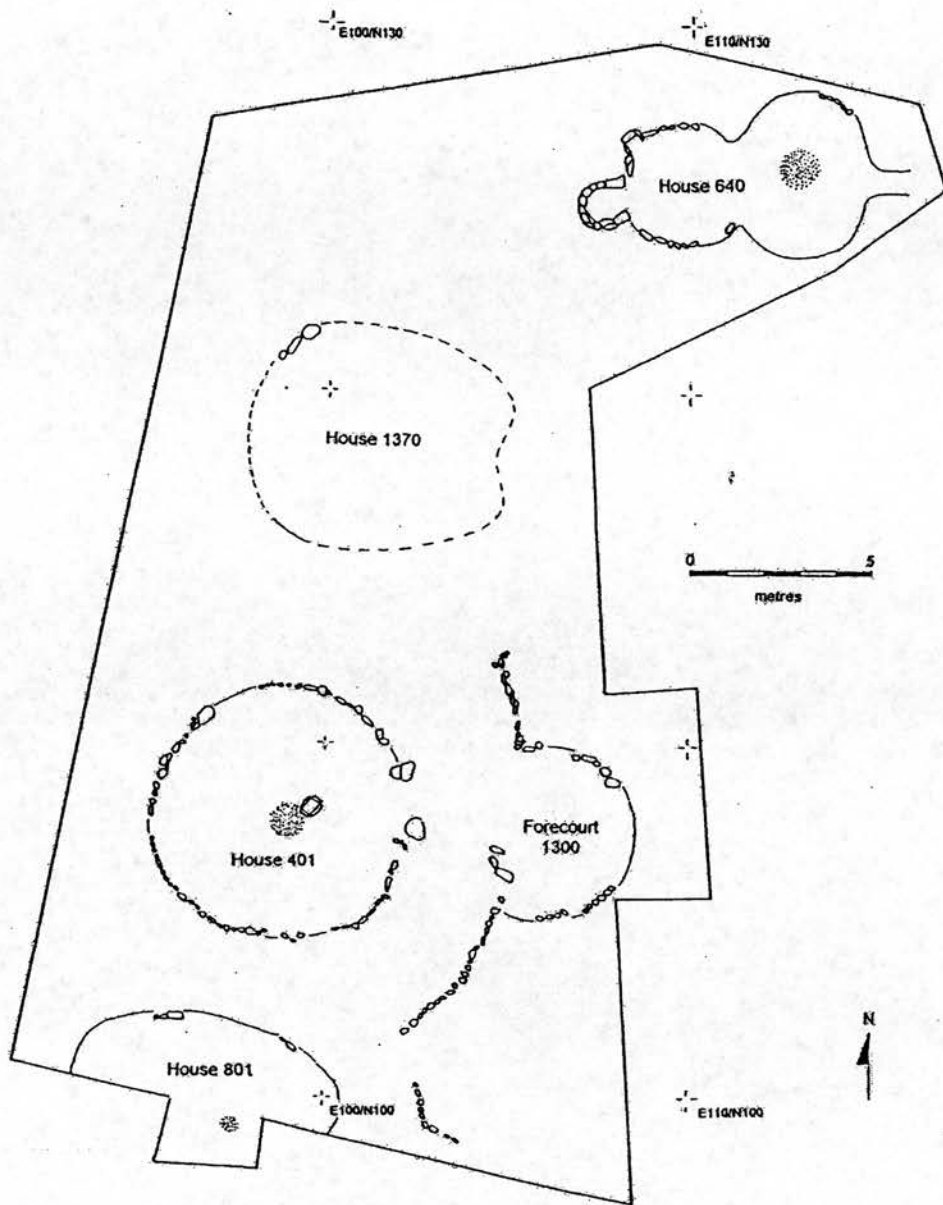
(After Parker-Pearson 2000)

Figure 2.12: Plan of Cladh Hallan Settlement, South Uist

343
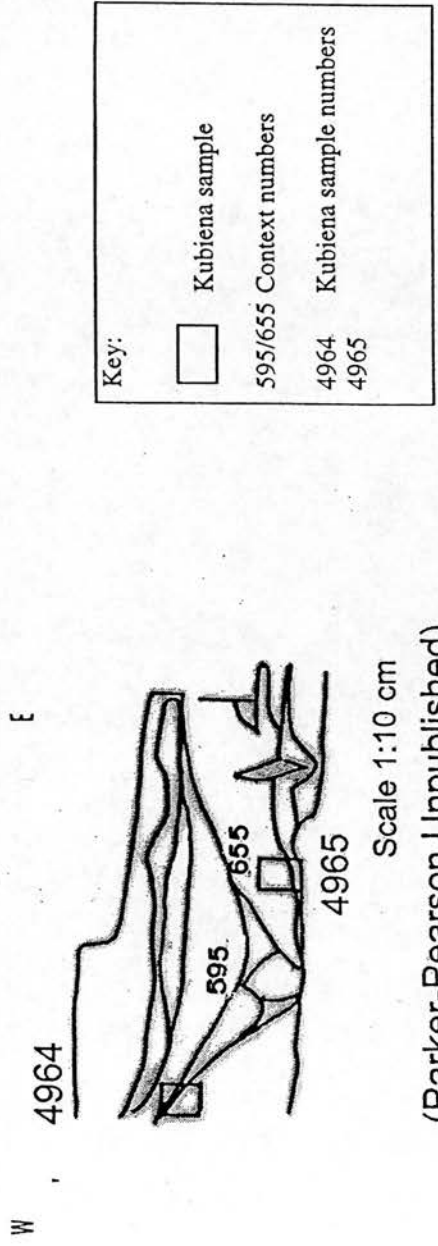
Figure 2.14: Location of Samples in the central area of the East-West transect, House 401, Cladh Hallan, South Uist
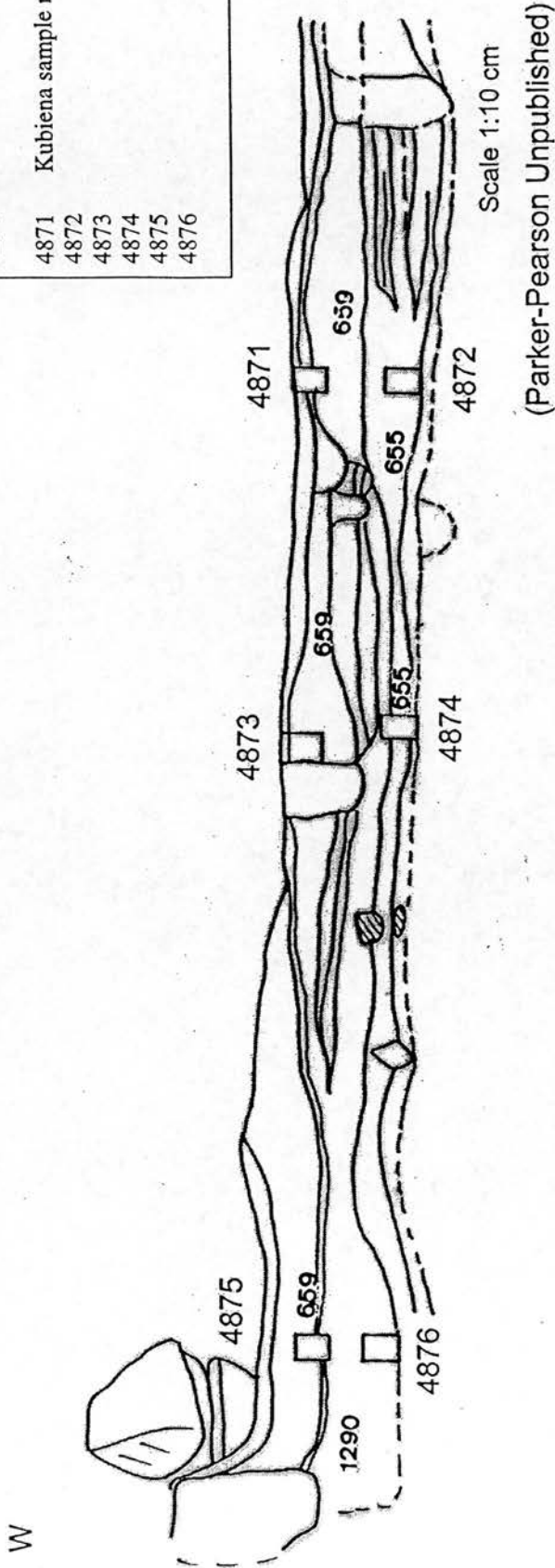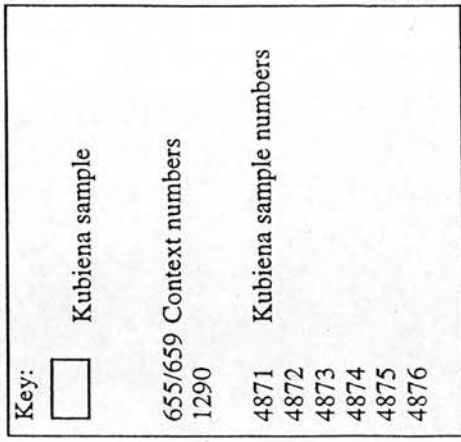
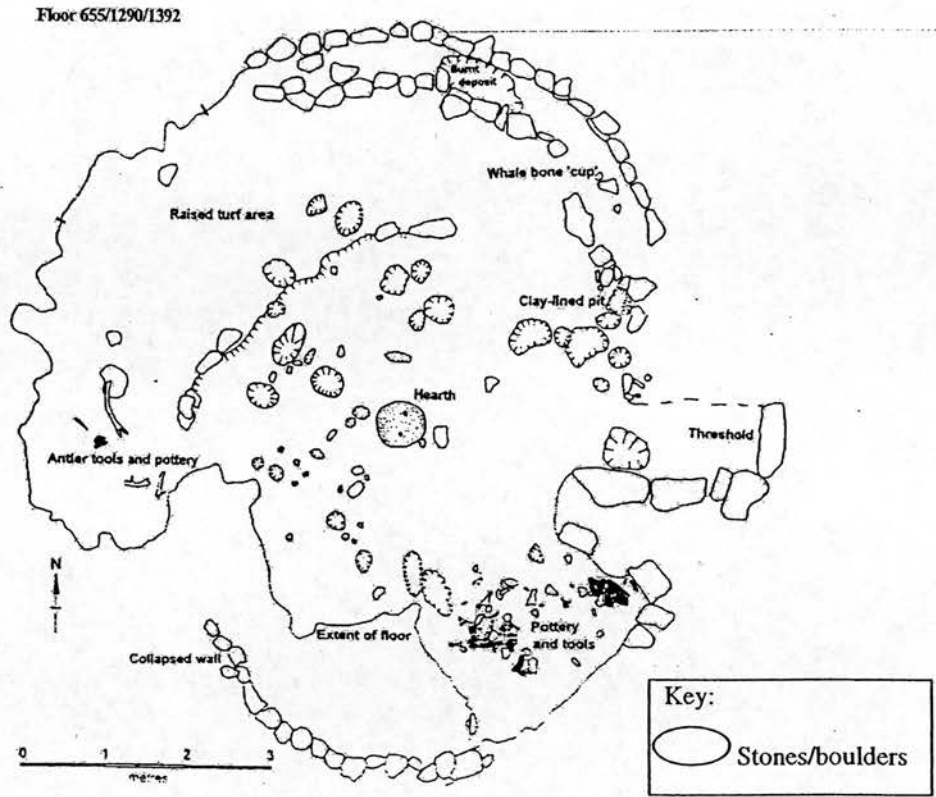Figure 2.15: Location of Samples in the western section of the East-West transect, House 401, Cladh Hallan, South Uist
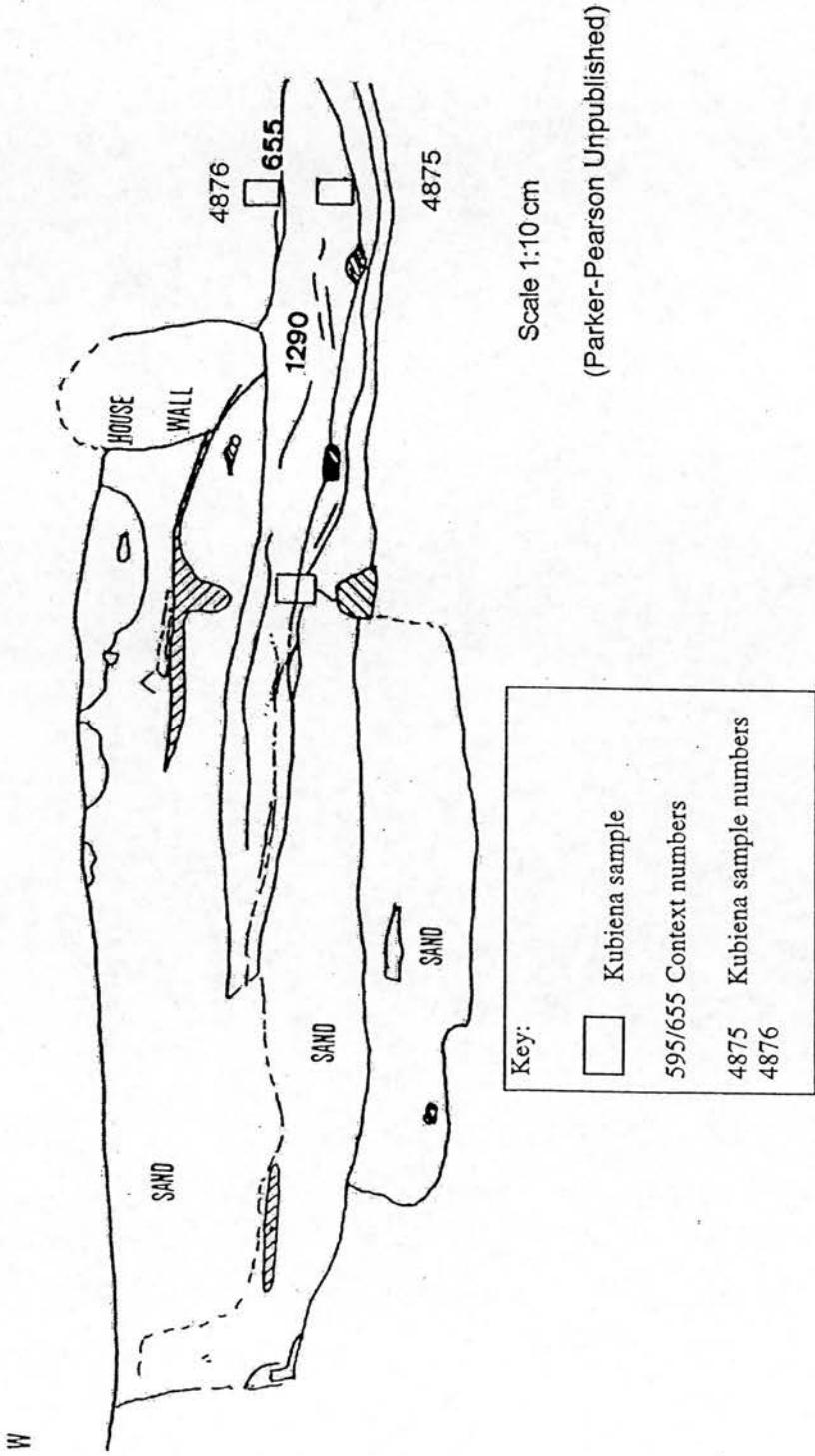
Figure 2.16: Location of samples in the far-Western section of the East-West transect, House 401, Cladh Hallan, South Uist

Scale 1:10 cm

(Parker-Pearson Unpublished)

Key:

☐   Kubiena sample

595/655   Context numbers

4875
4876   Kubiena sample numbers

Key:
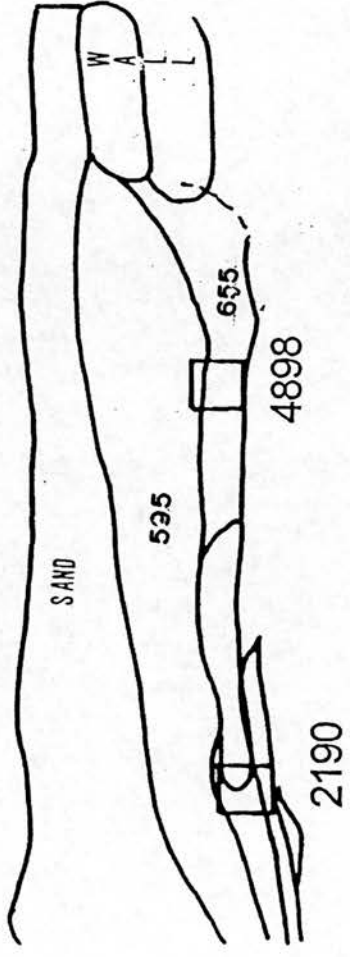
☐ Kubiena sample

595/655 Context number

2190 Kubiena sample numbers
4898

Scale 1:10 cm

(Parker-Pearson Unpublished)

Figure 2.17: Location of samples in the far-Northern section of the North-South transect, House 401, Cladh Hallan, South Uist

347
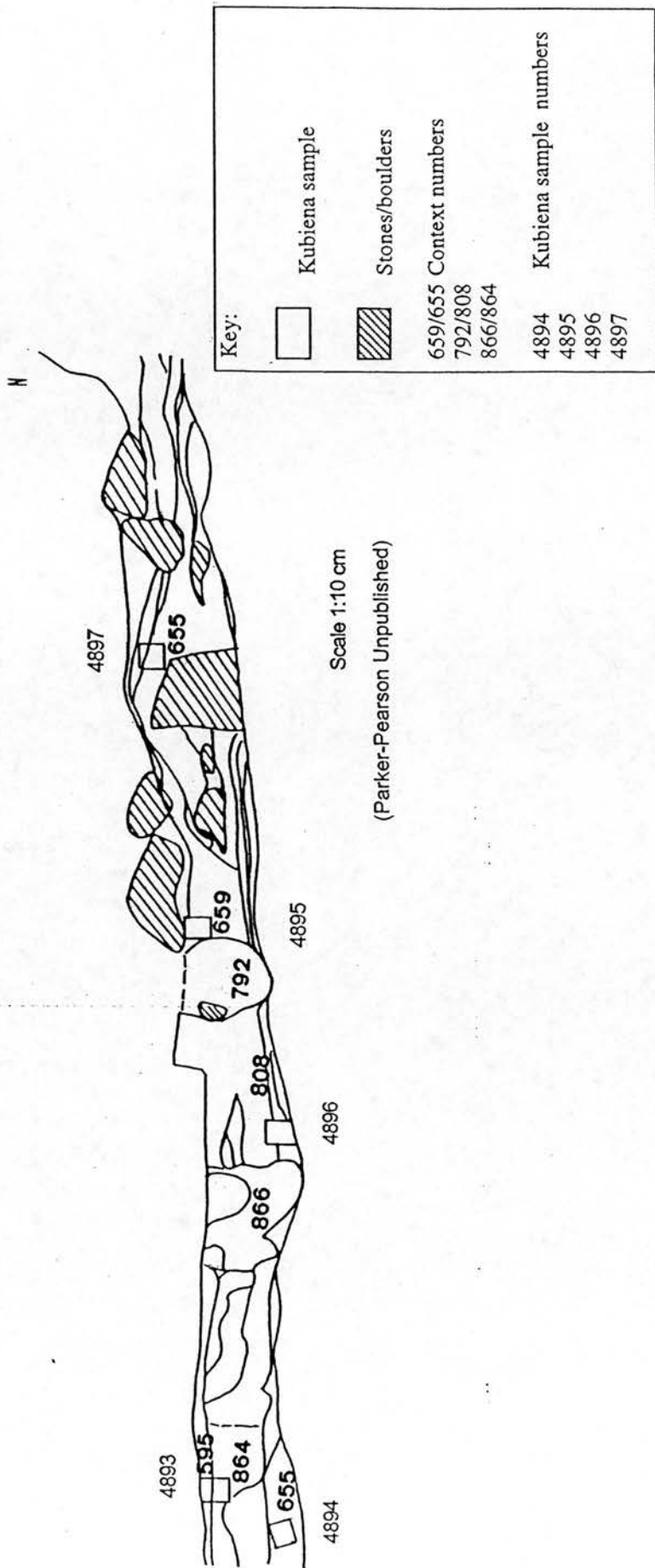
Figure 2.18: Location of samples in the Northern section of the North-South transect, House 401, Cladh Hallan, South Uist
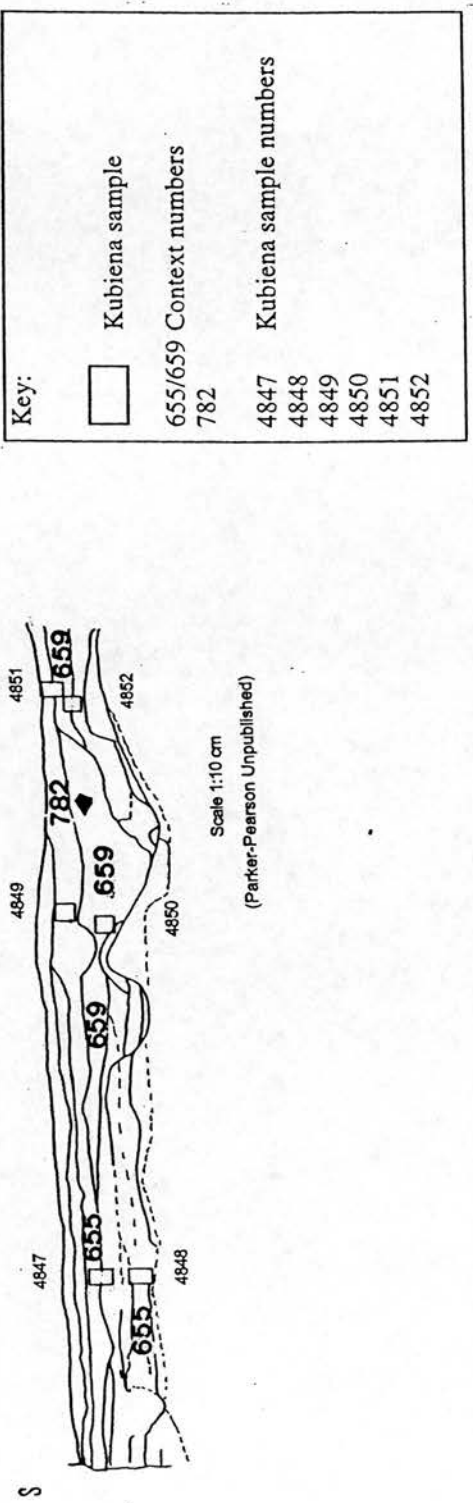
Figure 2.19: Location of samples in the Southern section of the North-South transect, House 401, Cladh Hallan, South Uiat

Floor 655/1290/1392

Raised turf area

Burnt deposit

Whale bone 'cup'

Clay-lined pit

Hearth

Threshold

Antler tools and pottery

N

Pottery and tools

Collapsed wall

Extent of floor

0   1   2   3
metres

Key:
Stones/boulders

(After Parker-Pearson 1998)

Figure 2.20: Plan of Floor 655, House 401, Cladh Hallan, South Uist

350
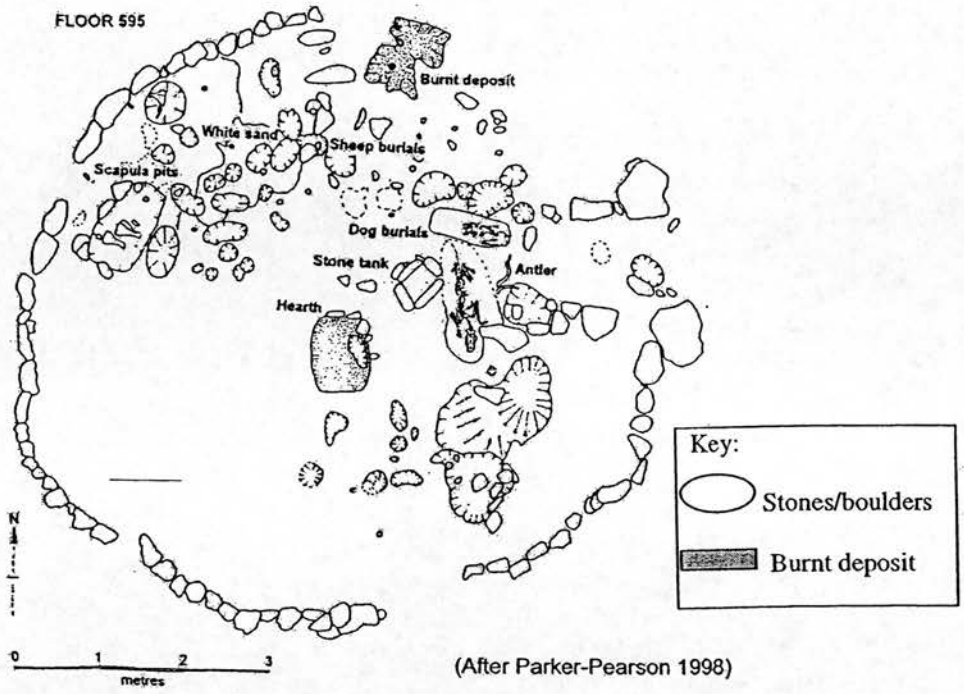
Figure 2.21: Plan of floor 595, House 401, Cladh Hallan, South Uist

Figure 2.22: Sample location in the East-West transect, House 640, Cladh Hallan, South Uist
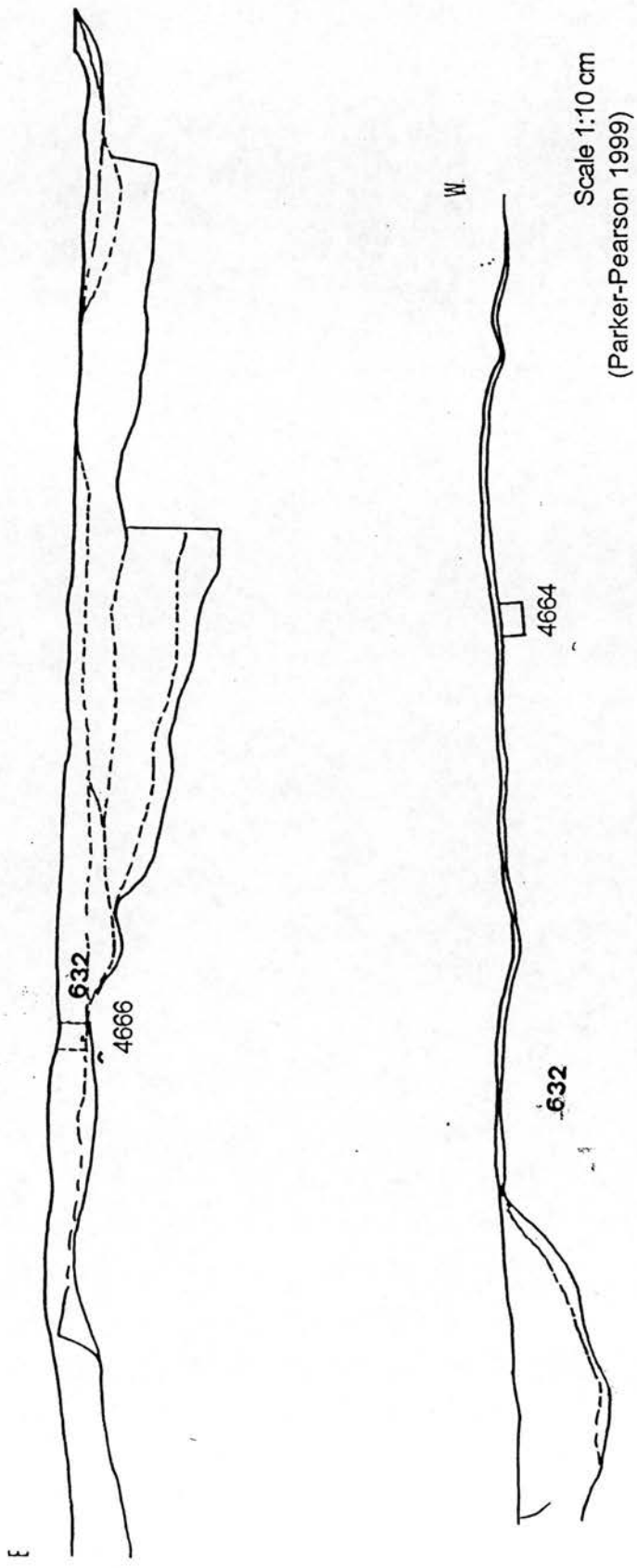
Scale 1:10 cm

(Parker-Pearson 1999)

Key:

☐ Kubiena sample

4664/4666 Sample number

632 Context number

Figure 2.23: Plan of House 640, Cladh Hallan, South Uist

Key:

1 Fire hearth
2 Wall of house
3 Ash deposits
4 Beach sand floor

AREA
DISTURBED

W

Scale 1:10 cm

(Parker-Pearson Unpublished)
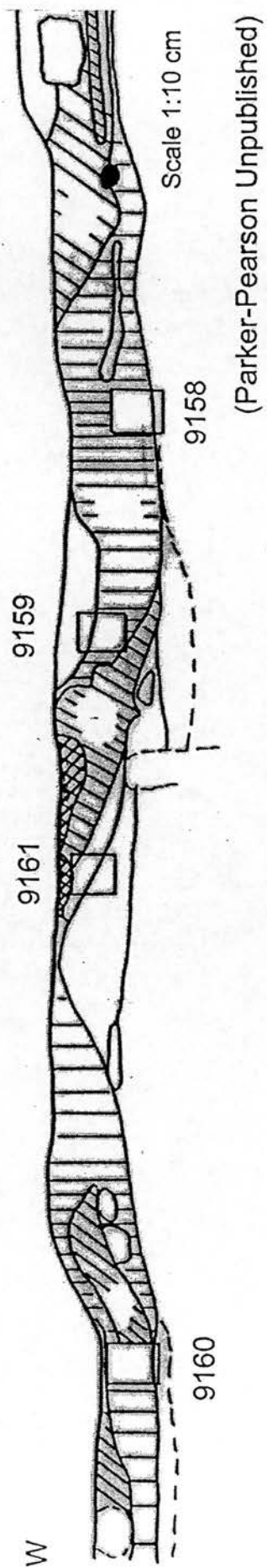
9158

9159

9161

9160

Key:

Kubiena sample

Charcoal from roof collapse

Sample numbers

9158
9159
9160
9161

Figure 2.24: Section through the floor and sample locations (East-West) of Mound 1, Bornais, South Uist

354

Key:

1 Fire hearth
2 Ash deposits
3 Stones/wall
4 Beach sand floor
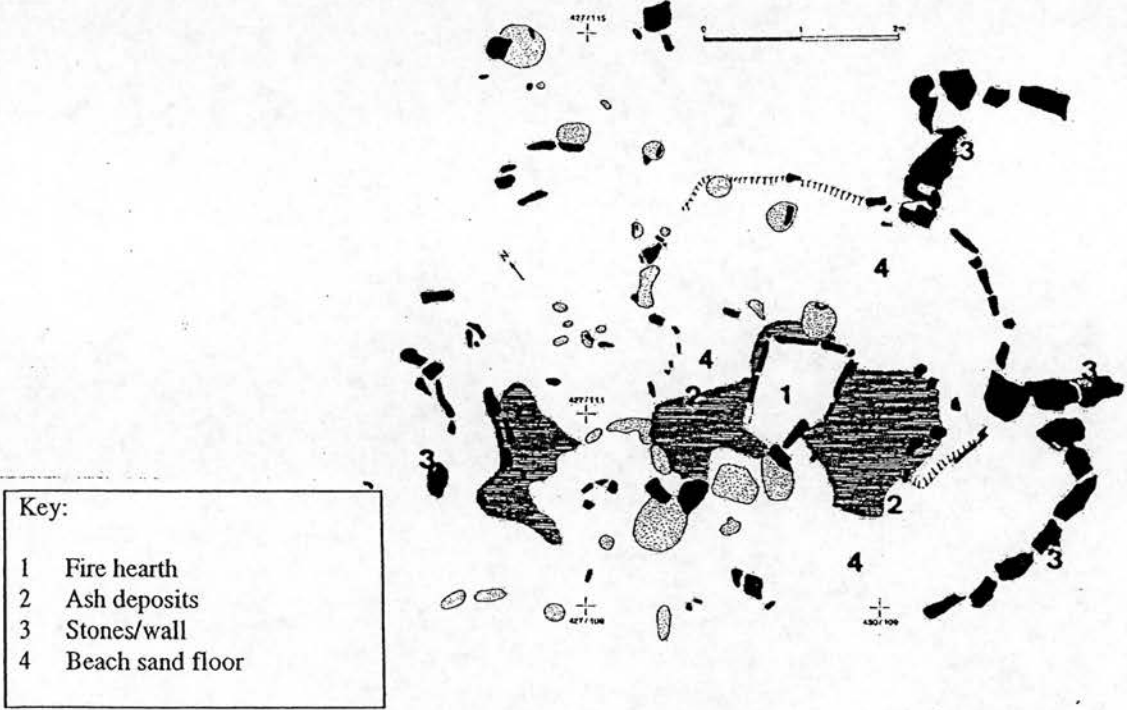
(After Sharples 1999)

Figure 2.25: Floor plan, House 1 (pre-burning), Mound 1 Bornais, South Uist
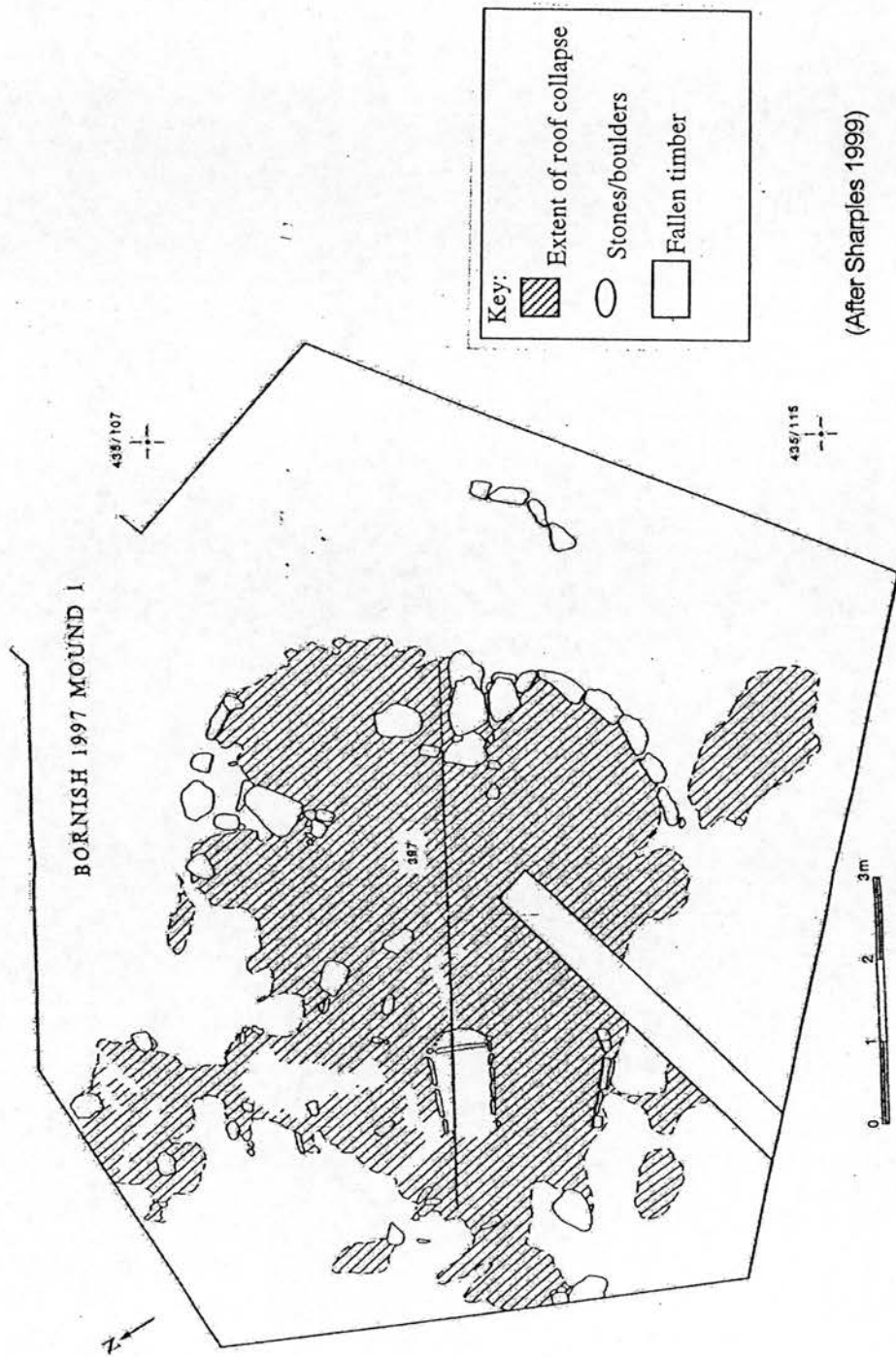
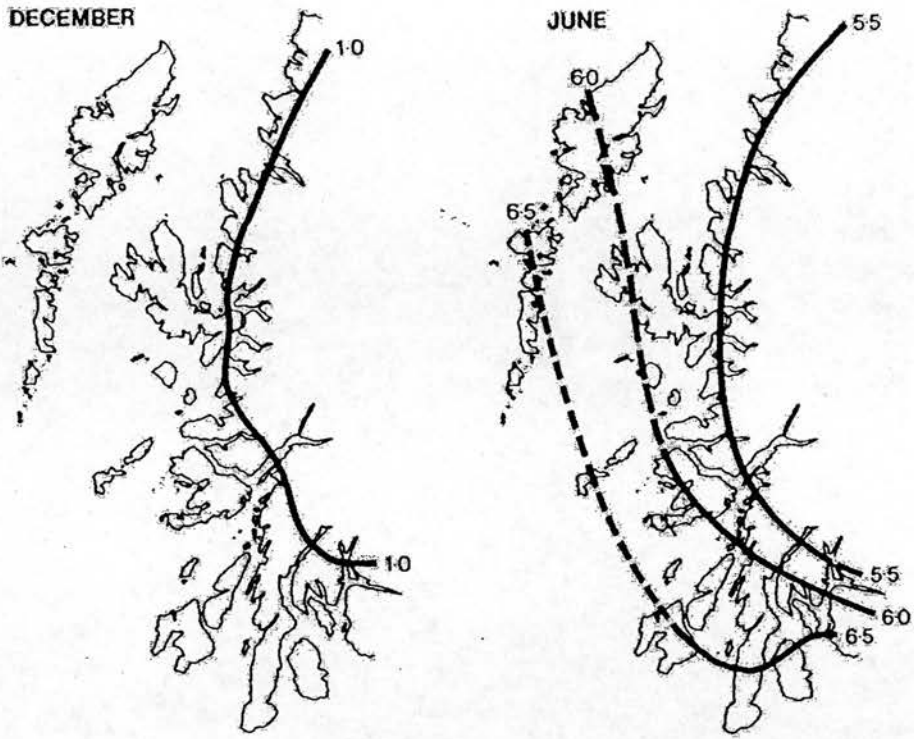Figure 2.26: Plan of floor 2 (post-burning), House 1 Mound 1, Bornais, South Uist
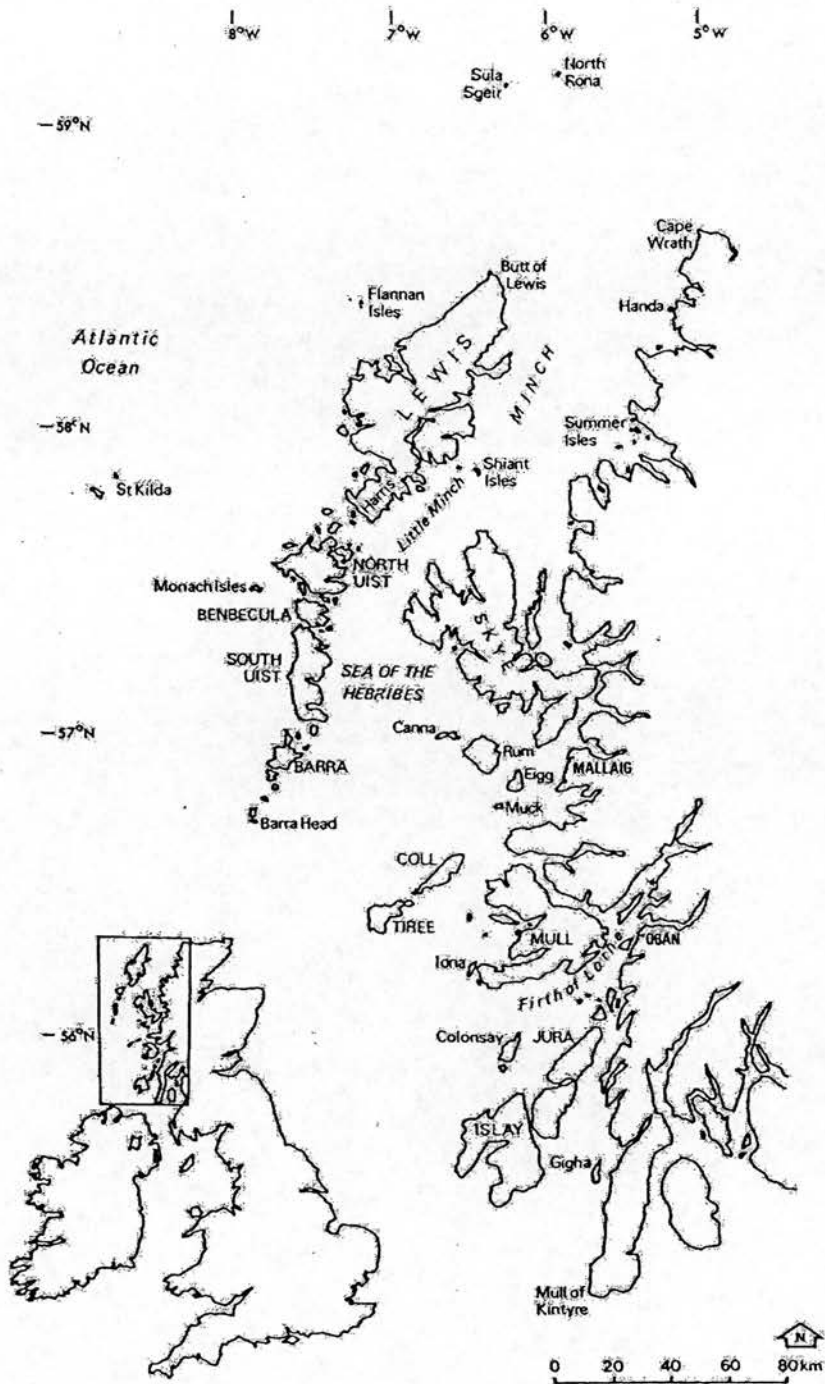
Figure 3.1: Location map of the Hebrides in relation to Scotland and the UK
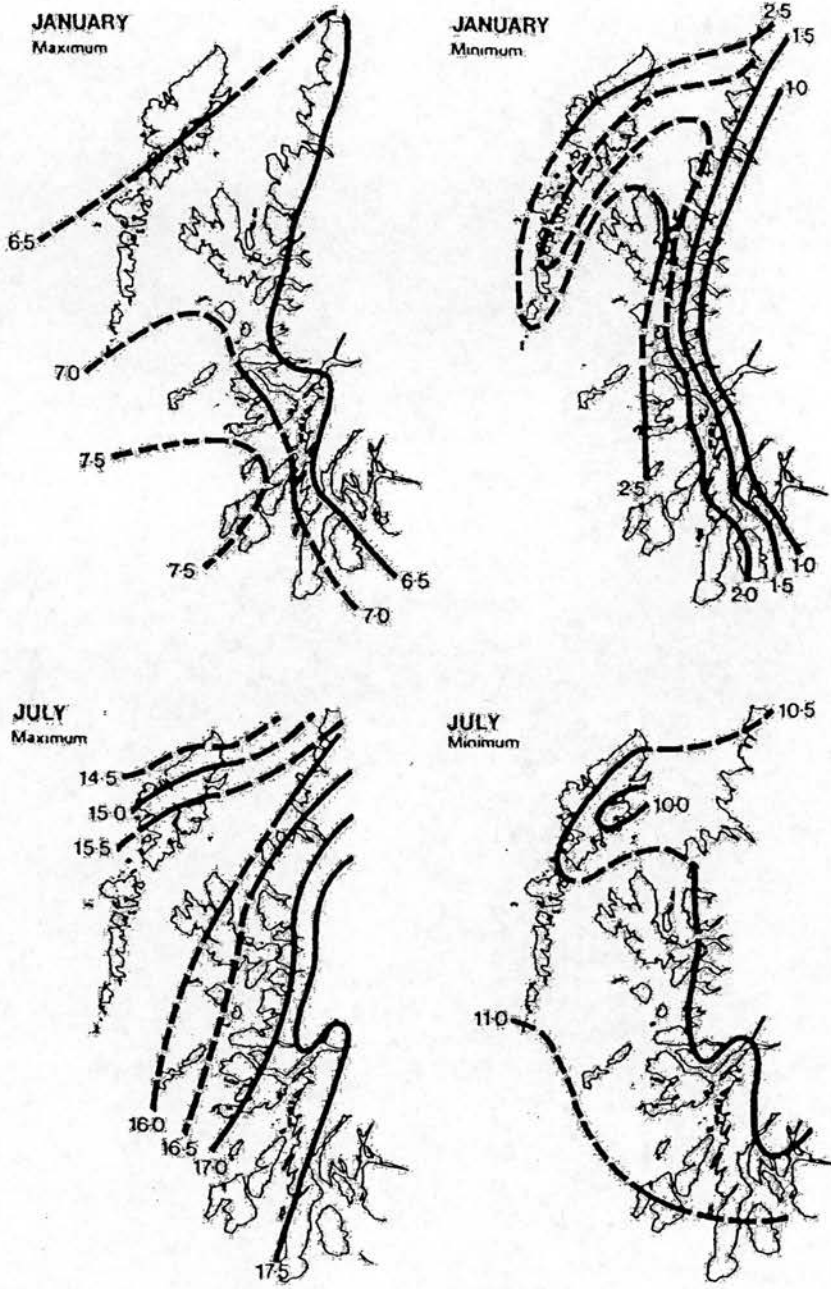(after Boyd and Boyd 1996)

(After Armit 1996)

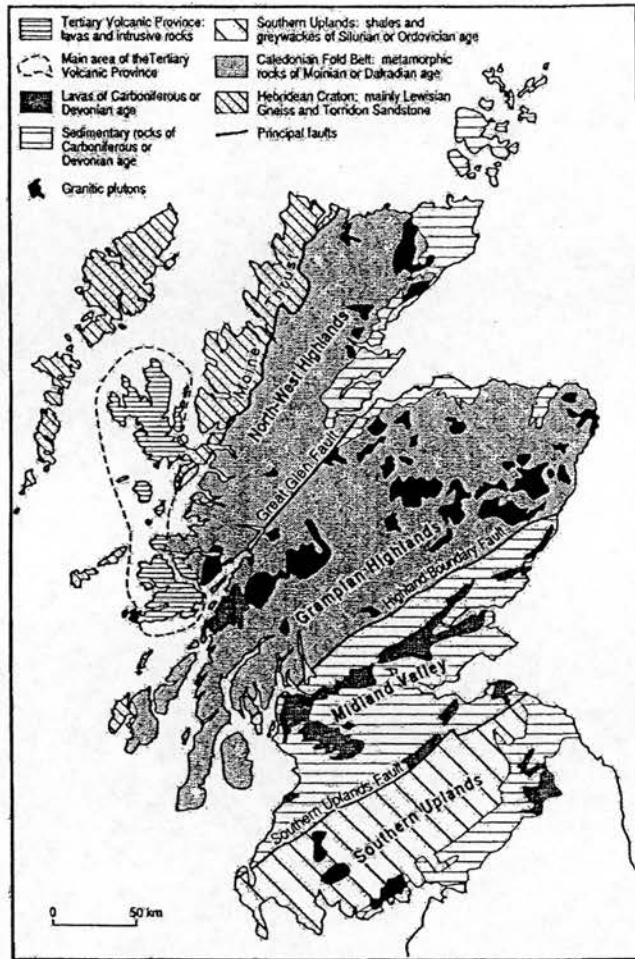Figure 3.2: Rainfall distribution (mm/year) map of the Outer Hebrides

DECEMBER

1·0

1·0

JUNE

5·5

6·0

6·5

6·5

5·5

6·0

6·5

(Scottish Meteorological Office 1989)

Figure 3.3:Average daily sunshine duration (Hours/day) in June and
December for the Hebrides

(Scottish Meteorological Office 1989)

Figure 3.4: Mean daily maximum and minimum temperatures (°C) in the Hebrides for January and July

Legend:

- Tertiary Volcanic Province: lavas and intrusive rocks
- Main area of the Tertiary Volcanic Province
- Lavas of Carboniferous or Devonian age
- Sedimentary rocks of Carboniferous or Devonian age
- Granitic plutons
- Southern Uplands: shales and greywackes of Silurian or Ordovician age
- Caledonian Fold Belt: metamorphic rocks of Moinian or Dalradian age
- Hebridean Craton: mainly Lewisian Gneiss and Torridon Sandstone
- Principal faults

North-West Highlands
Great Glen Fault
Grampian Highlands
Highland Boundary Fault
Midland Valley
Southern Uplands Fault
Southern Uplands

0   50 km

(After Ballantyne and Dalrymple 1997)

Figure 3.5: Geological distribution of Scotland, illustrating Gneiss dominance in the Outer Hebrides

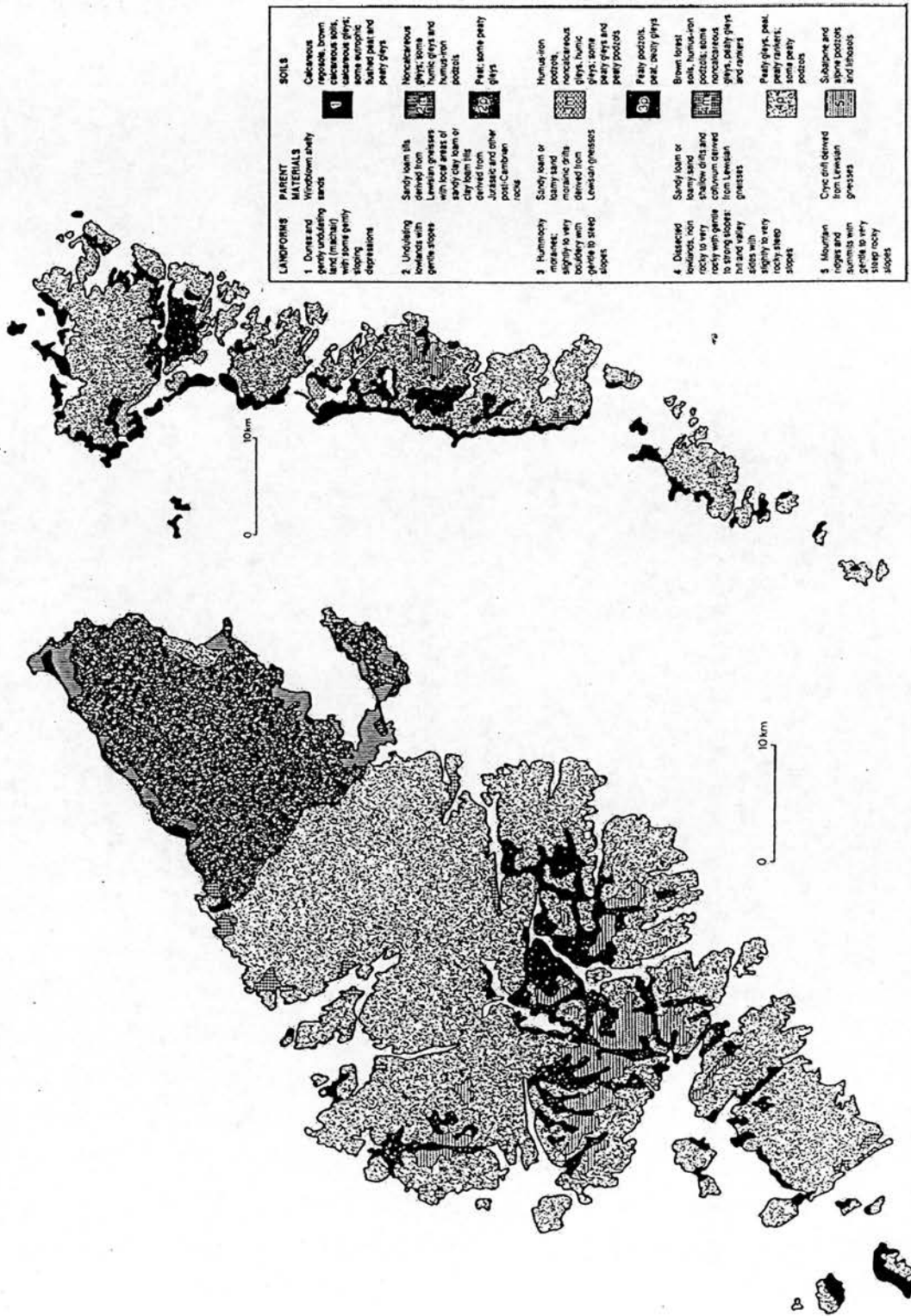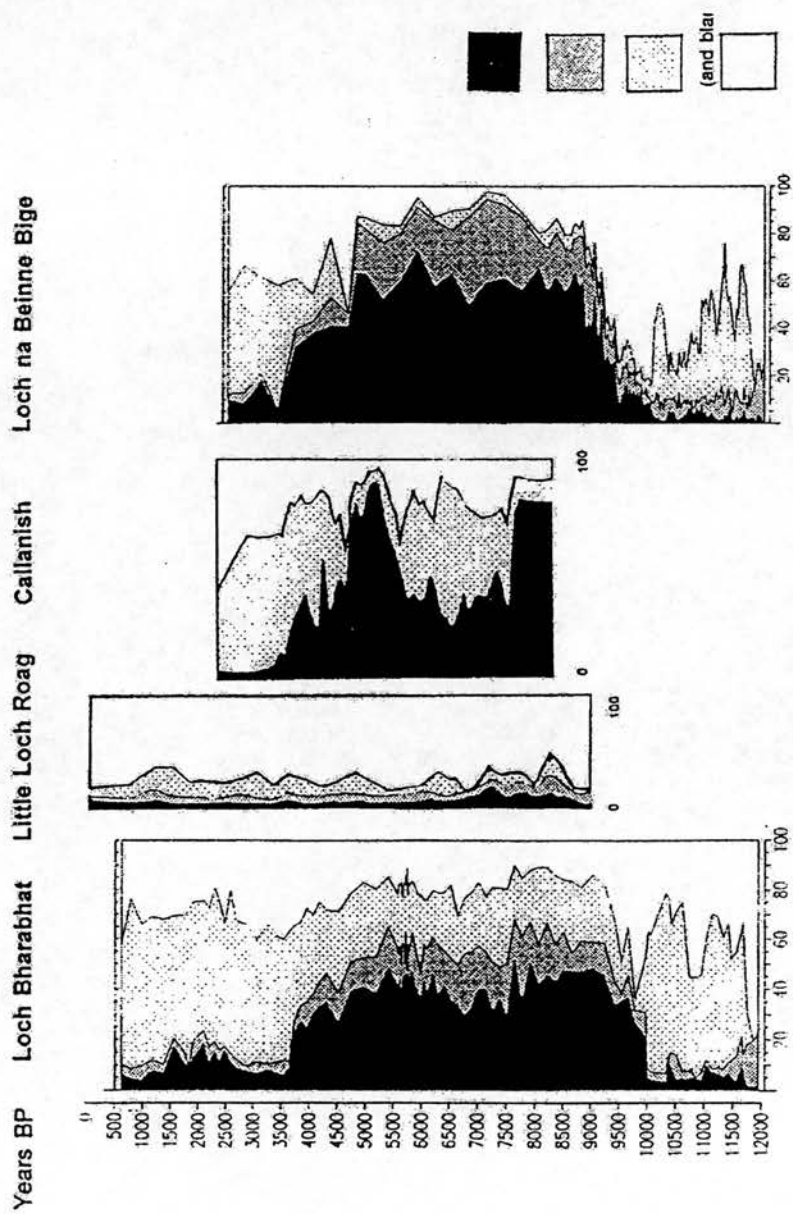Figure 3.6: Soils of Lewis and South Uist, Outer Hebrides, Scotland (After Pankhurst and Mullin 1994)

Figure 3.7: Pollen diagrams of vegetation change in the Calanais area, Isle of Lewis, Scotland

(After Edwards et a

(After Lindsay 1995)
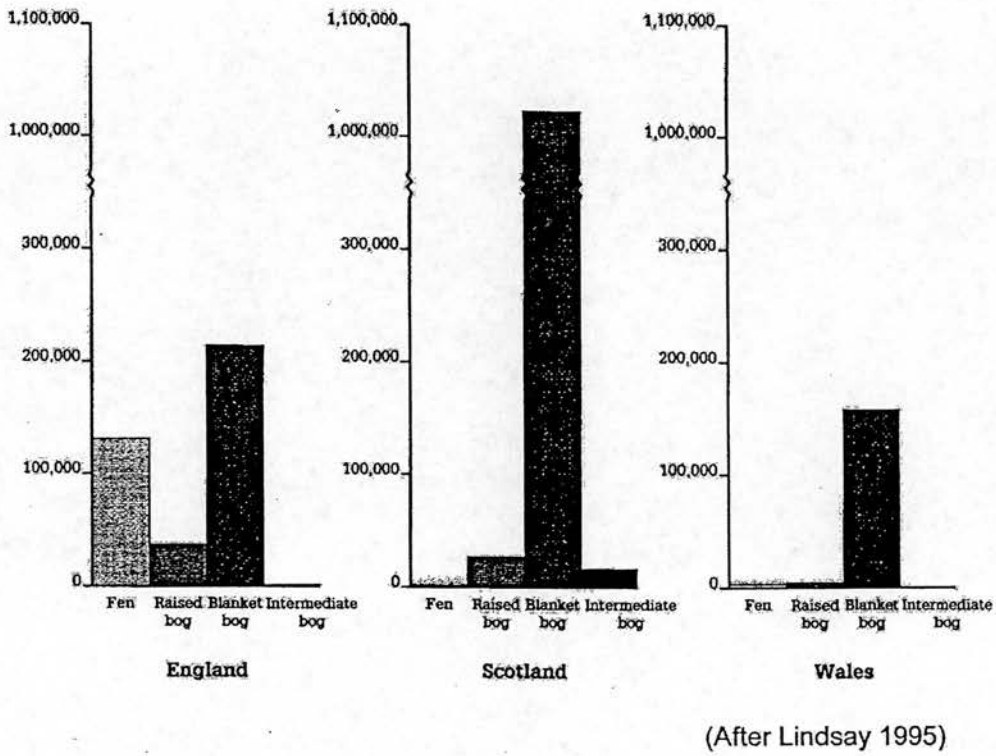
Figure 4.1: Summary of UK peat coverage (hectares)

Sandy Soil

Peat/Peaty Soil
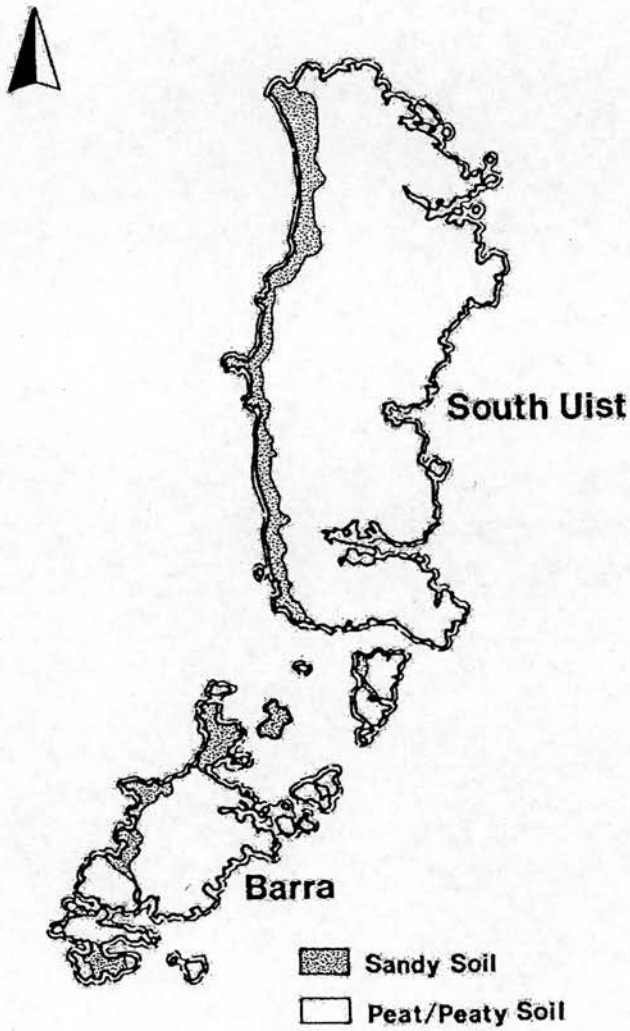
(After Armit 1996)

Figure 4.2: Peat distribution map of South Uist, Scotland

Cyclic vegetation change
Human activity
Arable agriculture
Lightning strikes
Grazing
Fire → Tree removal
Drought
Reduced interception and transpiration
Development of heathland
Charcoal
Soil erosion
Increased catchment run-off
Reduced soil porosity
Increased precipitation
Podsolization (pan formation)
Creation of silty, gleyed soils in valleys
Valley mire formation
INCREASED WATER INPUT TO MIRE
Temperature
Peat erosion
Evapotranspiration
Peatland drainage
Water retained
Water draining from the system
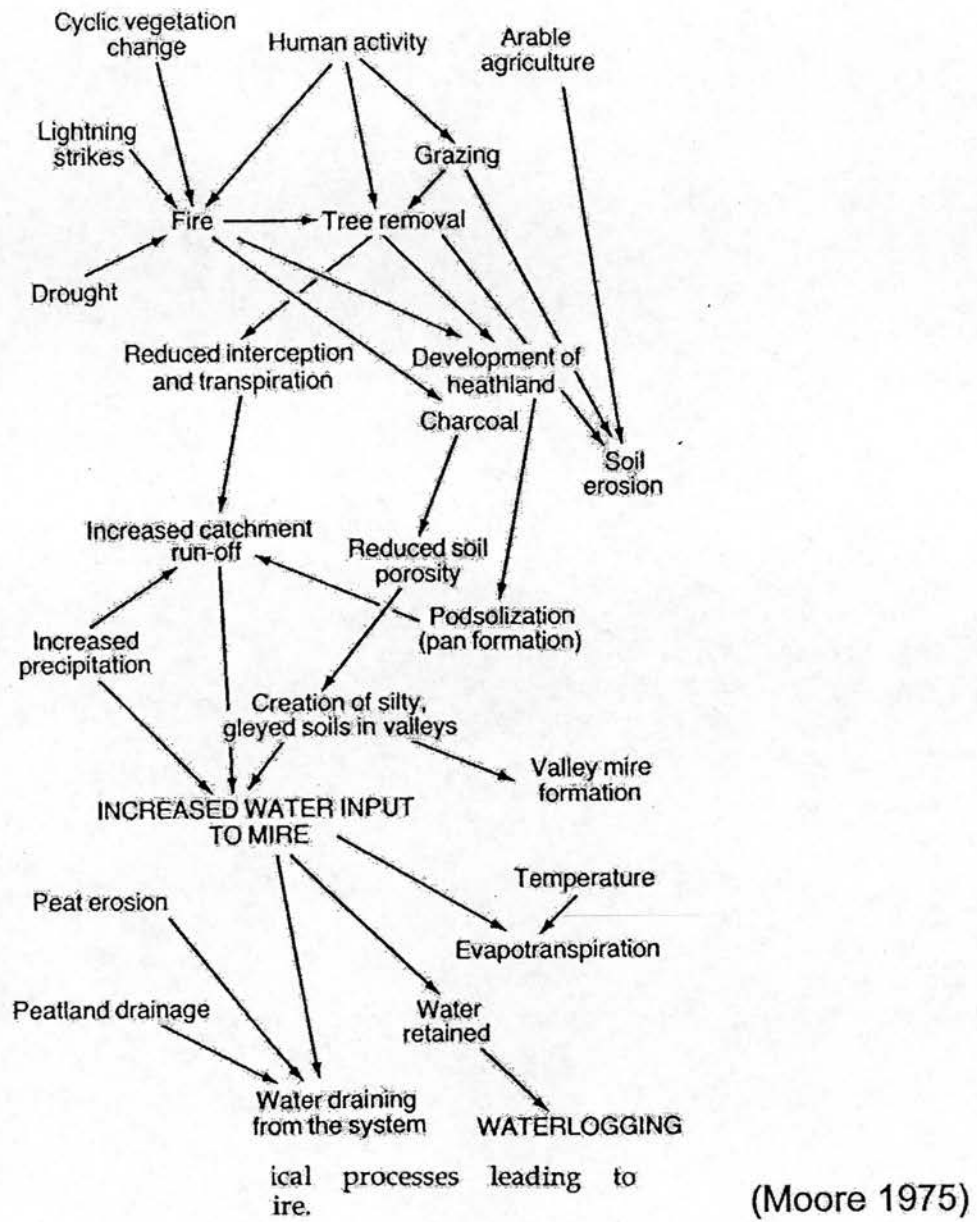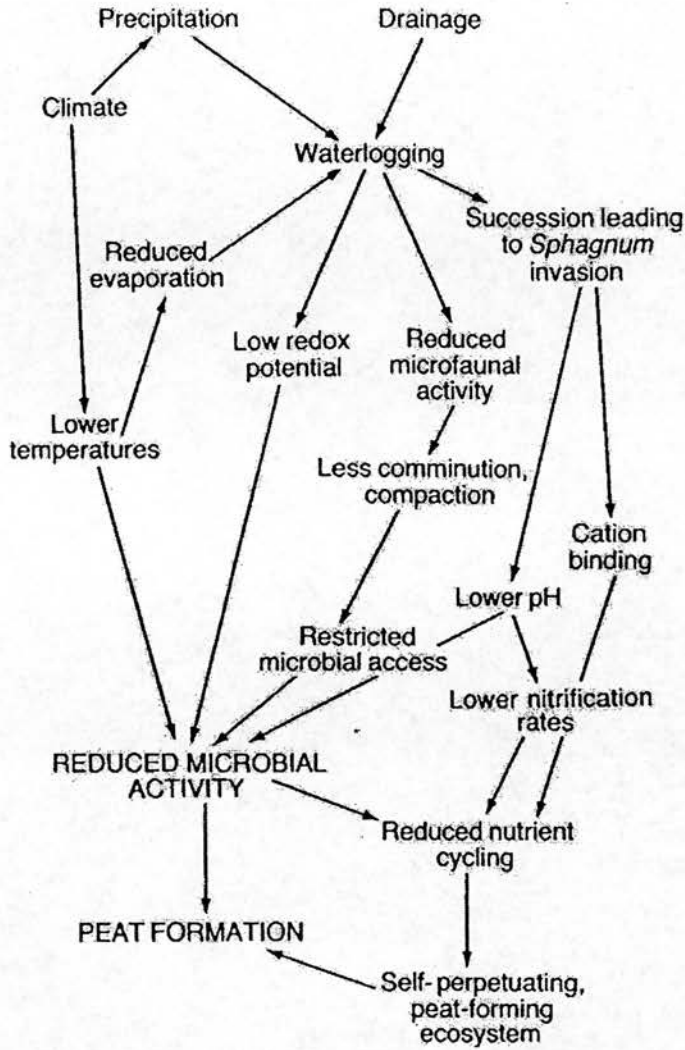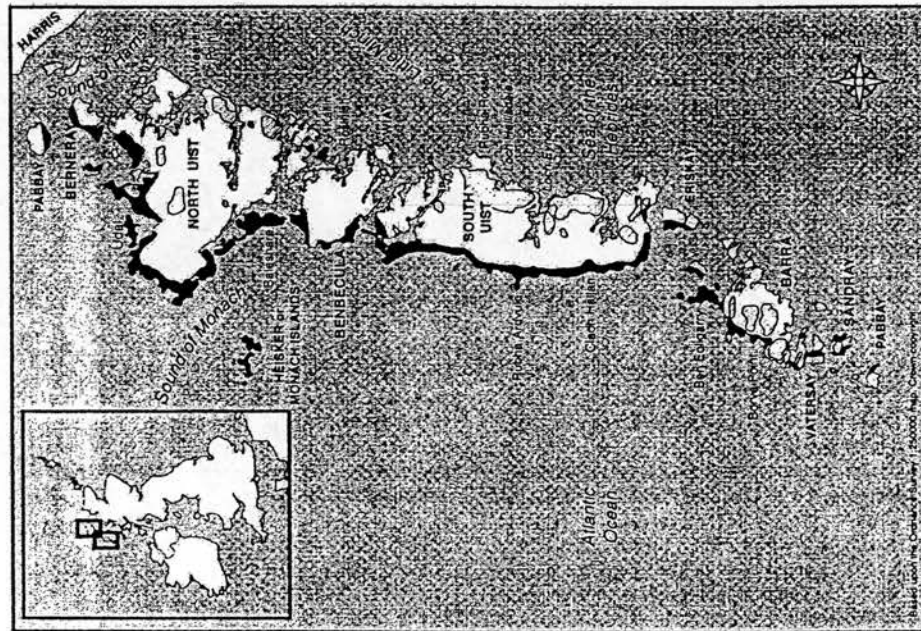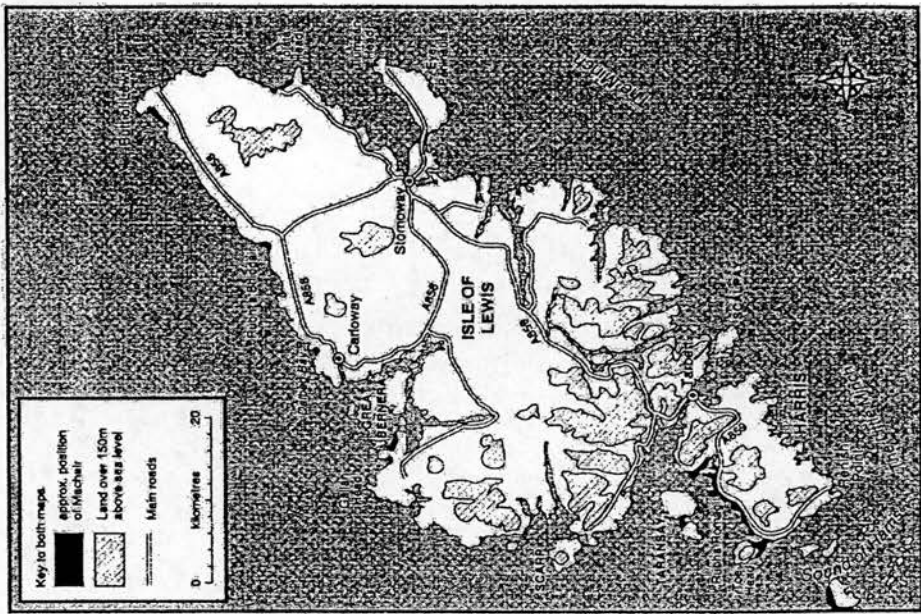WATERLOGGING

ical processes leading to ire.

(Moore 1975)

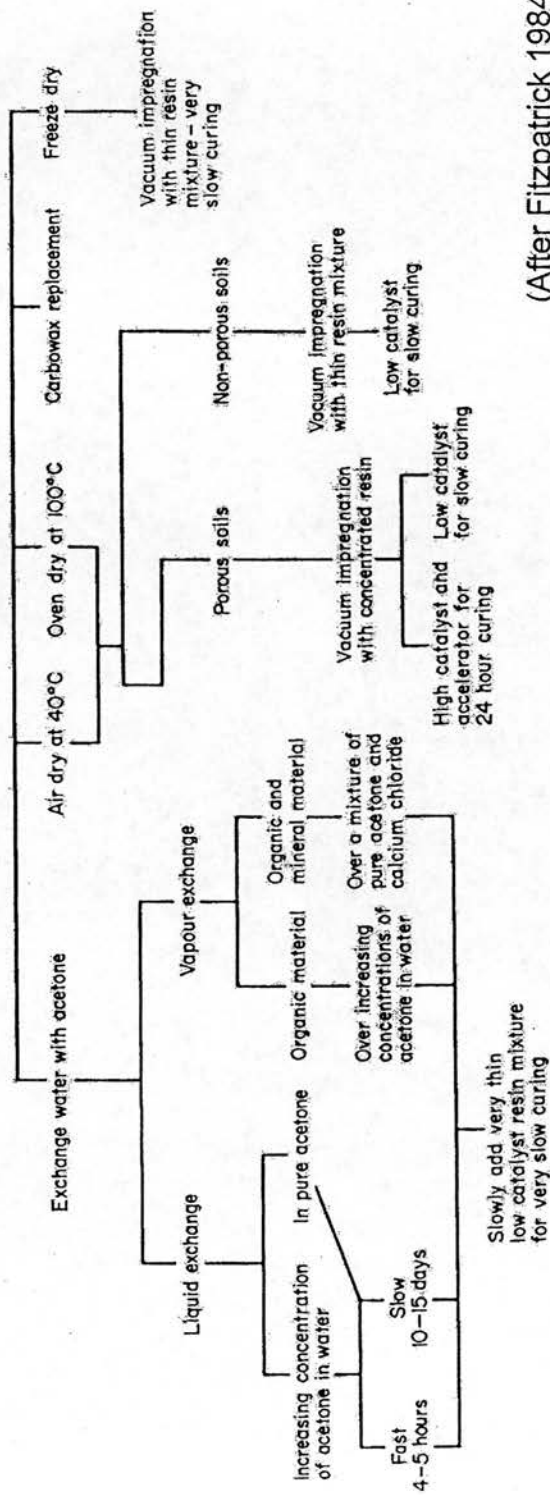Figure 4.3: Hydrological processes leading to waterlogging in a mire

(After Moore 1993)

Figure 4.4: Factors in the formation of peat

Figure 4.5: Machair distribution throughout the Outer Hebridean Islands

(After Ritchie 1991)

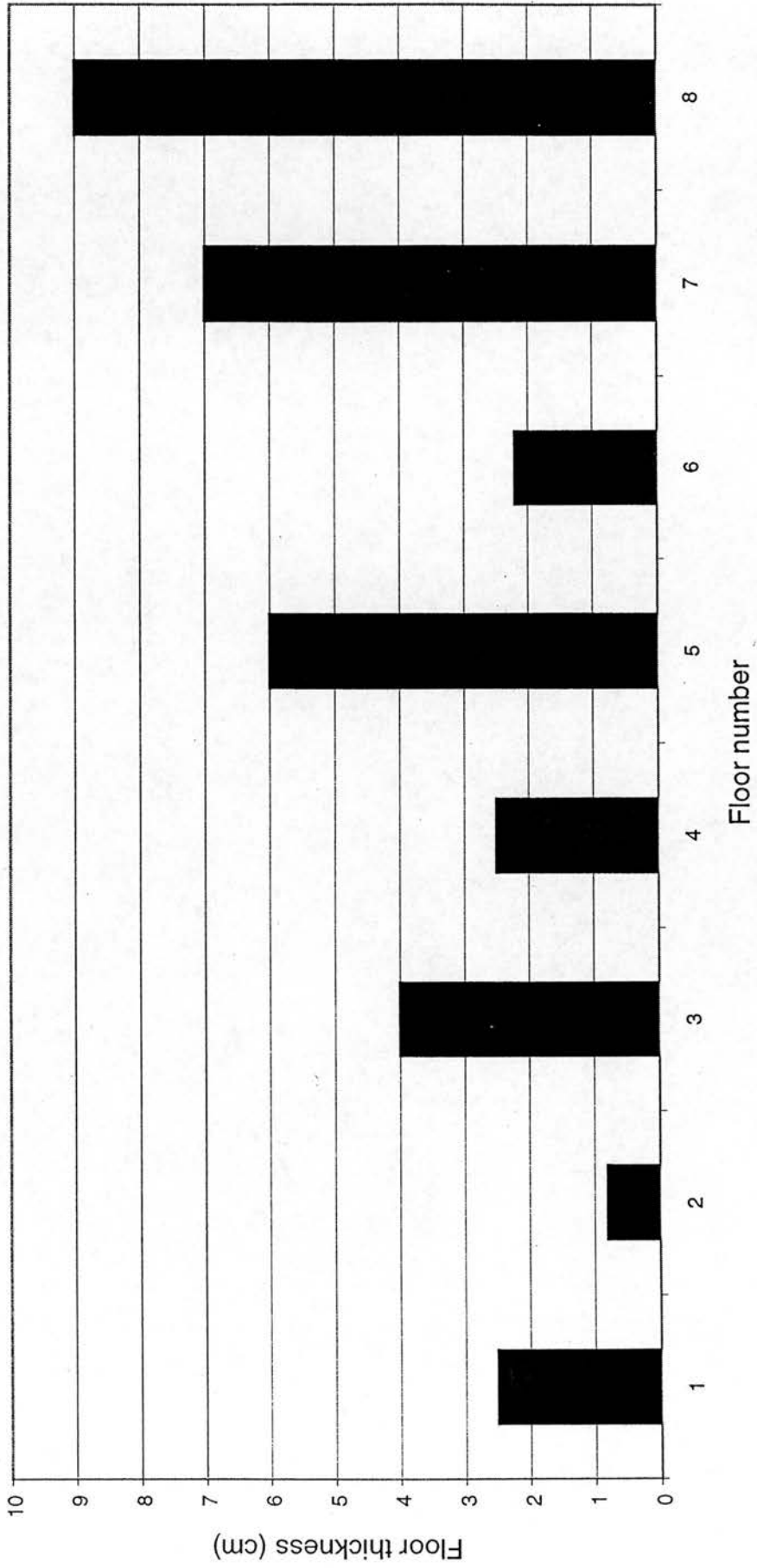Figure 5.1: Various methods of water replacement for thin section manufacture

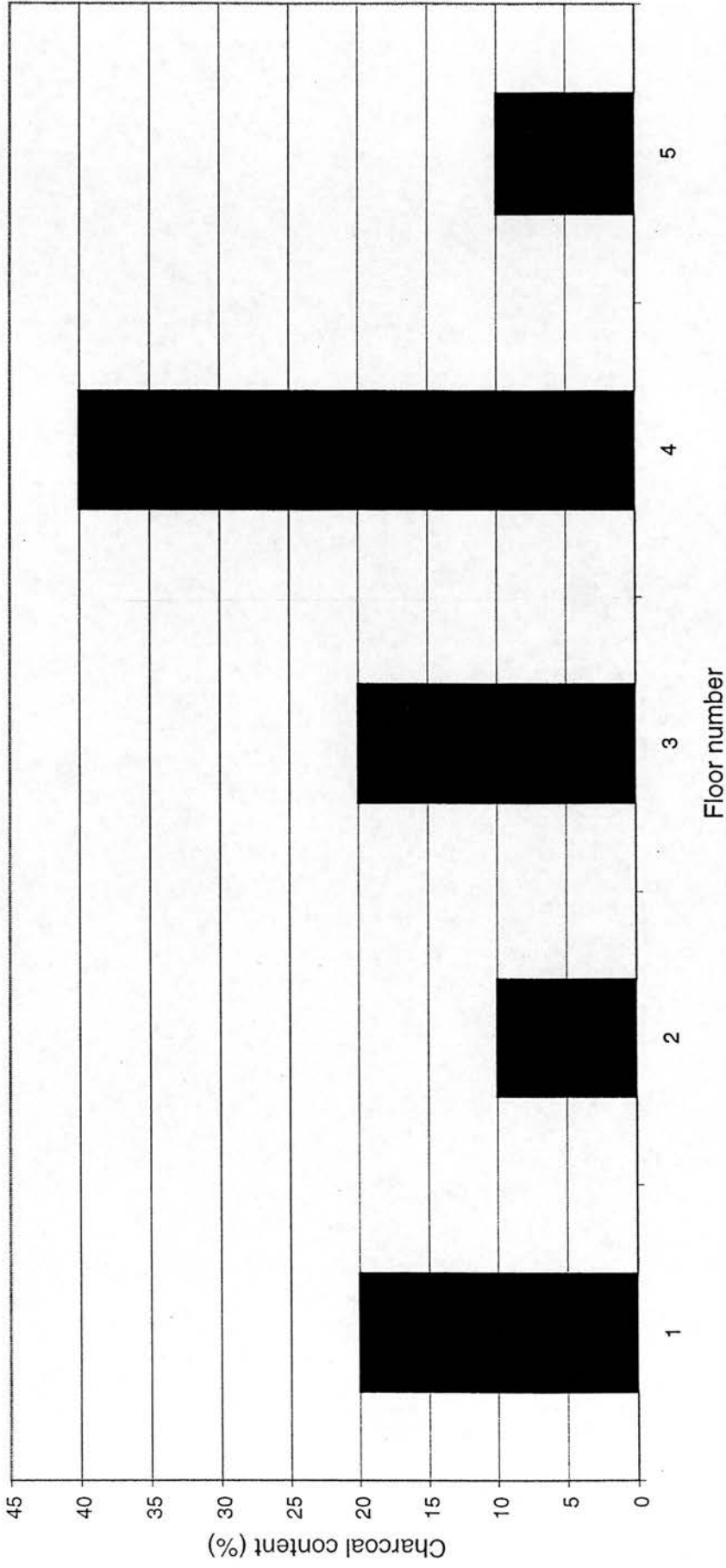(After Fitzpatrick 1984)

Bostadh Beach

Number and Thickness of Floors and Charcoal Content Graphs

(6.1-6.10)

Graph 6.1: House Three, Structure L, Sample 160: Number and Thickness of floors at the stepped area between structures L and G

Graph 6.2: House Three, Structure L: Sample 160: Charcoal content in each floor at the stepped area between structures L and G

Graph 6.3: House Three, Structure L, Sample 178: Number and thickness of floors at the entrance of the House

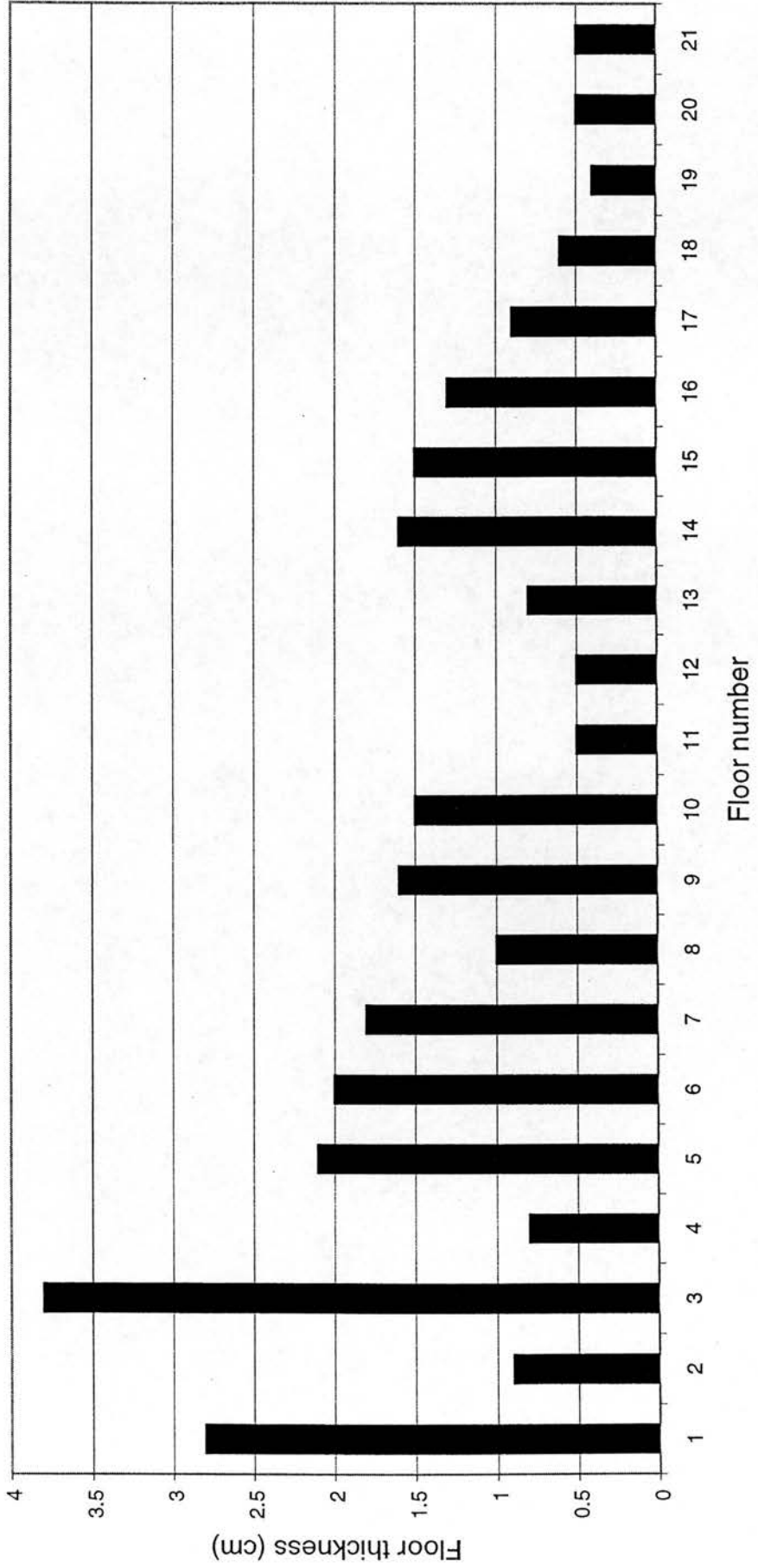Graph 6.4: House Three Structure L: Sample 178: Charcoal content of each floor at the entrance of the structure
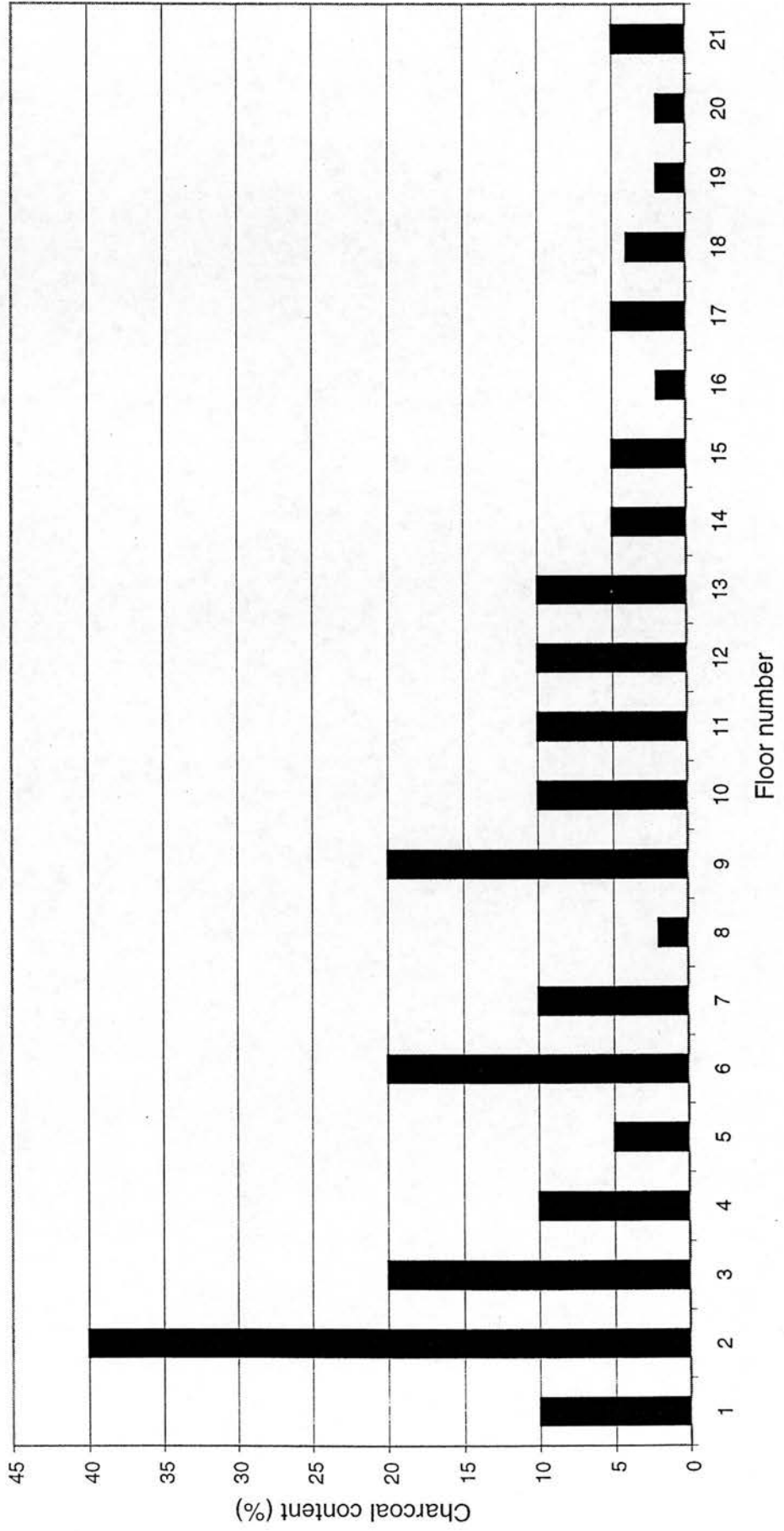
Graph 6.5: House Three, Structure L, Sample 120: Number and Thickness of floors in the central area of the structure
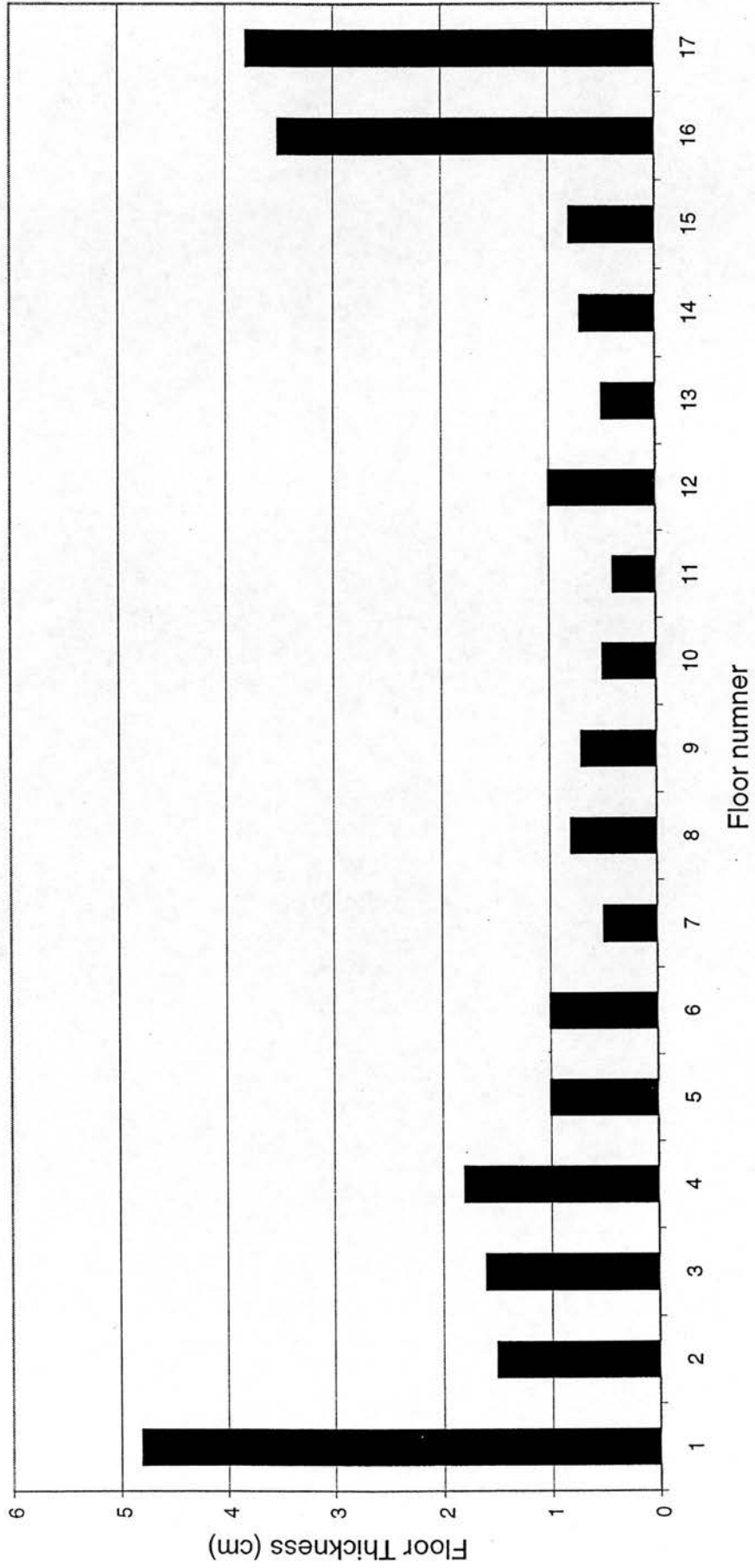
Graph 6.6: House Three Structure L: Sample 120: Charcoal content of each floor of the central area of the structure
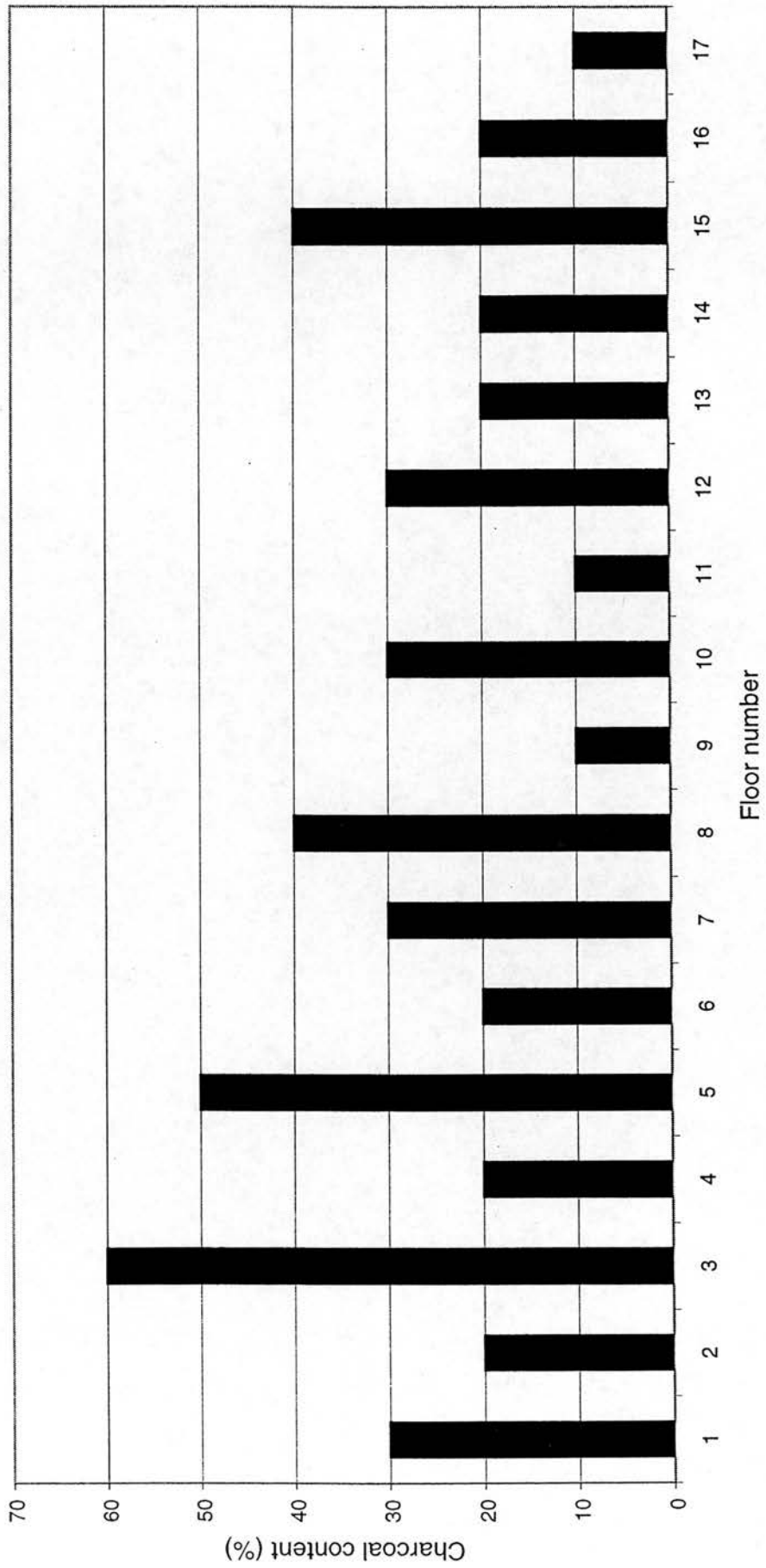
Graph 6.7: House Three, Structure H, sample 133: Number and Thickness of floors in the structure
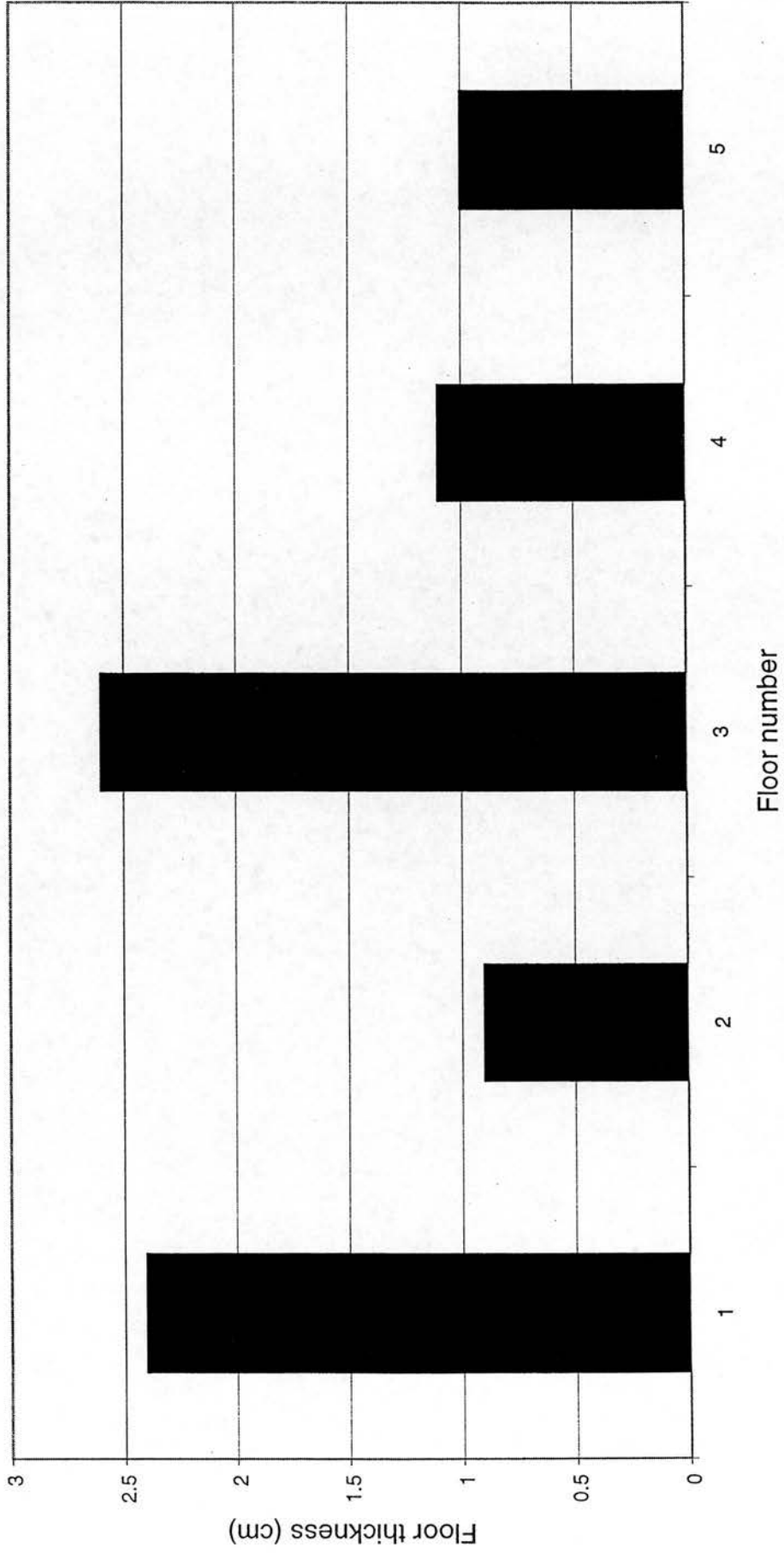
Graph 6.8: House Three Structure H: Sample 133: Charcoal content in each floor of the structure
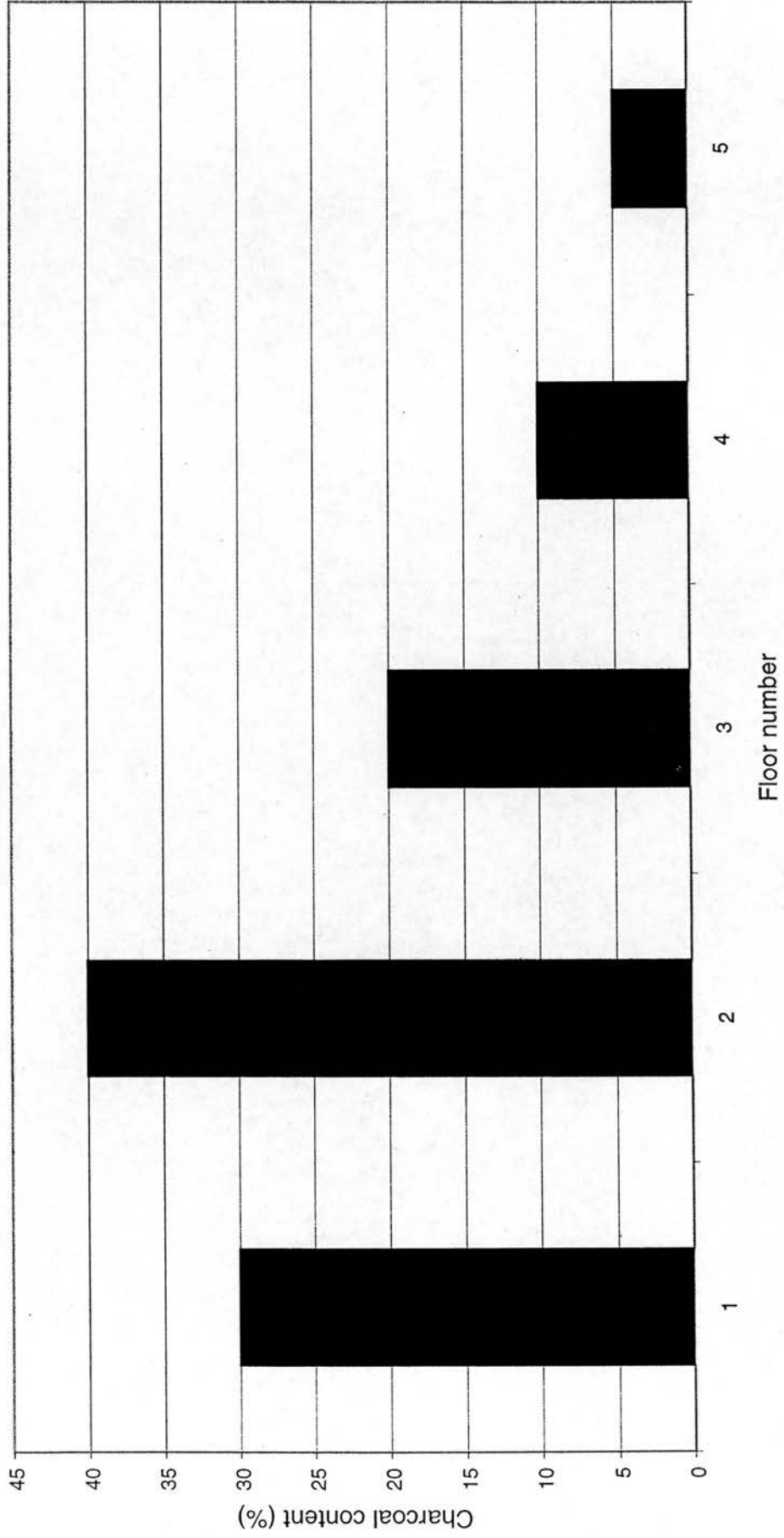
Graph 6.9: House Three, Structure J, Sample 128: Number and Thickness of floors in the structure
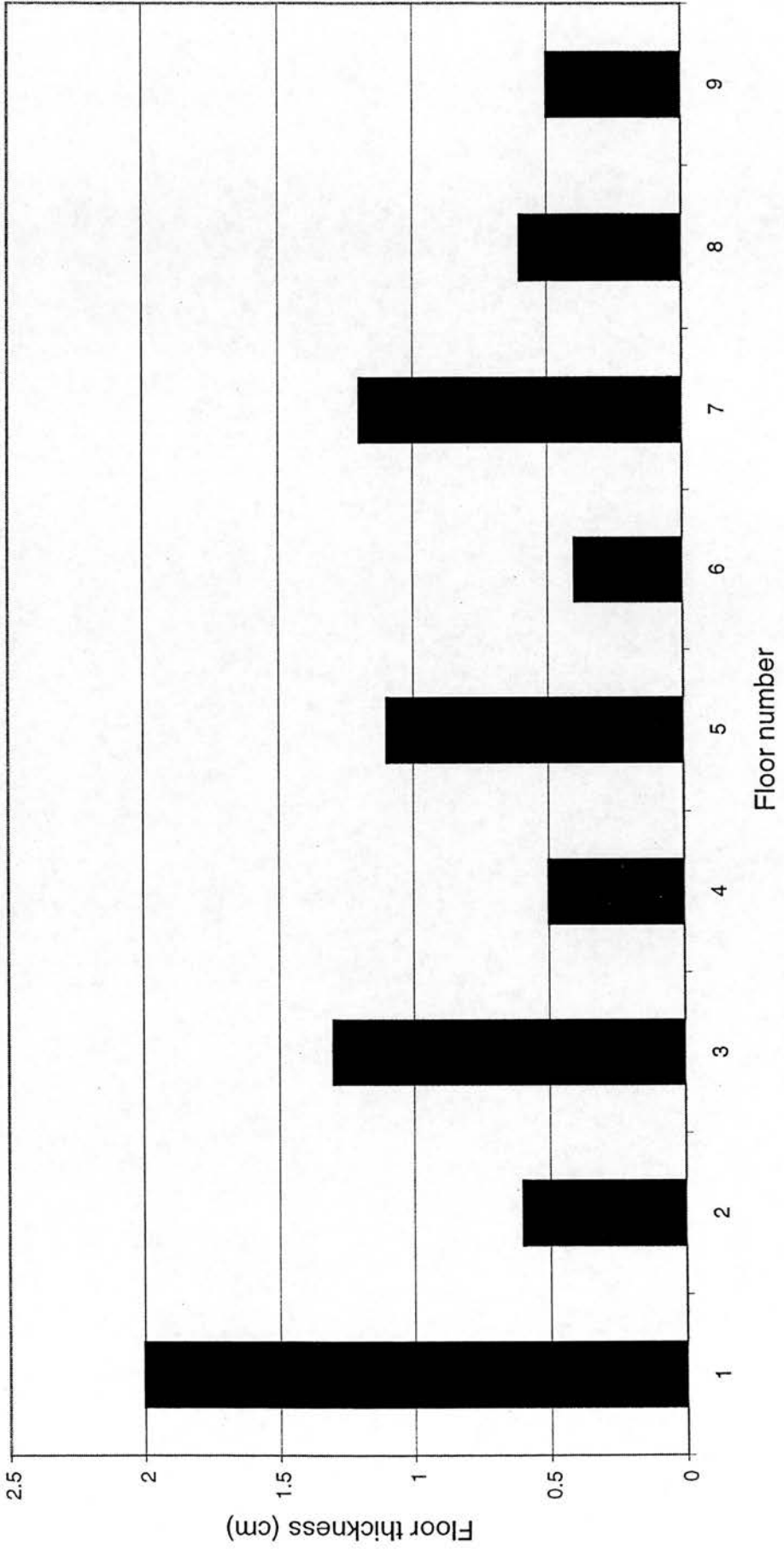
Graph 6.10: House Three Structure J: Sample 128: Charcoal content in each floor of the structure
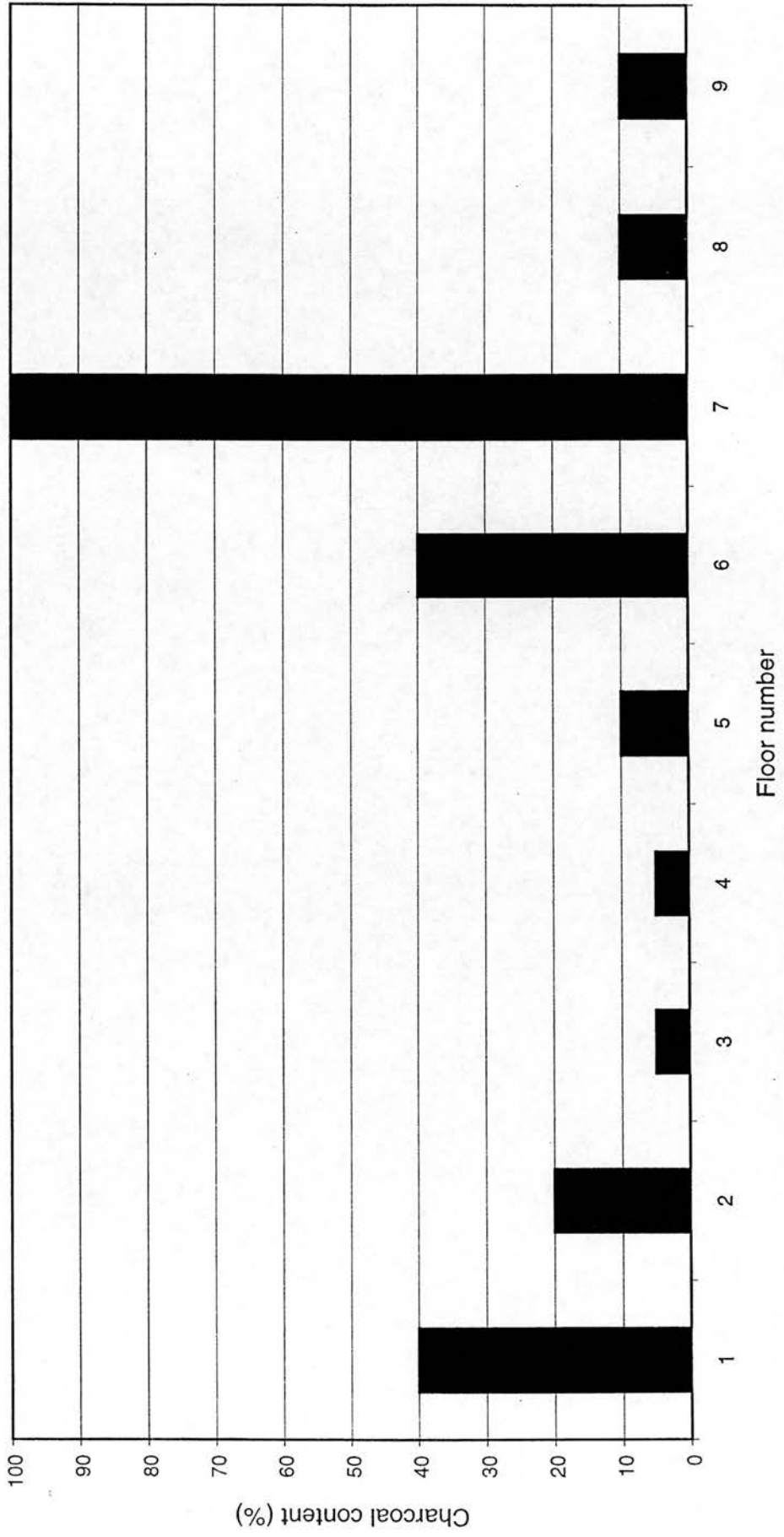
Cladh Hallan

Number and Thickness of Floors and and Charcoal Content Graphs

(7.1-7.9)

Graph 7.1: Floor Thickness and Charcoal content for House 640, Cladh Hallan
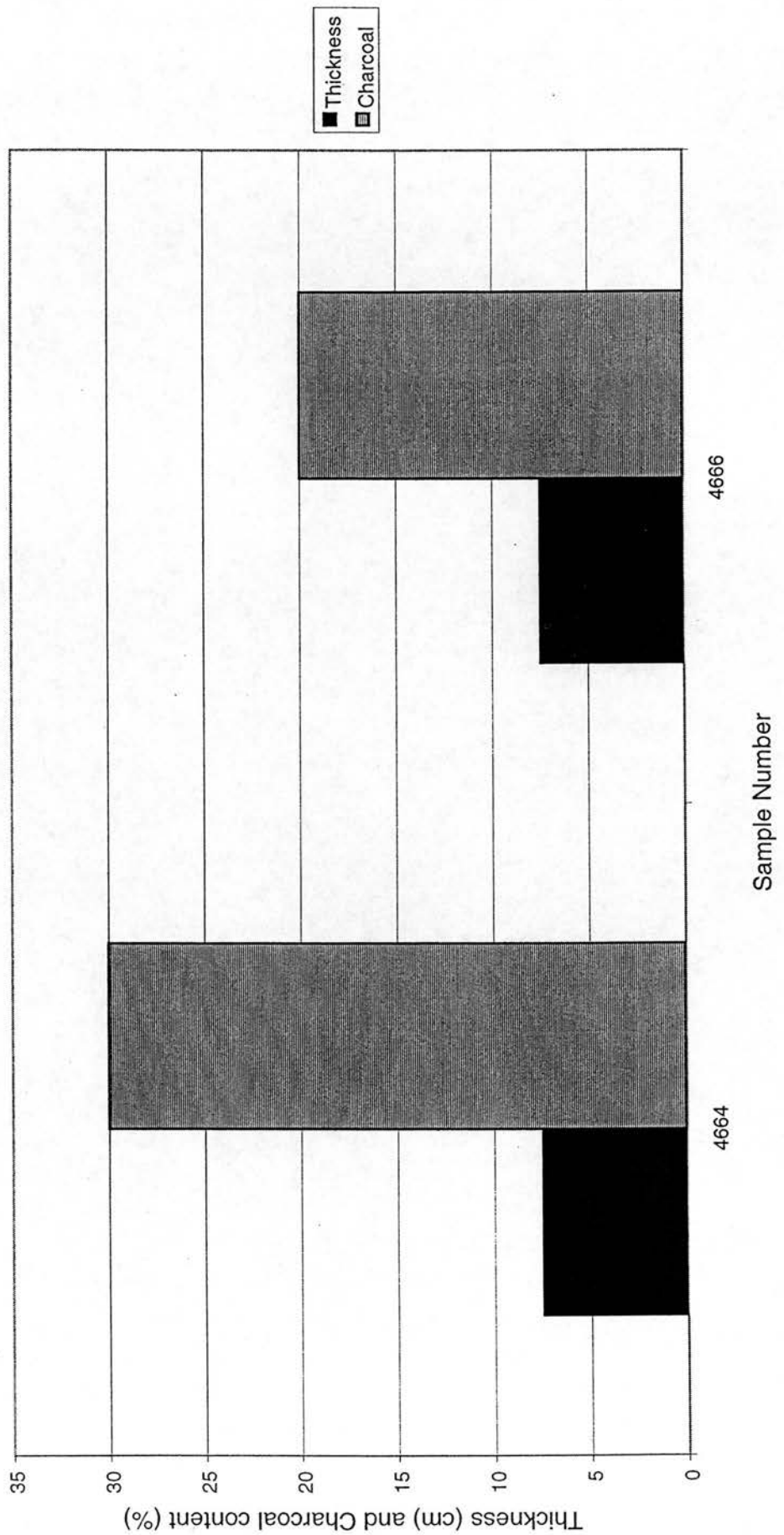
Graph 7.2: Cladh Hallan House 401: Number and Thickness of each floor layer in the east-west transect, Floor 595
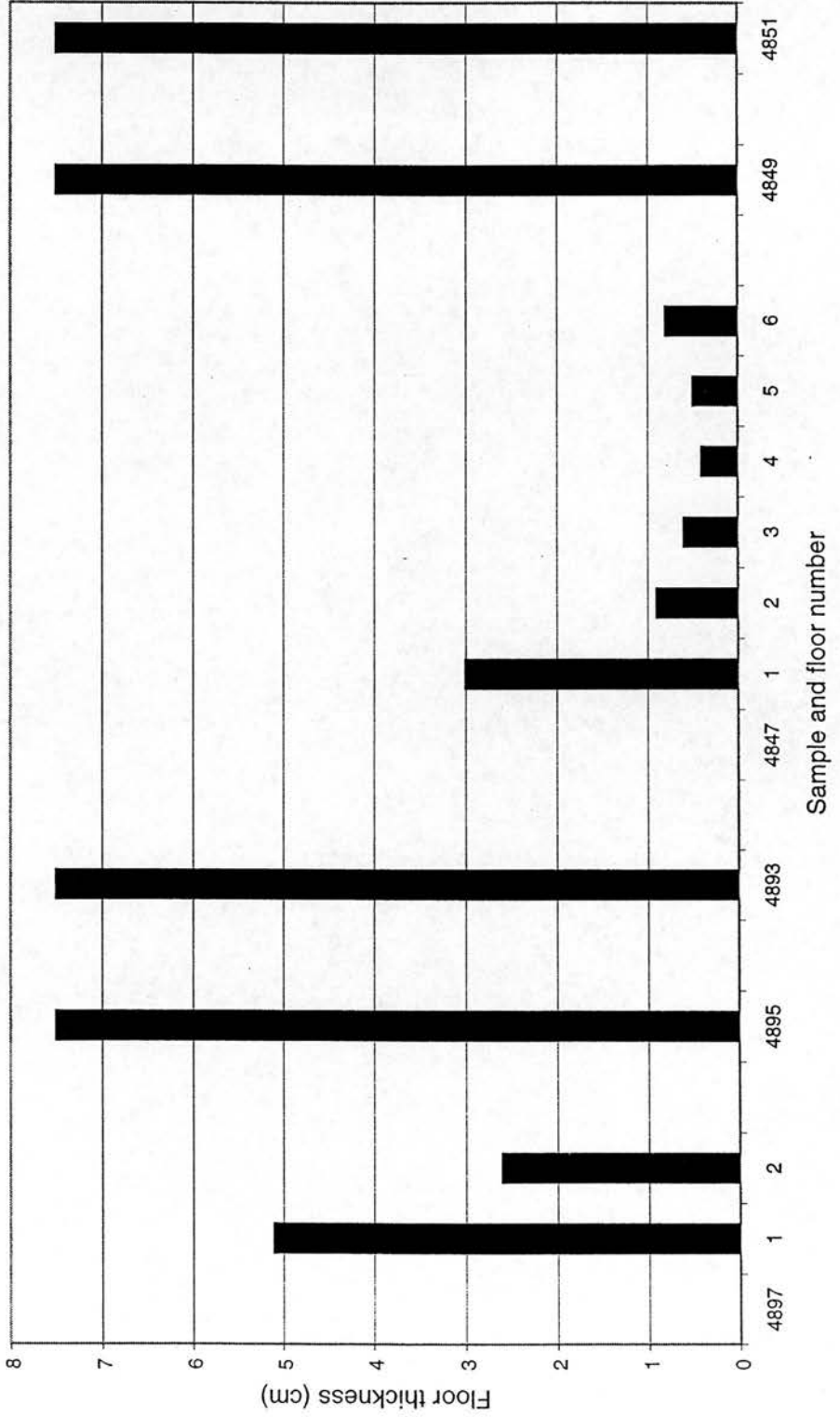
Graph 7.3: Cladh Hallan House 401: Charcoal content of each floor and sample in floor 595, North-South transect
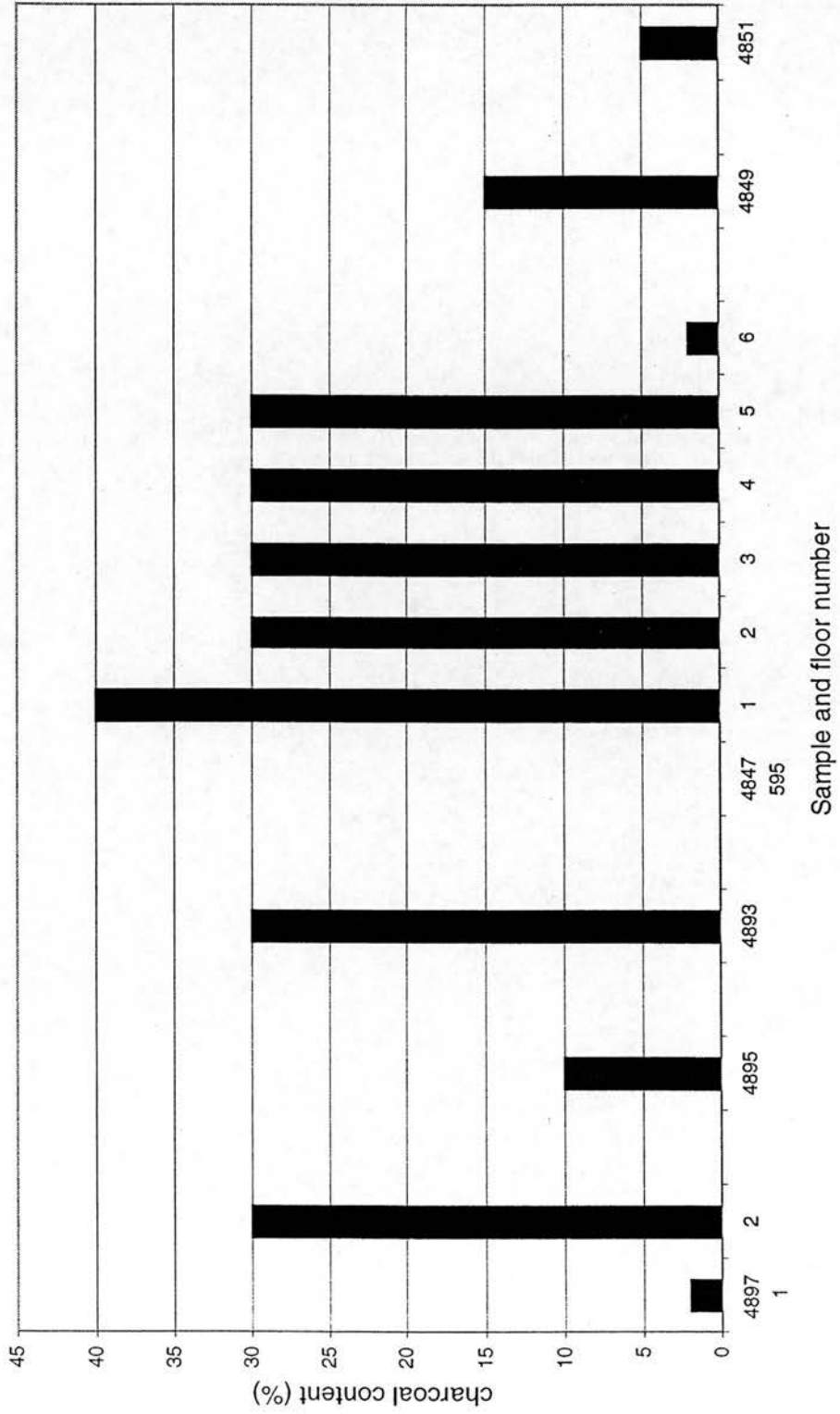
Graph 7.4: Cladh Hallan House 401: Number and Thickness of each floor layer in the west side of the east-west transect, Context 595
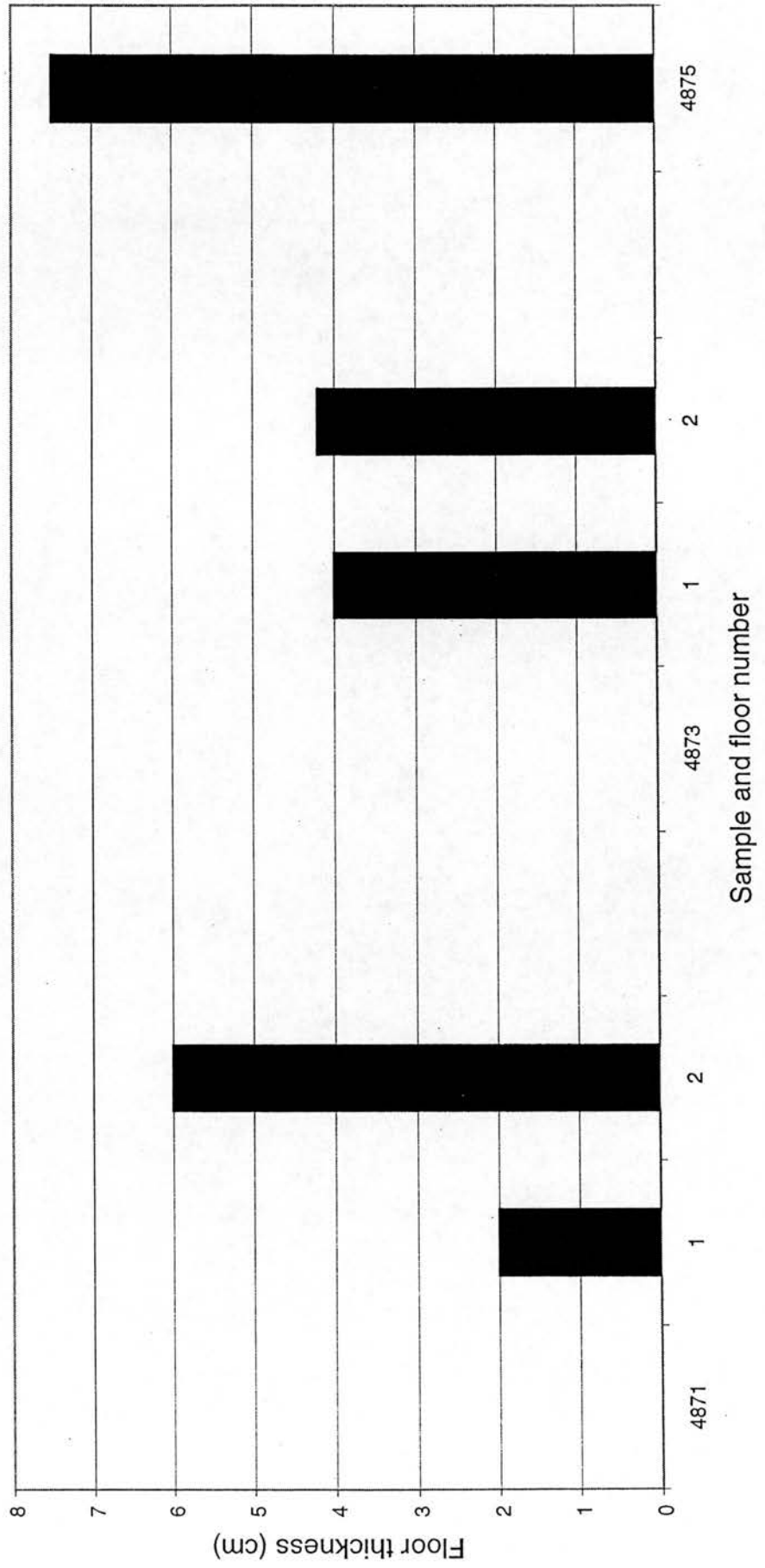
Graph 7.5: Cladh Hallan House 401: Charcoal content in each floor of Context 595, in the western side of the east-west transect
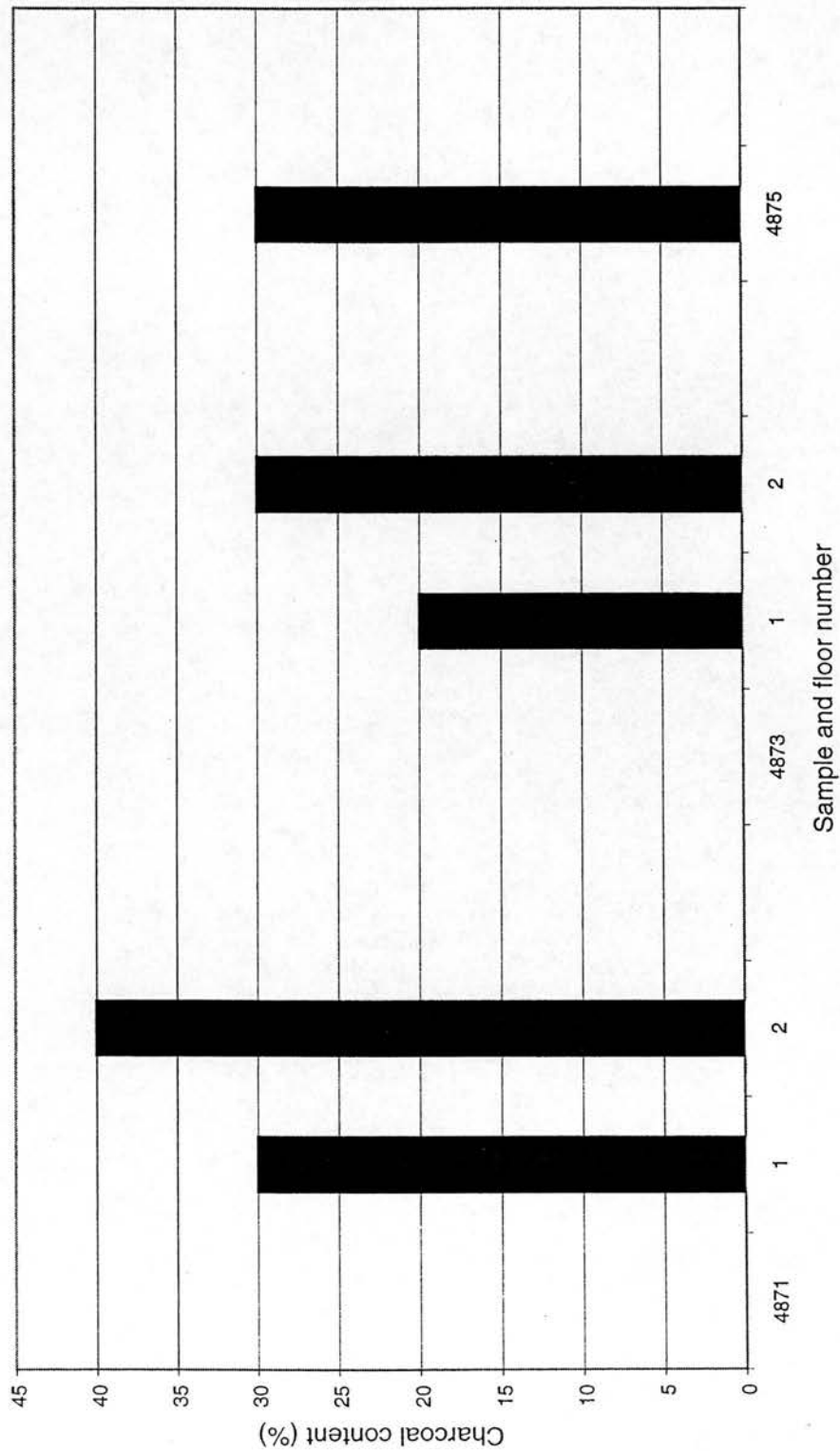
Graph 7.6: Cladh Hallan House 401: Number and Thickness of each floor in samples along the north-south transect, Context 655
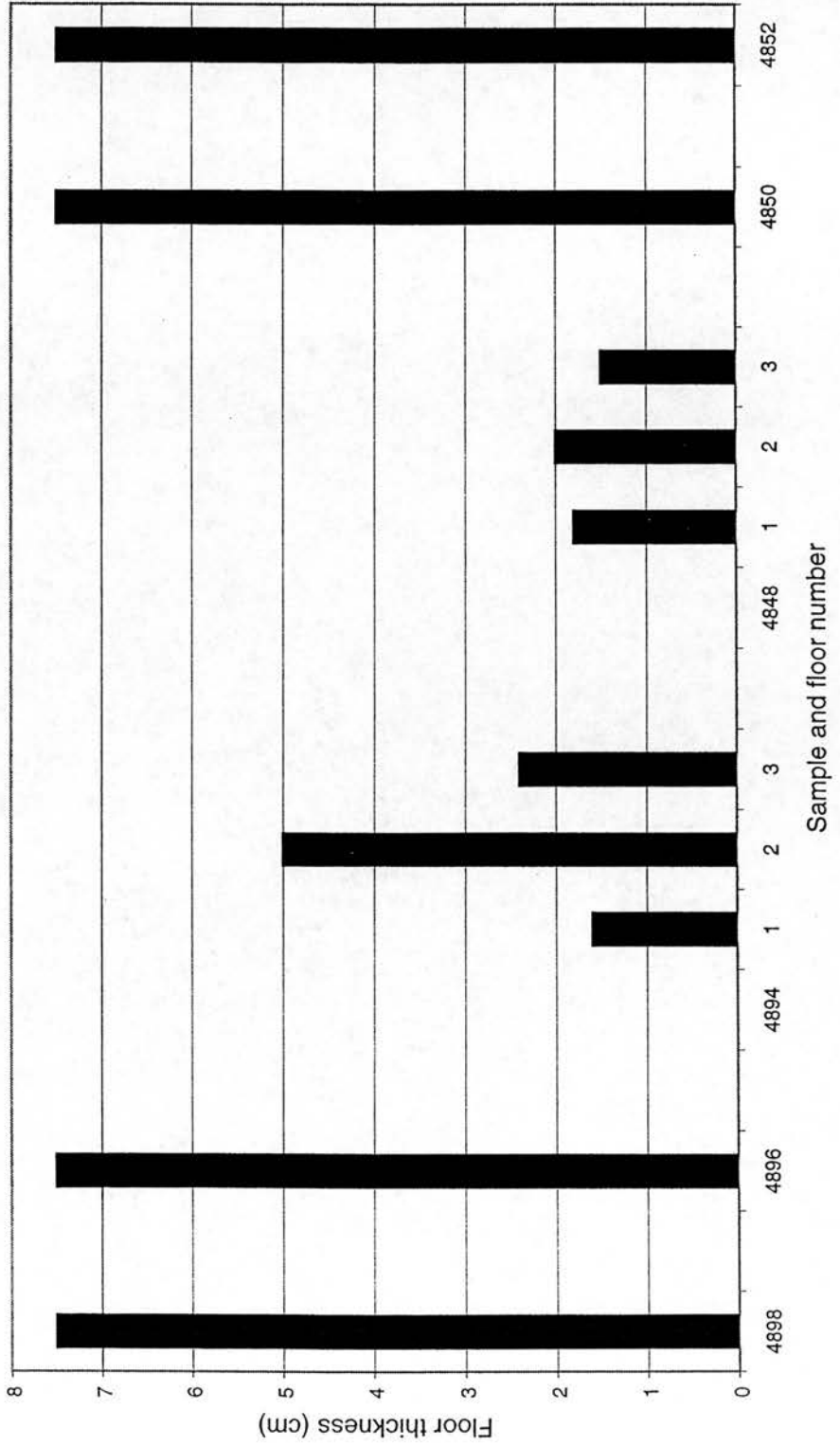
Graph 7.7: Cladh Hallan House 401: Charcoal content of each floor in the north-south transect, Context 655
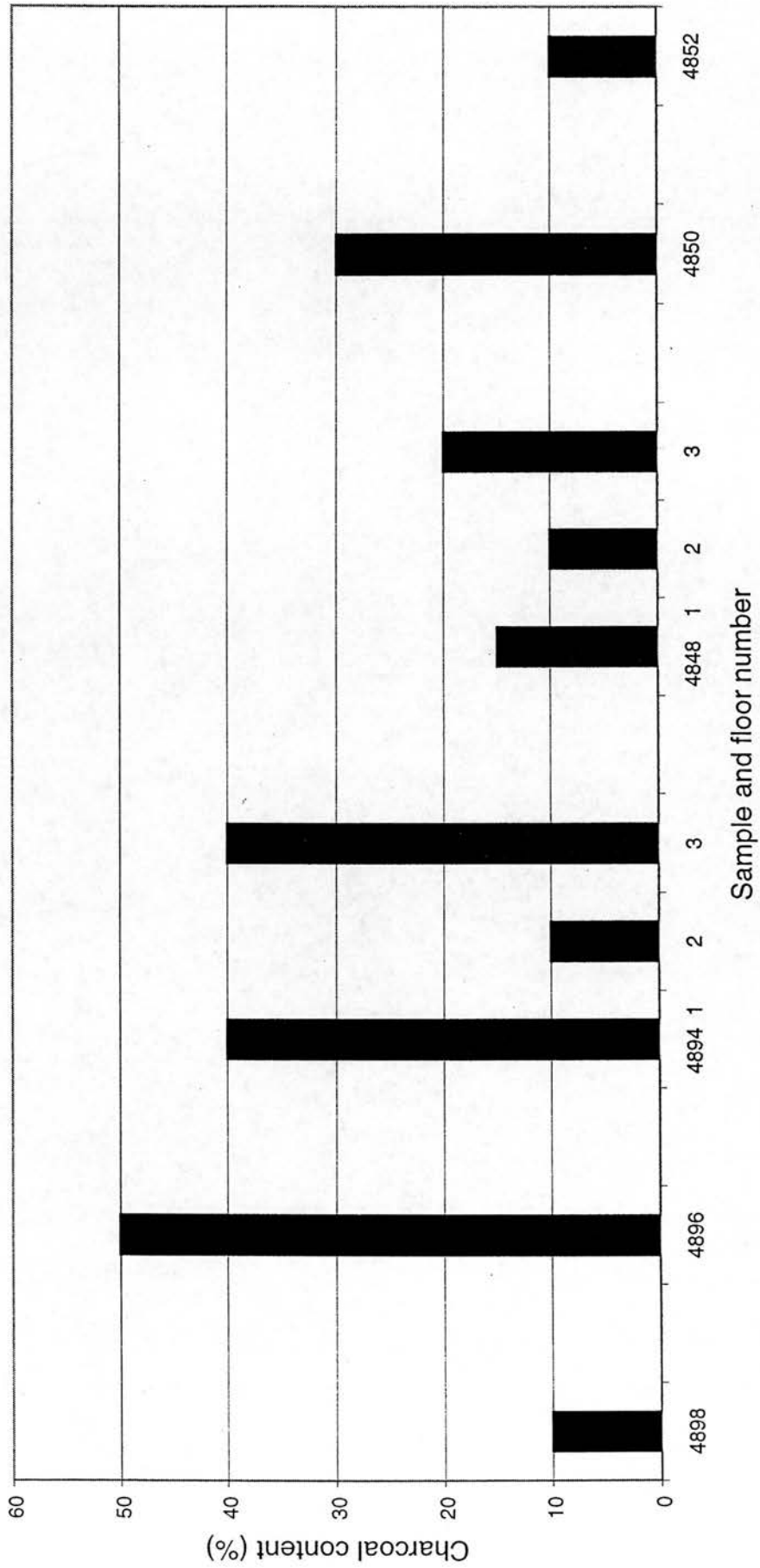
Graph 7.8: Cladh Hallan House 401: Number and Thickness of each floor in samples along the east-west transect, Context 655
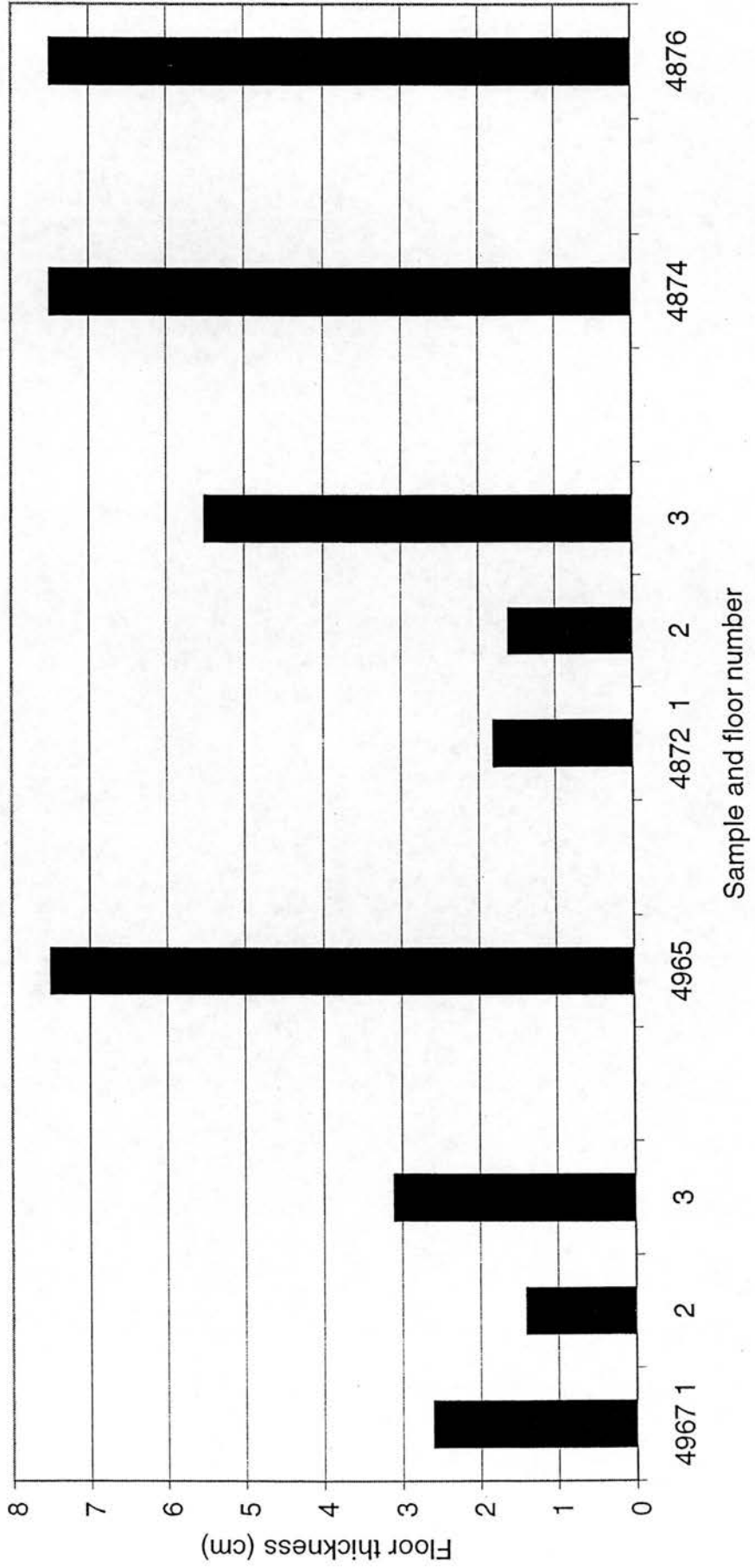
Graph 7.9: Cladh hallan House 401: Charcoal content in each floor layer of samples along the east-west transect, Context 655
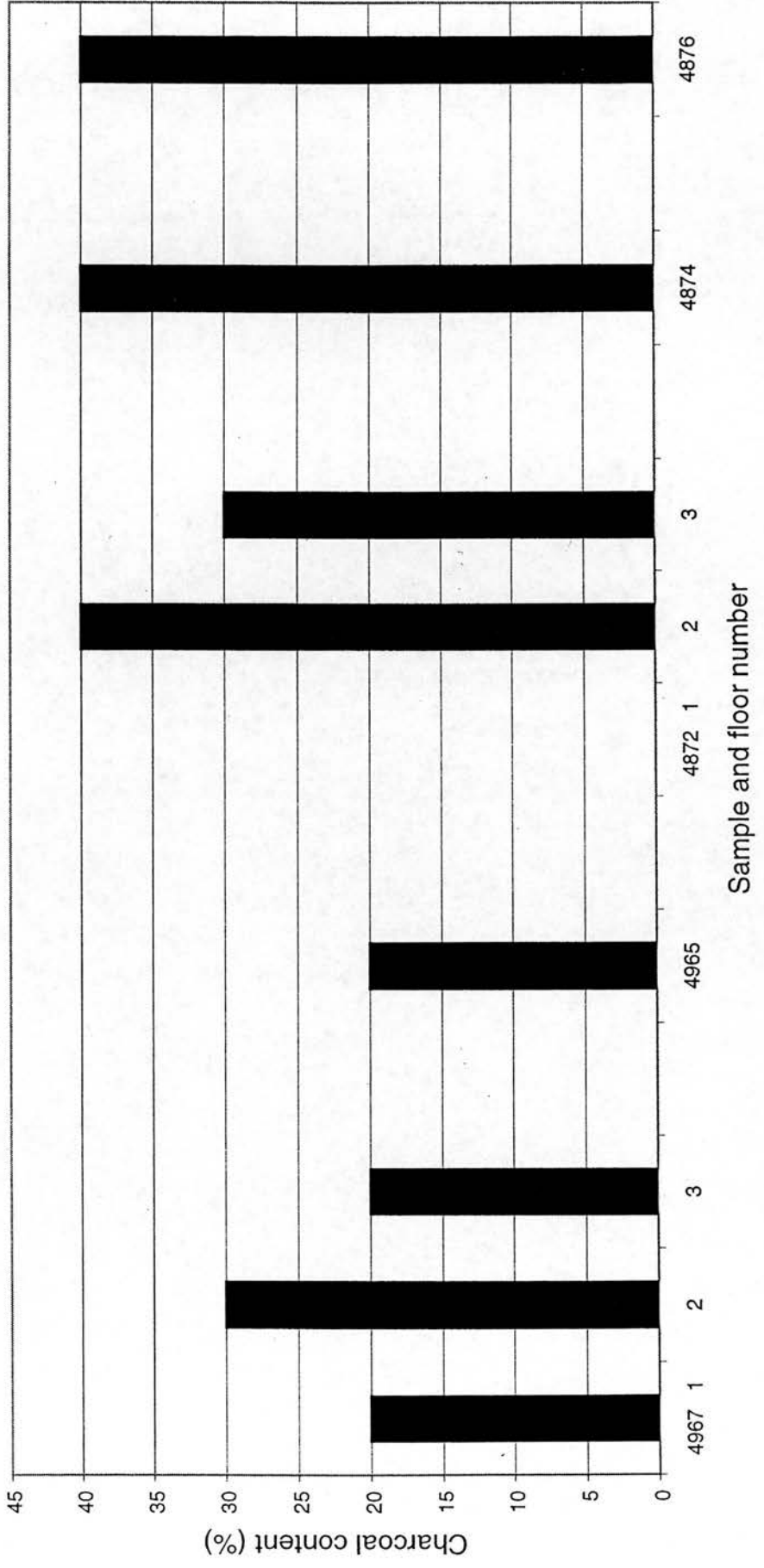
Bornais

Number and thickness of Floors and

Charcoal Content Graphs

(8.1-8.2)

Graph 8.1: Bornais House 1: Number and Thickness of floors along the East-West Transect
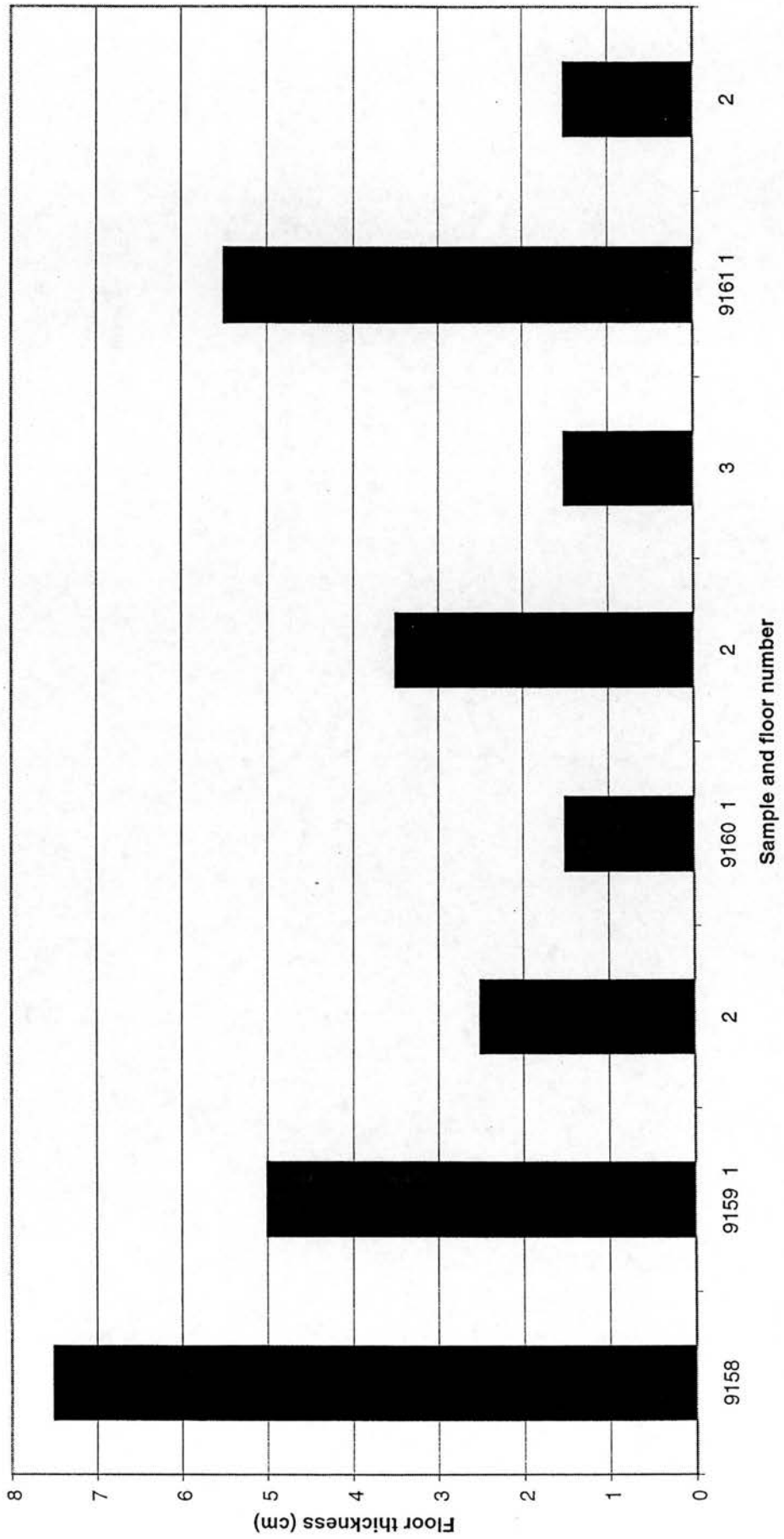
Graph 8.2: Borncoal House 1: Charcooal content of each floor in the east-west transect
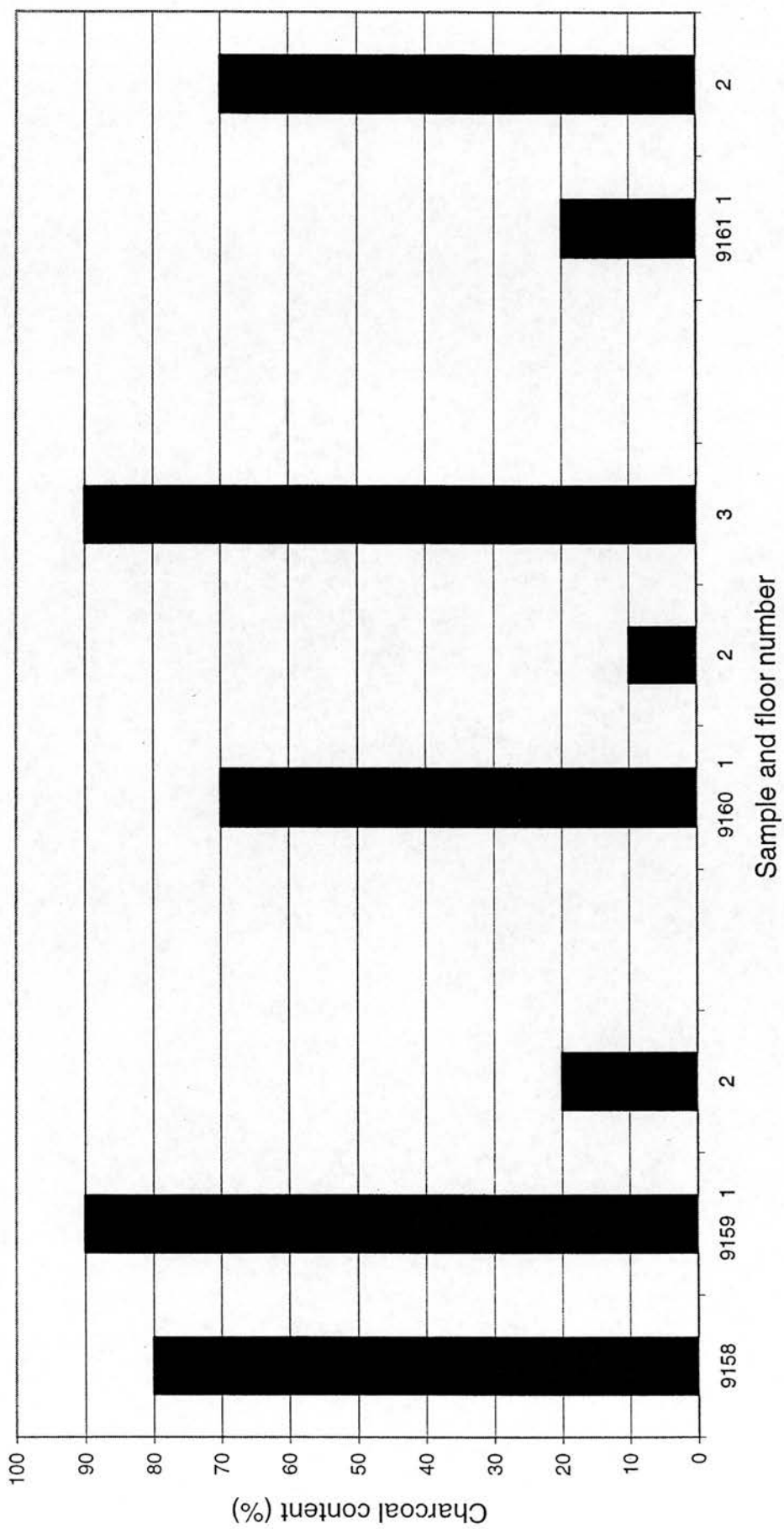
Miscellaneous
Tables

Table 1.1
Table 5.1
Table 6.11

Table 1.1: Nomenclature preferred for the description of the soil fabric after Fitzpatrick (1984)

Term	Concept
Assemblage	The totality of all the soil components and features and their inter-relationships e.g.: sand, silt, organic matter, porosity, clay coatings etc.
Fabric	The arrangement, size, shape and frequency of the individual solid soil components within the soil as a whole and within features themselves.
Matrix	Material forming a more or less continuous phase and enclosing coarse material, concretions, etc. Generally refers to material <2 um but can be much larger. Clay matrices are often uniform in colour but they may be speckled.
Structure	The spatial distribution and total organisation of the soil system as expressed by the degree of aggregation and the nature and distribution of the pores and pore space.

Table 5.1: Description of organic material based on Fitzpatrick (1993)

Classification	Degree of decomposition
Living	Live at the time of sampling; much of the lignified tissue shows first order interference colours and may show primary fluorescence
Fresh	Dead at the time of sampling but very slightly decomposed containing <25% fine residues and colloidal material; some parts show interference colours
Slightly decomposed	Clear evidence of decomposition through the loss of some cell structure and attack by the soil organisms, usually shows first order interference colours, 25-40% fine residues and colloidal material
Moderately decomposed	The plant material is still recognisable but shows considerable loss of structure and fragmentation. Interference colours are mainly absent but the undecomposed cellulose may show primary fluorescence, 40-55% fine residues and colloidal material.
Strongly decomposed	Plant material that is just recognisable and has lost most of its structure, 55-70% fine residues and colloidal material.
Very strongly decomposed	The amorphous remains of plant material that is recognised by its association with other plant material. It is generally isotropic with >70% fine residues and colloidal material.

(Fitzpatrick, 1993)

Table 6.11: Microstructure descriptions for types identified in the floors of all three settlement sites

Microstructure Type	Description
Single grain structure	Quartz (or other) grains loosely arranged with little or no fine material to provide aggregation. Much grain to grain contact.
Bridged grain structure	Quartz (or other) grains partially surrounded by fine material which forms bridges between the grains.
Intergrain microaggregate structure	Generally uncoated quartz (or other) grains with numerous organic microaggregates in the intergranular spaces.
Compact grain structure	Closely packed mineral grains with few simple voids between.
Crack structure	No fully separated aggregates. Material dense except for a few planes and occasional other voids.
Massive structure	No discrete peds and few, if any, voids.
Chamber structure	Dominant voids are chambers. No discrete aggregates.
Vughy structure	Numerous irregularly shaped vughs break up the continuity of the fine material. Occasional chambers. No aggregates.

(After Bullock et al., 1985)

Bostadh Beach Micromorphological Summary and Fine Residue Tables

(Tables 6.1-6.9)

Table 6.1: Summary of Micromorphological Features (Basic Components and Microstructure): Bostadh Beach, House Three Structure L Sample 160

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (< 10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
160	1	Single grain	100/0	Monic	++++	+++	++	++	++				None present	None present
	2	Crack	20/80	Open porphyric	++++	++	+	+++	++				Dark reddish brown	Undifferentiated
	3	Intergrain microaggregate	80/20	Gefuric	++++	++	++	++	++		++	+	Dark brown and light brown	Crystallitic
	4	Compact grain	90/10	Gefuric	++++	+++	++	++	++				Light brown	Crystallitic
	5	Compact grain	90/10	Gefuric	++++	+++	++	++	++				Dark brown	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

399

Table 6.2: Colour of fine organic and ash residues in each floor at the stepped area between Structures L and G, Sample 160.

Sample number	Floor number	Colour (PPL)	Colour (XPL)
160	1	No residues	No residues
	2	Dark brown	Isotropic
	3	Dark brown	Isotropic & crystallitic
	4	Quartz sand	Quartz sand
	5	Quartz sand	Quartz sand

Table 6.3 A: Summary of Micromorphological Features (Basic Components and Microstructure): Bosatdh Beach, House 3 Structure L Sample 178

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (<10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Fungal spores	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
S178	1	Single grain	90/10	Monic	+++	++	+	++	++++				Brown	Undifferentiated
	2	Single grain	90/10	Monic	++++	+++	++	++					Dark yellow	Undifferentiated
	3	Intergrain microaggregate	20/80	Open porphyric	++++	+++	+	++		++	+++	++	Dark yellow	Undifferentiated
	4	Massive	20/80	Open porphyric	++++	+++	++	+		++	++++	+	Dark yellow	Undifferentiated
	5	Massive	90/10	Gefuric	++++	+++	+	++	+	++	++		Dull yellow	Undifferentiated
	6	Crack	30/70	Open porphyric	++++	+++	++	+	++	++	++++	+	Dull yellow	Undifferentiated
	7	Chamber	30/70	Open porphyric	+++	+++	+	+	++++	++	++		Yellow	Undifferentiated
	8	Massive	80/20	Close porphyric	++++	+++	+	++	+++	+	+		Light yellow	Crystallitic
	9	Massive	20/80	Open porphyric	++++	++	++	+	++	++	++++	++	Light yellow	Crystallitic
	10	Massive	80/20	Close porphyric	++	++	++	+	++++				Yellow	Undifferentiated

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

Table 6.3B: Summary of Micromorphological Features (Basic Components and Microstructure): Bostadh Beach, House 3 Structure L Sample 178 floors 11-21

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (< 10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Fungal spores	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
S178	11	Massive	90/10	Close porphyric	++	++	+	+	++++	+++	+++	+	Dark yellow	Undifferentiated
	12	Massive	90/10	Close porphyric	++	+	++	+	+		++	++	Yellow	Undifferentiated
	13	Massive	80/20	Close porphyric	++++	+++	+	+	+				Yellow	Undifferentiated
	14	Massive	20/80	Close porphyric	+++	++	+	+	++++	++	++	+	Yellow	Undifferentiated
	15	Single grain	90/10	Monic	++++	+++	++	++	+++	+	+	+	Yellow	Undifferentiated
	16	Massive	10/90	Close porphyric	+++	++	+	+	++++	+++	++++	++	Yellow	Undifferentiated
	17	Single grain	10/90	Monic	++	++	+	+	++++	++	++++	+	Yellow	Undifferentiated
	18	Massive	10/90	Open porphyric	+++	++	+	++	++++	++	++++	+	Yellow	Undifferentiated
	19	Massive	10/90	Open porphyric	++++	++	++	+		++	+++		Yellow	Crystallitic
	20	Massive	60/40	Close porphyric	++++	+	+	+	++	+	++		Yellow	Crystallitic
	21	Massive	20/80	Open porphyric	++++	+	+	++	++	++	+		Yellow	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

Table 6.4: Colour of coarse and fine organic residues for each floor in Structure L, Sample 178. Coarse organic component colour is in **bold**. Dominant material within the floor is in *Italics*.

Sample number	Floor number	Colour (PPL)	Colour (XPL)
178	1	Beach sand	Beach sand
	2	Brown	Isotropic
	3	Yellow	Isotropic
	4	*Yellow*	*Isotropic*
		Dark reddish brown	**Black**
	5	*Light yellow*	*Isotropic*
		Dark reddish brown	**Isotropic**
	6	Beach sand	Beach sand
	7	*Yellow*	*Isotropic*
		Dark reddish brown	**Black**
	8	***Dark yellow***	*Isotropic*
		Dark reddish brown	Isotropic
	9	Light yellow	Isotropic
		Brown	**Isotropic**
	10	*Dark yellow*	*Isotropic*
		Brown	Dark reddish brown
	11	*Yellow*	*Isotropic*

	Dark reddish brown	**Isotropic**
12	*Light yellow*	*Isotropic*
	Dark reddish brown	**Isotropic**
13	*Grey-yellow*	*Isotropic*
	Brown	Reddish brown
14	*Dark yellow*	*Isotropic*
	Orange-brown	**Reddish brown**
15	Dark yellow	Isotropic
16	Orange-brown	Isotropic
17	Dark yellow	Isotropic
18	Beach sand	Beach sand
19	**Dark yellow**	Isotropic
	Orange-brown	**Isotropic**
20	*Dark yellow*	*Isotropic*
	Orange-brown	Isotropic
21	Orange-brown	Isotropic

Table 6.5 A: Summary of Micromorphological Features (Basic Components and Microstructure): Bostadh Beach House 3 Structure L Sample 120 .

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 µm)								FINE COMPONENT (< 10 µm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Fungal spores	Phytoliths	Diatoms	Colour of Fine Material (PPL) (Dominant fabric)	Birefringence Fabric (XPL)
S120	1	Single grain	90/10	Monic	+++	++	+	+	++++				Brown	Undifferentiated
	2	Massive	30/70	Close porphyric	++++	+++	++	+	++		+++	++	Grey	Undifferentiated
	3	Massive	70/30	Close porphyric	+++	++	+	++	++		+++	+	Brown	Undifferentiated
	4	Chamber and crack	70/30	Close porphyric	+++	++	++	++	+			+	Brown	Undifferentiated
	5	Massive	80/20	Close porphyric	++++	+++	+	++	+		+++	+	Light brown	Crystallitic
	6	Massive	20/80	Open porphyric	++++	+++	+	+	+		+++	+	Grey brown	Undifferentiated
	7	Chamber	80/20	Close porphyric	++++	+++	+	+	++++				Brown	Crystallitic
	8	Massive and Chamber	60/40	Close porphyric	++++	+++	+	+	+				Grey brown	Undifferentiated
	9	Chamber	60/40	Open porphyric	++	++	+	++	++++		++	+	Grey brown	Undifferentiated
	10	Single grain	90/10	Monic	++++	++	+	++	+++				Grey	Undifferentiated
	11	Massive and chamber	30/70	Open porphyric	+++	++	++	+	++++				Brown	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), +++ = dominant (30-50 %)

Table 6.5 B: Summary of Micromorphological Features (Basic Components and Microstructure): Bostadh Beach, House 3 Structure L Sample 120

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 µm)								FINE COMPONENT (< 10 µm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Fungal spores	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
120	12	Chamber	70/30	Close porphyric	++++	+++	+	++	++		++	++	Grey brown	Undifferentiated
	13	Chamber	80/20	Close porphyric	++++	+++	+	+	++		+++		Grey brown	Undifferentiated
	14	Chamber	80/20	Close porphyric	++++	+++	++	++	++	+++	+++		Grey brown	Undifferentiated
	15	Massive and chamber	70/30	Close porphyric	++++	+++	++	++	++	++			Brown	Crystallitic
	16	Chamber and crack	70/30	Close porphyric	+++	+++	++	+	+++	++++	++		Light brown	Crystallitic
	17	Bridged grain	90/10	Gefuric	++	+++	+	+	++++				Brown	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), +++ = dominant (30-50 %)

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Table 6.6: Colour of fine residues in each floor of Structure L, Sample 120. Dominant material within the floor is in *Italics*.

Sample number	Floor number	Colour (PPL)	Colour (XPL)
120	1	Beach sand	Beach sand
	2	*Brown*	*Dark brown*
		Grey	Isotropic
		Yellow-brown	Isotropic
	3	*Brown*	*Dark brown*
		Grey	Isotropic
	4	*Dark brown*	*Black/isotropic*
		Grey	Isotropic
		Orange-brown	Isotropic
	5	*Dark brown*	*Dark reddish brown*
		Light brown	Isotropic
		Grey-brown	Isotropic
	6	*Dark brown*	*Dark reddish brown*
		Grey	Isotropic
		Light brown	Isotropic
		Reddish brown	Dull reddish brown
	7	Grey	Isotropic
		Dark brown	*Dull reddish brown*
		Light brown	Isotropic
	8	*Dark brown*	*Black/isotropic*
		Light brown	Isotropic
		Grey-brown	Isotropic
	9	Brown	Dark brown
	10	Brown	Dark brown
	11	*Grey-brown*	*Isotropic*
		Grey	Isotropic

12	*Brown*	*Isotropic*
13	**Grey**	Isotropic
	Reddish brown	Dark reddish brown
14	*Brown*	*Isotropic*
	Grey-brown	Isotropic
	Brown	*Isotropic*
15	Grey-brown	Isotropic
	Brown	*Isotropic*
16	*Brown*	*Isotropic*
17	Grey	Isotropic
	Dark brown	Isotropic

Table 6.7: Summary of Micromorphological Features (Basic Components and Microstructure): Bostadh Beach, House 3 Structure H, Sample 133

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (<10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Fungal spores	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
133	1	Chamber	70/30	Close porphyric	+++	+++	++	++	+++		++	+	Grey-brown	Undifferentiated
	2	Chamber	80/20	Close porphyric	+++	+++	++	++	+++		+		Grey-brown	Undifferentiated
	3	Chamber	30/70	Open porphyric	+++	++	++	++	+++		++++	++	Grey	Undifferentiated
	4	Chamber	20/80	Open porphyric	++++	+++	++	++	+++		++	+	Yellow-brown	Crystallitic
	5	Chamber	20/80	Open porphyric	++++	+++	++	++	++		+++	+	Grey	Undifferentiated

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

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Table 6.8: Colour of fine residues in the each floor of Structure H, House Three. Dominant fine residues within the floor are in *Italics*.

Sample number	Floor number	Colour (PPL)	Colour (XPL)
133	1	Dark brown	Dark reddish brown
	2	*Reddish brown*	*Dark reddish brown*
		Light grey	Isotropic
	3	*Light grey*	*Isotropic*
		Very light brown	Isotropic
		Brown	Orange-brown
	4	Light grey	Isotropic
		Brown	*Reddish brown*
	5	*Yellowish brown*	*Isotropic or dark yellow brown*
		Grey	Isotropic
		Strong brown	Yellow brown

*Most abundant residue in a floors is in *Italics*

Table 6.9: Summary of Micromorphological Features (Basic Components and Microstructure): Bostadh Beach, House 3 Structure J, Sample 128

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (< 10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Fungal spores	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
S128	1	Single grain	90/10	Open porphyric	+++	++	++	++	++++				Brown	Crystallitic
	2	Chamber and crack	30/70	Open porphyric	++++	++	++	+++	+++		++	+	Yellow-brown	Crystallitic
	3	Chamber and crack	20/80	Open porphyric	++	+	+	+	+++		++++	++	Grey	Undifferentiated
	4	Chamber and crack	20/80	Open porphyric	+++	++	+	+	++++		++++	++	Yellow-brown	Crystallitic
	5	Chamber and crack	20/80	Open porphyric	++++	++	+	++	+		++++	++	Yellow-grey	Crystallitic
	6	Chamber and crack	70/30	Close porphyric	+++	++	++	+	+++		++++	+	Grey-brown	Undifferentiated
	7	Chamber and crack	20/80	Open porphyric	++++	++	+	++	++		++		Dark-brown	Crystallitic
	8	Chamber and crack	40/60	Open porphyric	++++	++	+	+	+		++		Grey	Undifferentiated
	9	Chamber and crack	40/60	Open porphyric	++	+	+	+	++++		++		Grey-brown	Undifferentiated

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

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Table 6.10: Colour of fine residues in each floor of Structure J. Dominant fine residues are in *italics*

Sample number	Floor number	Colour (PPL)	Colour (XPL)
128	1	Beach sand	Beach sand
	2	Grey	Isotropic
		Light brown	*Dull reddish brown*
	3	*Yellow*	*Isotropic*
		Light yellow brown	Isotropic
	4	**Light grey**	Isotropic
		Brown	*Dark reddish brown*
	5	Light brown	Isotropic
		Brown	*Isotropic*
		Orange-brown	Isotropic
	6	Grey-brown	Isotropic
		Light yellow brown	Isotropic
		Dark brown	*Dark reddish brown*
	8	As 5	As 5
	9	Grey	Isotropic
		Dark brown	Dull reddish brown
		Light brown	*Dark reddish brown*
		Yellow brown	isotropic

*Most abundant residue in a floors is in *Italics*

Cladh Hallan Micromorphological Summary and Fine Residue Tables

(Tables 7.1-7.9)

Table 7.1: Summary of Micromorphological Features (Basic Components and Microstructure): Cladh Hallan House 640 Samples 4664 and 4666

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 µm)								FINE COMPONENT (< 10 µm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
4664	1	Compact grain	80/20	Gefuric	++++	++	+	++	++++				Brown	Crystallitic
4666	1	Compact grain	100/0	Monic	++++	++	++	+	+++					

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

Table 7.2: Colour of fine residues in the floor samples of House 640, Cladh Hallan, South Uist

Sample number	Floor number	Colour (PPL)	Colour (XPL)
4664	1	Light brown	Dark brown
4666	1	Light brown	Dark brown

Table 7.3 A: Summary of Micromorphological Features (Basic Components and Microstructure): Cladh Hallan House 401, Floor 595 North-South Transect

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 µm)								FINE COMPONENT (<10 µm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
4897	1	Single/bridged grain	90/10	Monic	++++	+++	+	+	+				Light brown	Undifferentiated
	2	Bridged grain	70/30	Close porphyric	++++	+++	+	++	+				Brown	Crystallitic
4895	1	Single/bridged grain	90/10	Monic/gefuric	++++	++	+	+	++				Brown	Crystallitic
4893	1	Single/bridged grain	90/10	Monic/gefuric	++++	+++	++	++	++				Brown	Undifferentiated
4847	1	Compact grain / intergrain microaggregate	80/20	Gefuric/chitonic	++++	+++	++	+	++				Brown	Undifferentiated
	2	Compact grain/intergrain microaggregate	80/20	Close porphyric	++++	++	+++	++	++				Light brown	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

Table 7.3B: Summary of Micromorphological Features (Basic Components and Microstructure): Cladh Hallan House 401, Floor 595 North-South Transect

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (< 10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
4847	3	Compact grain/intergrain microaggregate	80/20	Gefuric/chitonic	++++	+++	++	+	++				Brown	Crystallitic
	4	Compact grain/intergrain microaggregate	60/40	Close porphyric	++++	+++	+	+	++				Grey-brown	Undifferentiated
	5	Compact grain/intergrain microaggregate	70/30	Close porphyric	++++	++	+	++	+++				Brown	Crystallitic
	6	Compact grain/intergrain microaggregate	70/30	Close porphyric	++++	+++	+	+	++++				Dark –brown	Crystallitic
4949	1	Single/bridged grain	90/10	Monic/gefuric	++++	++	+	+	++++				Brown	Crystallitic
4851	1	Single/bridged grain	90/10	Monic/gefuric	++++	+++	+	+	+++				Brown	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).

Table 7.4: Colour of fine residues in the floor samples of House 401, North-South transect (Floor 595), Cladh Hallan.

Sample number	Floor number	Colour (PPL)	Colour (XPL)
North section			
4897	1	Light brown	Dark brown
4895	1	Light brown	Isotropic
4893	1	Light brown	Isotropic
South section			
4847	1	Brown	Isotropic
	2	Light brown	Isotropic & crystallitic
	3	Brown	Isotropic
	4	Grey-brown	Isotropic
	5	Brown	Isotropic
	6*	**Dark brown**	*Isotropic & crystallitic*
		Orange-brown	Isotropic
		Grey-brown	Isotropic and crystallitic
4849	1	Brown	Isotropic
4851	1	Brown	Isotropic

Table 7.5: Summary of Micromorphological Features (Basic Components and Microstructure): Cladh Hallan House 401, Floor 595 East-West Transect

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 µm)								FINE COMPONENT (< 10 µm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
4871	1	Complex	70/30	Gefuric/chitonic	++++	+++	++	+	++				Dark-brown	Crystallitic
	2	Compact grain	60/40	Close porphyric	++++	++	+	++	++				Dark-brown	Crystallitic
4873	1	Single grain	90/10	Monic	++++	++	+	+	+++				Dark –brown	Crystallitic
	2	Bridged grain	70/30	Chitonic	+++	++	++	+	++++				Light-brown	Crystallitic
4875	1	Bridged grain	95/5	Monic	++++	+++	++	+	++				Light-brown (very rare)	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), +++ = dominant (30-50 %)

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Table 7.6: Colour of fine residues in floor samples of House 401, East-West transect (Floor 595), Cladh Hallan.

Sample number	Floor number	Colour (PPL)	Colour (XPL)
East section only			
4871	1	**Dark brown**	Isotropic & crystallitic
	2	Dark brown	Isotropic & crystallitic
4873	1	Brown	Isotropic & crystallitic
	2*	*Dark brown*	*Isotropic & crystallitic*
		Light brown	Isotropic & crystallitic
		Grey brown	Isotropic & crystallitic
4875	1	Light brown	Isotropic

*Most abundant residue in a floors is in *Italics*

Table 7.7 A: Summary of Micromorphological Features (Basic Components and Microstructure): Cladh Hallan House 401 Floor 655 North-South Transect

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (< 10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
4898	1	Bridged grain	60/40	Chitonic/gefuric	++++	++	+	+	++		++		Light yellow-brown	Undifferentiated
4896	1	Bridged grain	60/40	Chitonic/gefuric	++++	+++	+	+	++				Light yellow-brown	Undifferentiated
4894	1	Bridged/compact grain	70/30	Enaulic	++++	++	++	+	+++				Light-brown	Crystallitic
	2	Massive	30/70	Chitonic	++++	++	++	++	+++		+++	++	Yellow-brown Grey-brown	Crystallitic Undifferentiated
	3	Bridged/compact grain	70/30	Chitonic	++++	+++	+	+	++				Light-brown	Undifferentiated
4848	1	Bridged/compact grain	80/20	Chitonic	++++	+	++	+	+++				Dark/light-brown	Crystallitic
	2	Bridged/compact grain	60/40	Enaulic	++++	++	++	++	+				Dark/light-brown	Crystallitic
	3	Compact grain	80/20	Chitonic	++++	+++	++	+	++				Reddish brown	Undifferentiated

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

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Table 7.7 B: Summary of Micromorphological Features (Basic Components and Microstructure): Cladh Hallan House 401, Floor 655 North-South Transect

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (<10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
4850	1	Bridged grain	70/30	Chitonic/gefuric	++++	++	++	+	+++				Orange-brown	Crystallitic
4852	1	Bridged grain	90/10	Monic	++++	+++	+	++	++				Light-brown	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

Table 7.8: Colour of fine residues in the floor samples of House 401, North-South transect (Floor 655), Cladh Hallan.

Sample number	Floor number	Colour (PPL)	Colour (XPL)
North section			
4898	1	Light yellow-brown	Isotropic
4896	1	Light yellow-brown	Isotropic
4894	1	Light brown	Isotropic
		Yellow brown	Isotropic
		Grey brown	Isotropic
South section			
4848	1	**Dark brown**	**Isotropic**
		Light brown	Isotropic
	2	Dark brown	Isotropic
		Light brown	Isotropic
	3	Reddish brown	Isotropic
4850	1	Light brown	Isotropic
4852	1	Orange-brown	Isotropic

*Most abundant residue in a floors is in *Italics*

Table 7.9 A: Summary of Micromorphological Features (Basic Components and Microstructure): Cladh Hallan House 401, Floor 655 East-West Transect

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (< 10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
4967	1	Compact grain	95/5	Monic	+++	++	+	+	++++				Light-brown (very rare)	Crystallitic
	2	Compact/ bridged grain	70/30	Enaulic	++++	++	++	+	++				Light-brown	Crystallitic
	3	Compact grain	90/10	Monic	+++	+	++	++	++++				Brown	Crystallitic
4965	1	Bridged grain	70/30	Chitonic	++++	++	+	+	+++		++	+	Light-brown Grey Grey-brown	Crystallitic Undifferentiated Undifferentiated
4963	1	Bridged grain	70/30	Chitonic	++++	+++	++	+	++				Light-brown Yellow-brown	Undifferentiated Crystallitic
4872	1	Compact grain	70/30	Enaulic/chitonic	++++	++	++	+	+++	+			Yellow	Undifferentiated
	2	Compact grain	50/50	Close porphyric	++++	+++	+	++	++	+			Light-brown	Undifferentiated
	3	Compact grain	60/40	Gefuric/enaulic	++++	+++	+	+	++	+			Dark-brown	Undifferentiated

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985)
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

Table 7.9 B: Summary of Micromorphological Features (Basic Components and Microstructure): Cladh Hallan House 401, Floor 655 East-West Transect (continued)

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 µm)								FINE COMPONENT (< 10 µm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
4874	1	Bridged grain /Intergrain microaggregate	80/20	Gefuric	++++	+++	+	++	++				Dark-brown	Undifferentiated
4876	1	Bridged grain	80/20	Gefuric	++++	++	+	++	+++				Light-brown	Undifferentiated

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50 %)

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Table 7.10: Colour of fine residues in floor samples of House 401, East-West transect (Floor 655), Cladh Hallan.

Sample number	Floor number	Colour (PPL)	Colour (XPL)
East section			
4965	1	*Light brown*	*Dark brown*
		Grey	Isotropic
		Greyish brown	Isotropic
4963	1	*Light brown*	*Isotropic*
		Yellow	Isotropic
West section			
4872	1	**Dark brown**	Isotropic
	2	Yellow	Isotropic & crystallitic
		Light brown	*Isotropic & crystallitic*
	3	Dark brown	Isotropic
4874	1	Dark brown	Isotropic
4876	1	Dark brown	Isotropic

*Most abundant residue in a floors is in *Italics*

Bornais Micromorphological Summary and Fine Residue Tables

(Tables 8.1 and 8.2)

Table 8.1: Summary of Micromorphological Features (Basic Components and Microstructure): Bornais Mound 1 House 1

Sample Number	Floor Number	MICROSTRUCTURE			COARSE MINERAL COMPONENT (>10 μm)								FINE COMPONENT (<10 μm)	
		Microstructure	C/F Ratio	C/F Related Distribution	Quartz	Feldspar	Gneiss	Hornblende	Calcium Carbonate	Bone	Phytoliths	Diatoms	Colour of Fine Material (PPL)	Birefringence Fabric (XPL)
9158	1	Granular/chamber	30/70	Open porphyric	++++	++	++	+	++				Black charred material	Isotropic
9159	1	Massive	30/70	Open porphyric	++++	++	++	++	+++				Light-brown	Crystallitic
	2	Massive	20/80	Open porphyric	++++	+++	+++	++	++		++++	+	Grey-brown	Crystallitic
9160	1	Complex	30/70	Open porphyric	++++	+++	+	+	+++				Black charred material	Isotropic
	2	Compact grain	90/10	Gefuric	++++	+++	++	+	++				Light-brown	Crystallitic
	3	Complex	30/70	Open porphyric	++++	+++	+++	+	+++				Black charred material	Isotropic
9161	1	Bridged grain	20/80	Open porphyric	++++	+++	++	++	+++				Black charred material	Isotropic
	2	Bridged grain	80/20	Gefuric	++++	++	+	+++	+++				Brown	Crystallitic

Frequency Class refers to appropriate area of thin section (After Bullock and co-workers 1985).
+ = very few (<5%), ++ = few (5-15 %), +++ = frequent (15-30 %), ++++ = dominant (30-50%)

Table 8.2: Colour of fine residues in the floor samples from Mound 1, Bornais, South Uist

Sample number	Floor number	Colour (PPL)	Colour (XPL)
9158	1	Black	Isotropic
9159	1	Black	Isotropic
	2	Grey brown	Crystallitic
9160	1	**Black**	**Isotropic**
	2	Black	Isotropic
	3	Black	Isotropic
9161	1	Light brown	Isotropic
	2	Light brown	Isotropic
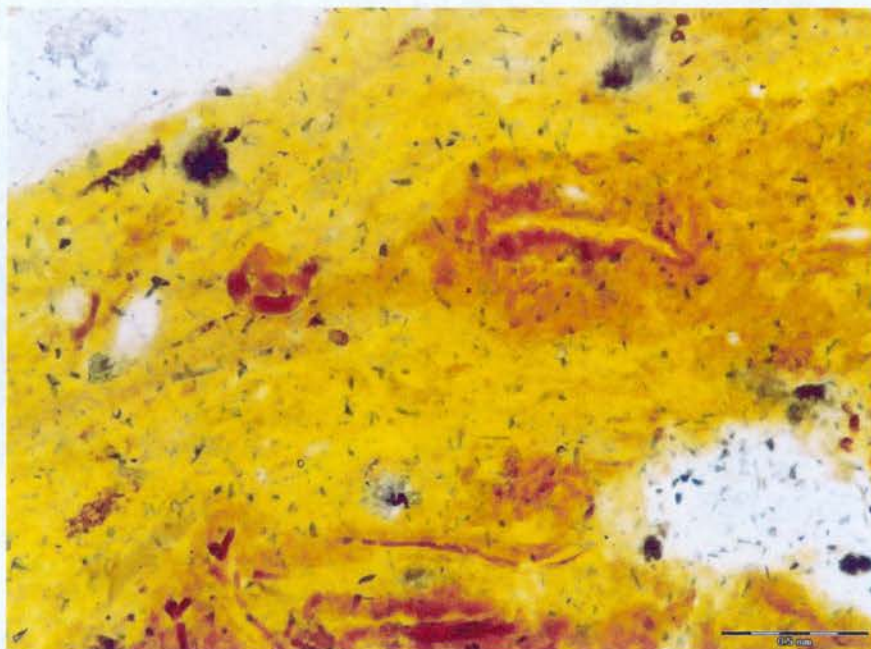
Plate 1: S178A Well humified peat floor (floor 2), with massive microstructure.
PPL, x10. Bostadh Beach.
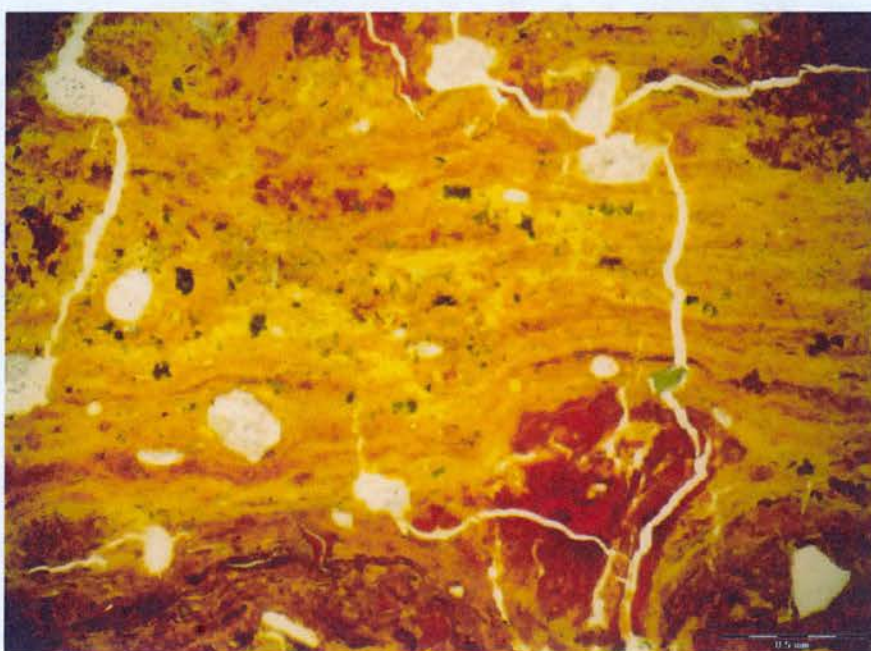
Plate 2: S178B, horizontally aligned decomposed plant tissues in well humified peat
Floor 8. Also illustrating plant residues in varying stages of decomposition
And a microstructure of vertical and horizontal cracks. Bostadh Beach.

Plate 3: S178B, floor 7 composed of peaty machair turf. Illustrated is the quartz
abundance when compared with the well humified peat floors in Plates 1 and 2
PPL x2.5

Plate 4: As Plate 3 in XPL.
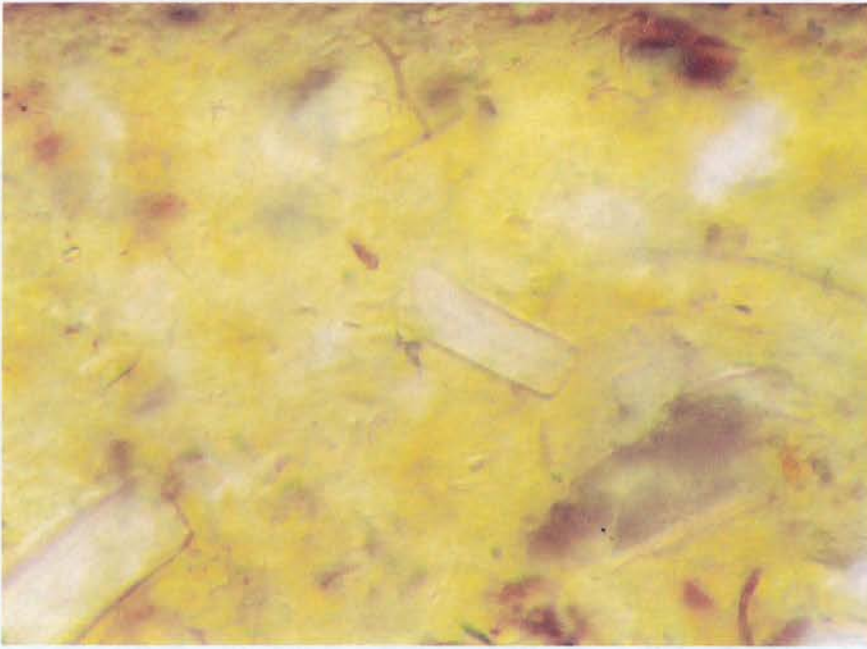
Plate 5: S178A in tact diatoms and phytoliths in floor 2, Bostadh Beach. Well Humified peat floor. PPL x40.
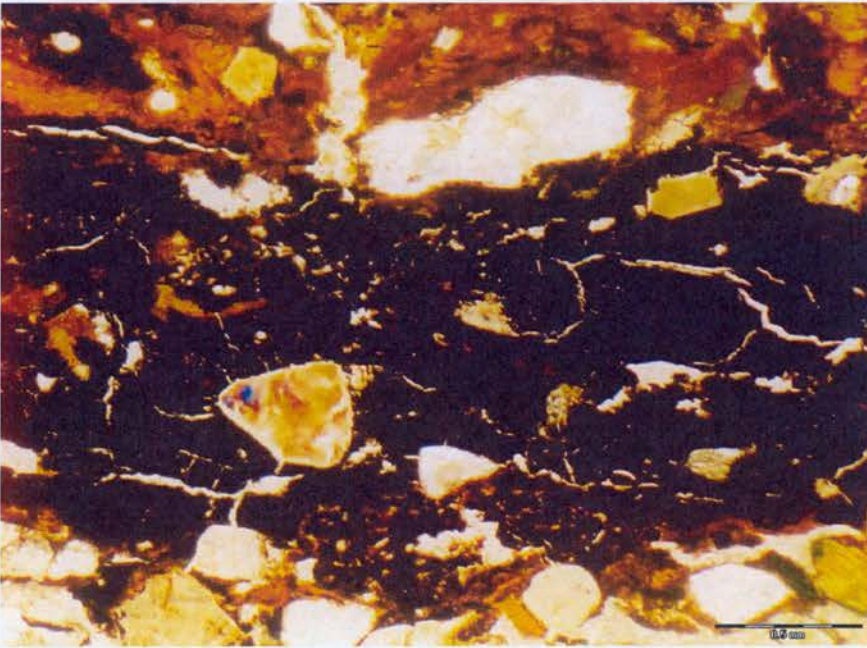
Plate 6: S128 Bostadh Beach. Illustration of the in-situ charcoal layer in the floor sequence. PPL x2.5

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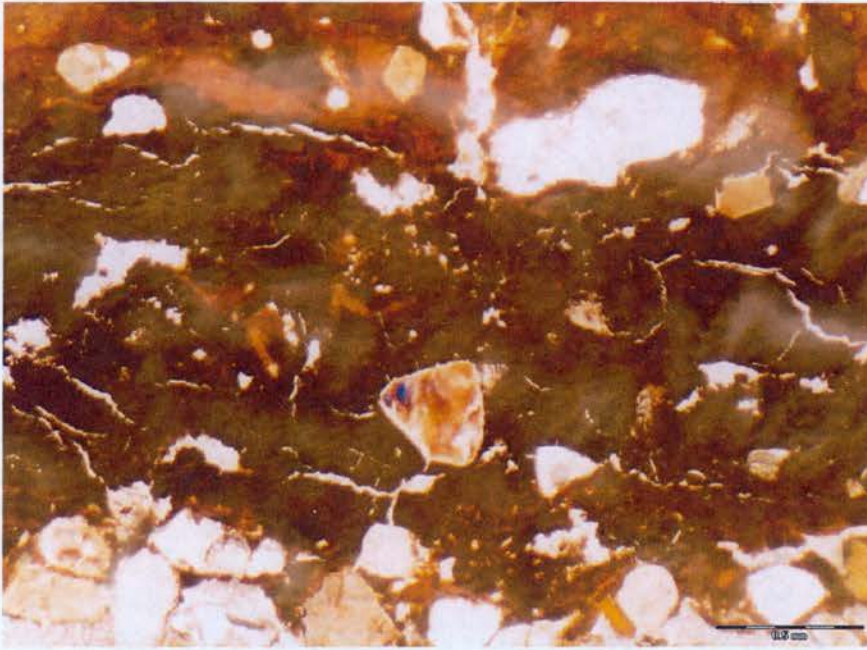
Plate 7: S128, Bostadh Beach floor 4. Grey ash residue, characteristic of many floors
in the sequence. Occurring as patches mixed in with other ashes. PPL x25.
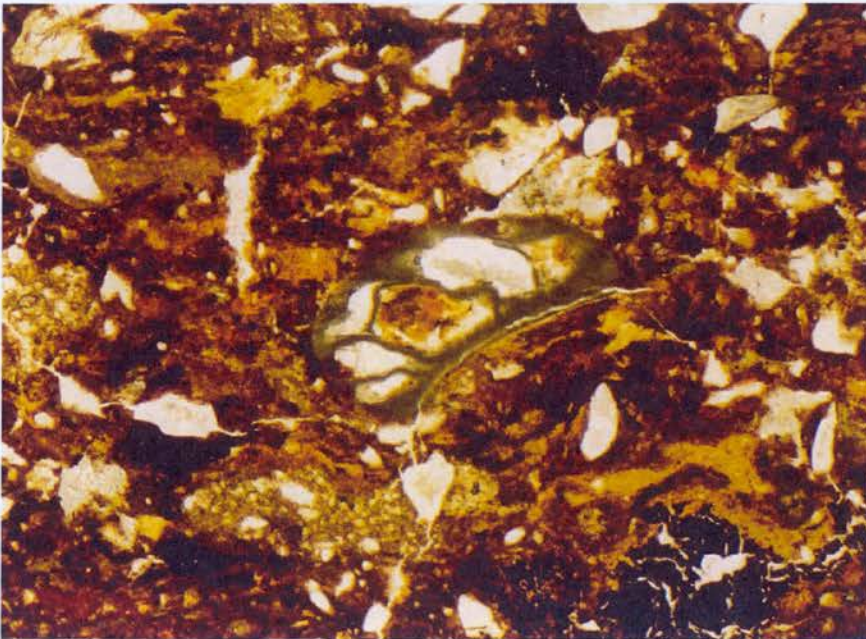
Plate 8: S128, Bostadh Beach, floor 9. Burned shell fragment in well humified
peat and peaty turf ash. PPL x25.

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Plate 9: As Plate 8, but in XPL. Burned fragment appears birefringent.
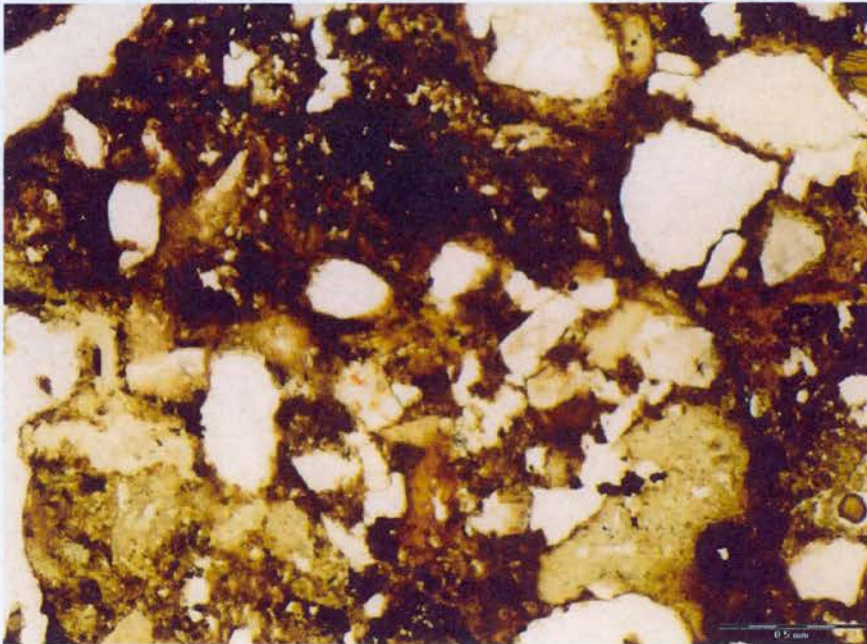
Plate 10: S128, Bostadh Beach, floor 6. Light brown/colourless ash residue, abundant in fused siliceous material. Mixed with well humified peat and peaty turf ash. PPL x40.
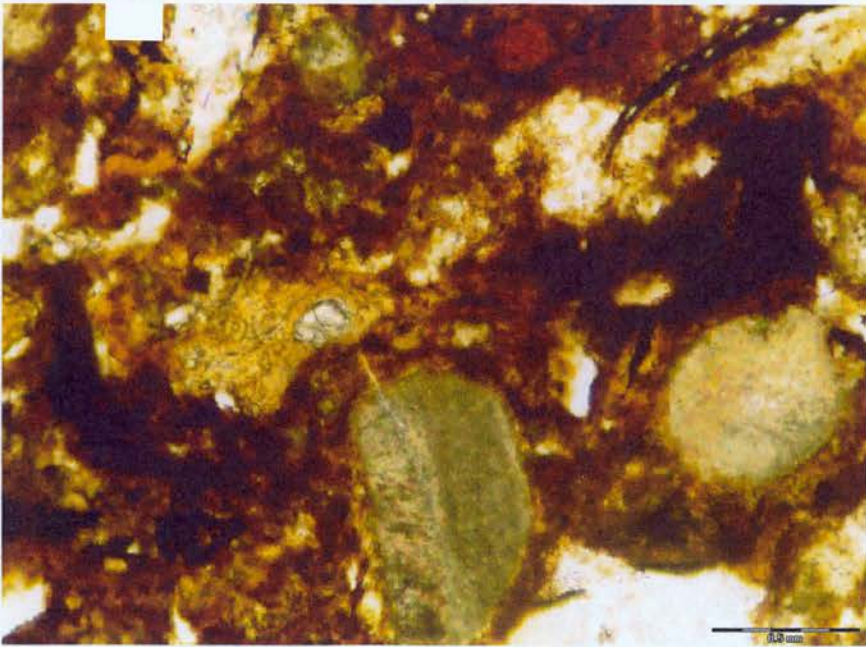
Plate 11: S133 Bostadh Beach, floor 4. Mix of well humified peat and peaty turf ashes characteristic of the floors in this sample. PPL x2.5.
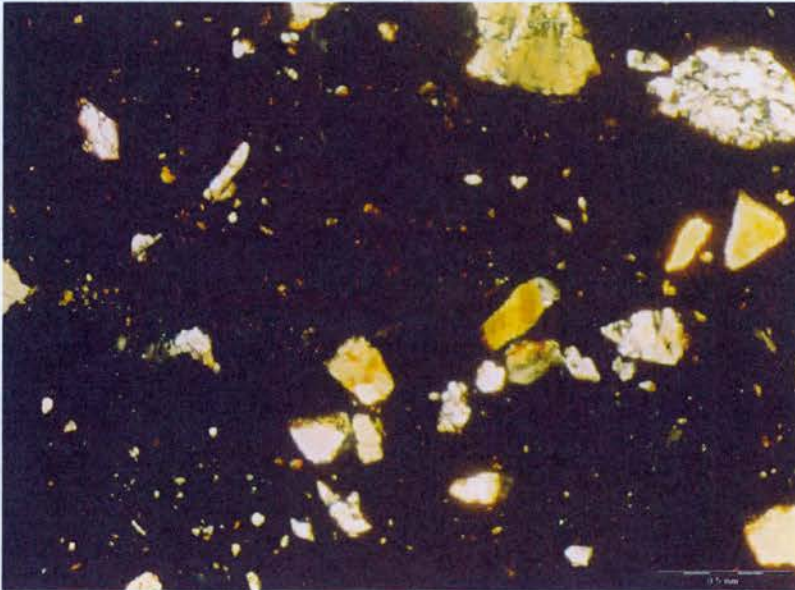
Plate 12: As Plate 11 in XPL, illustrating the isotropic form of the ash residue, x 2.5.
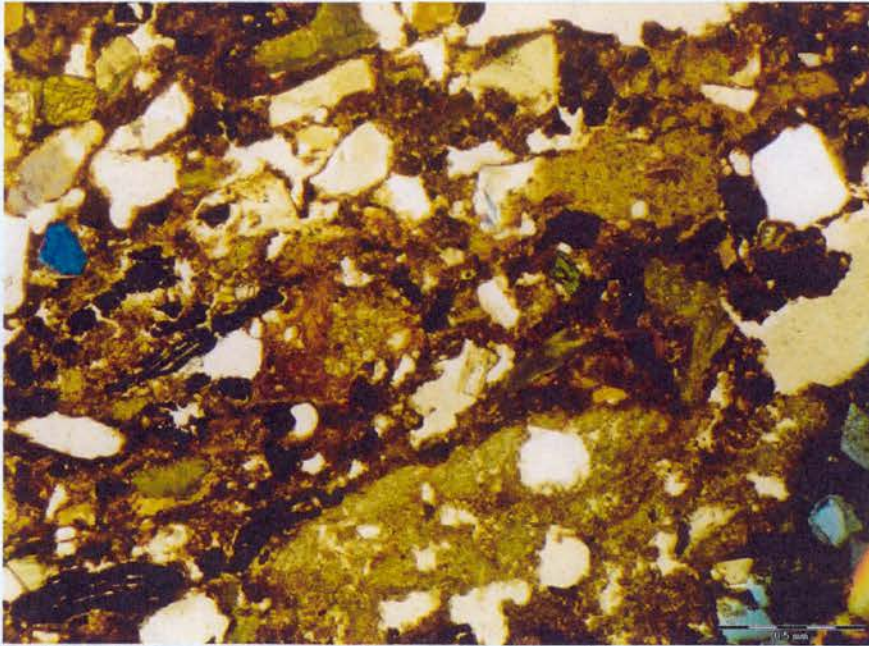
Plate 13: S120/2 Bostadh Beach, Floor 8. Well humified pat ash forming the floor,
Black charcoal fragments are embedded in the ashes. Massive
Microstructure. PPL x10.
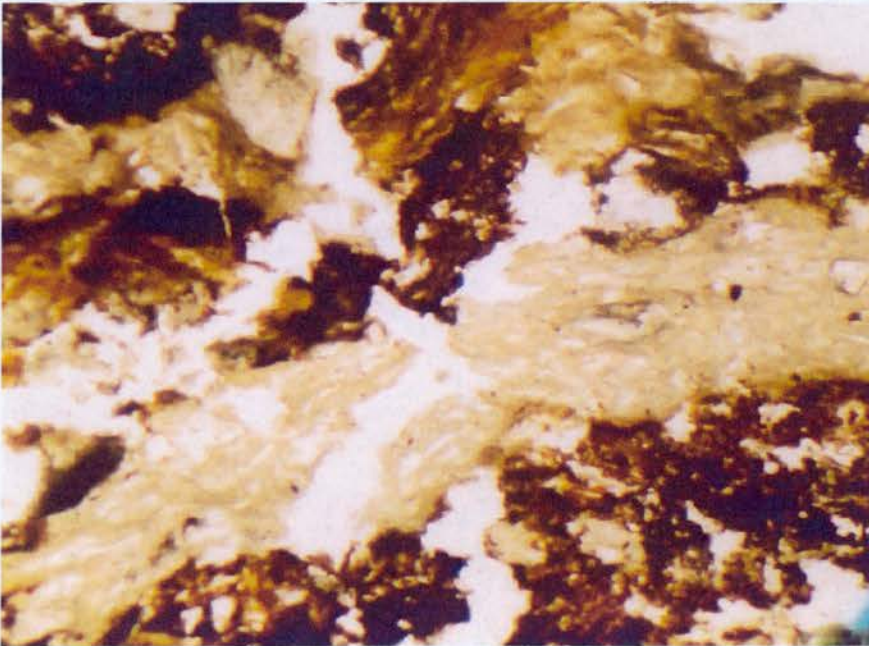
Plate 14: S120/3: Bostadh Beach, floor 3. Peaty turf ash (yellow-grey) forming matrix
of the floor. These floors had a higher charcoal content than the well
humified peat floors. PPL, x2.5.

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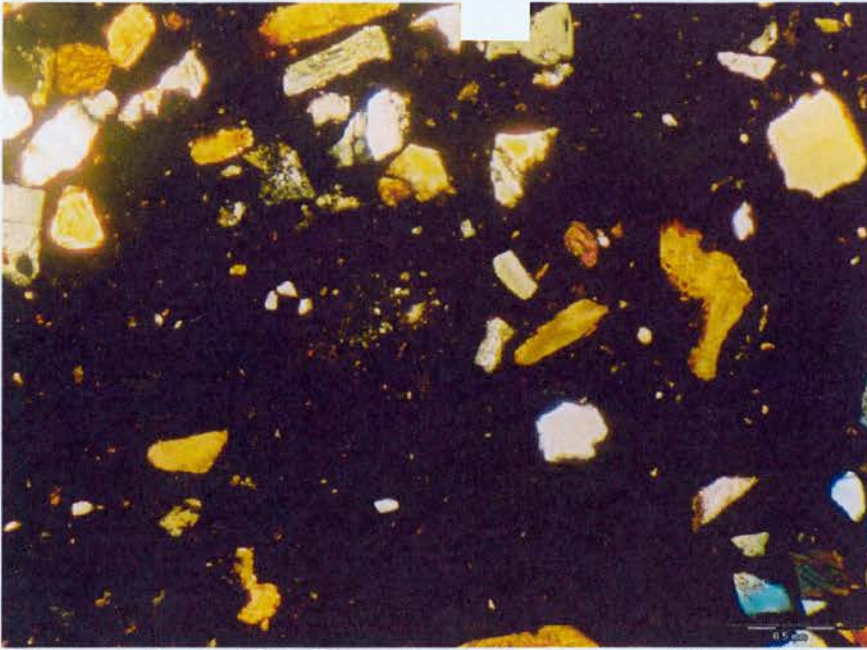
Plate 15: as Plate 14, but in XPL illustrating the isotropism of the turf ashes.
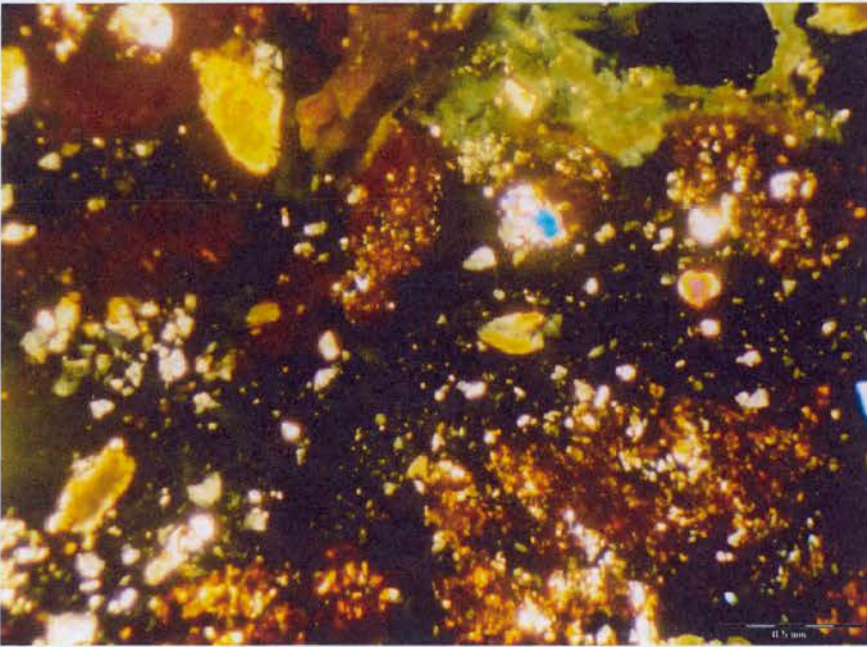
Plate 16: Reference sample of well humified peat ash from the experimental hearth
experiments, Calanais Farm. XPL, x 2.5. Note the birefringent quartz grains
and the isotropism (black) of some ash.
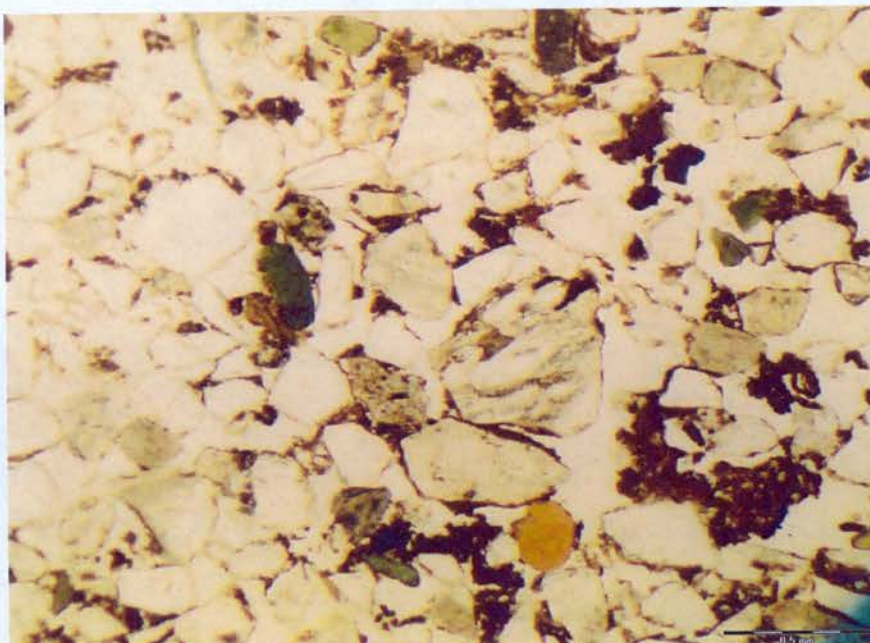
Plate 17: CH99 4963 EW 655, Cladh Hallan, House 401. Photograph illustrating Typical floor composition of the house and context 655. Single grain Microstructure with fine, well decomposed residues. Quartz dominance. PPL, x2.5
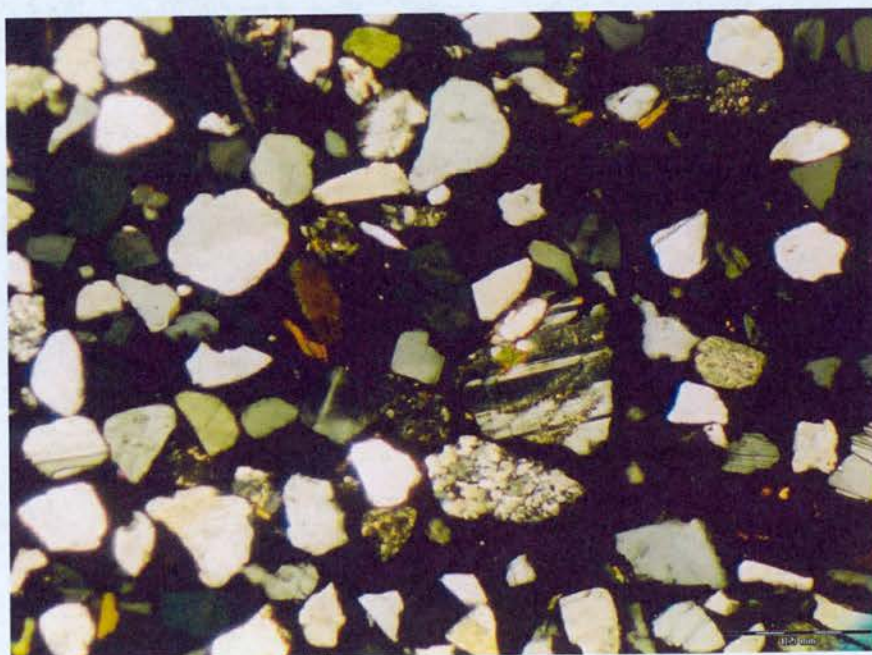
Plate 18: as Plate 17, with same mineralogy and microstructure, shown in XPL. Quartz dominance and isotropic fine material. XPL, x2.5
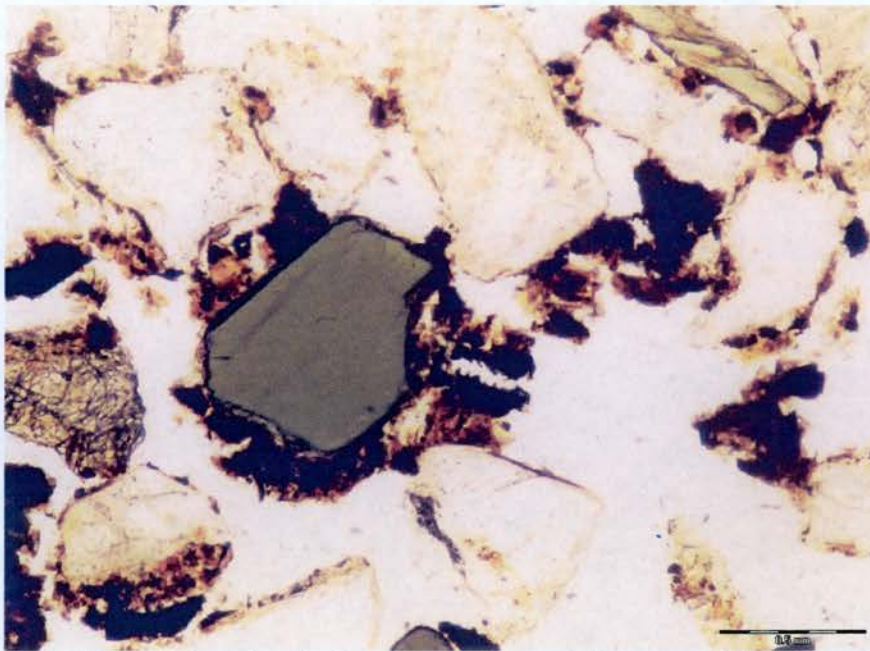
Plate 19: as Plate 17, showing detail of well decomposed fine material surrounding a single hornblende grain. Single grain microstructure. PPL, x2.5.
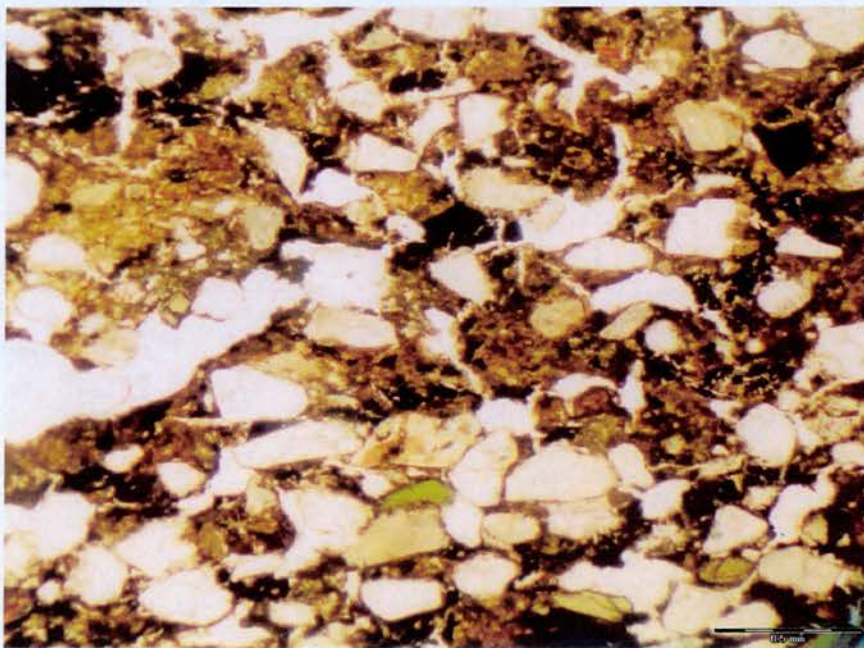
Plate 20: CH99 4847 NS 595, Cladh Hallan. Ash residue in central hearth area of House 401, floor 595. Mineral grains embedded in peaty turf ash, PPL x2.5.
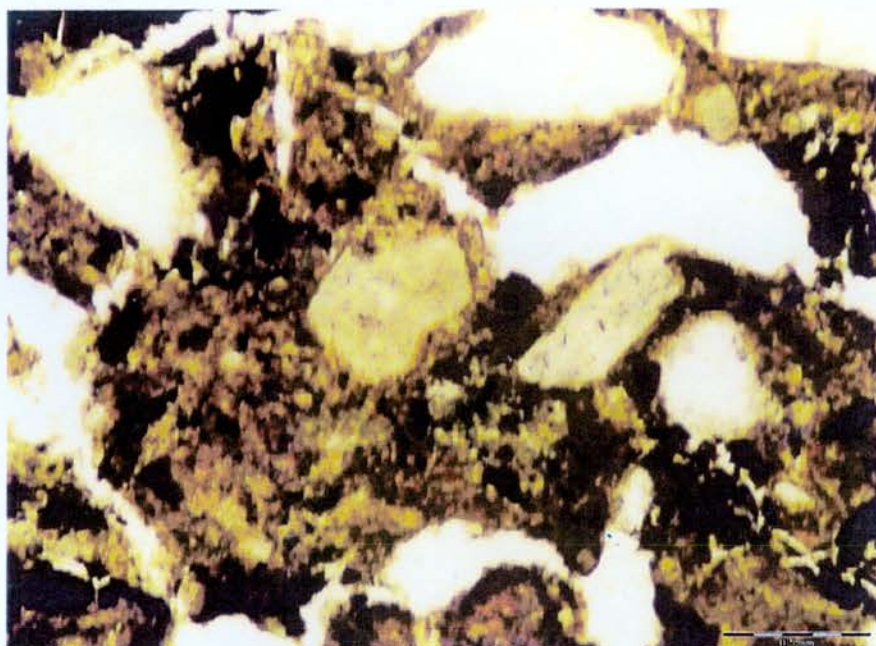
Plate 21: CH99 4847 NS 595, Cladh Hallan. As Plate 20 at x10 magnification.
Showing dense matrix of ash residues and quartz grains embedded
In residues. PPL, x10.
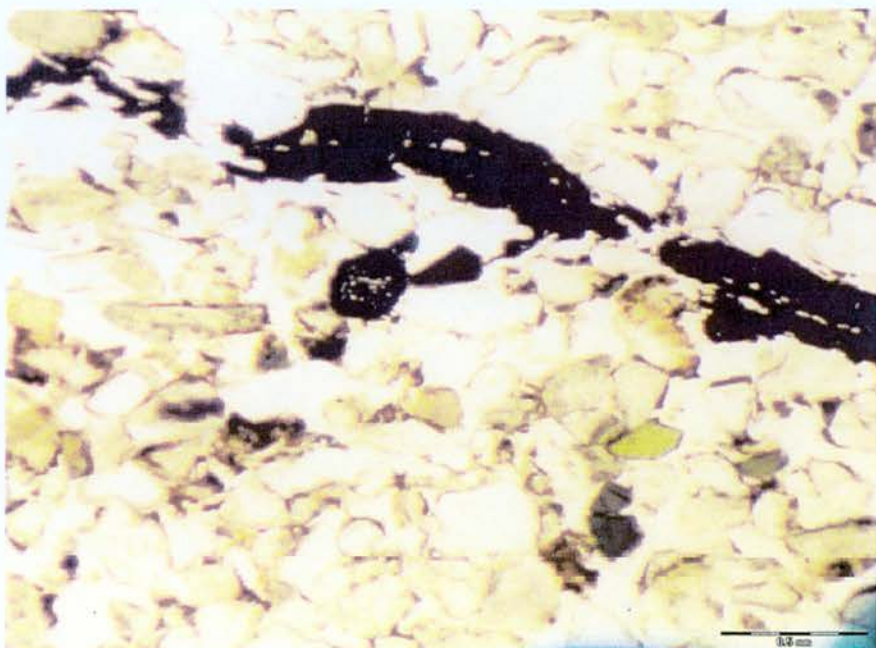
Plate 22: CH99 1799 NS 595, Cladh Hallan. Charcoal fragments in embedded
in the quartz dominant, single grain microstructure typical of floor 595,
House 401. PPL, x 2.5.
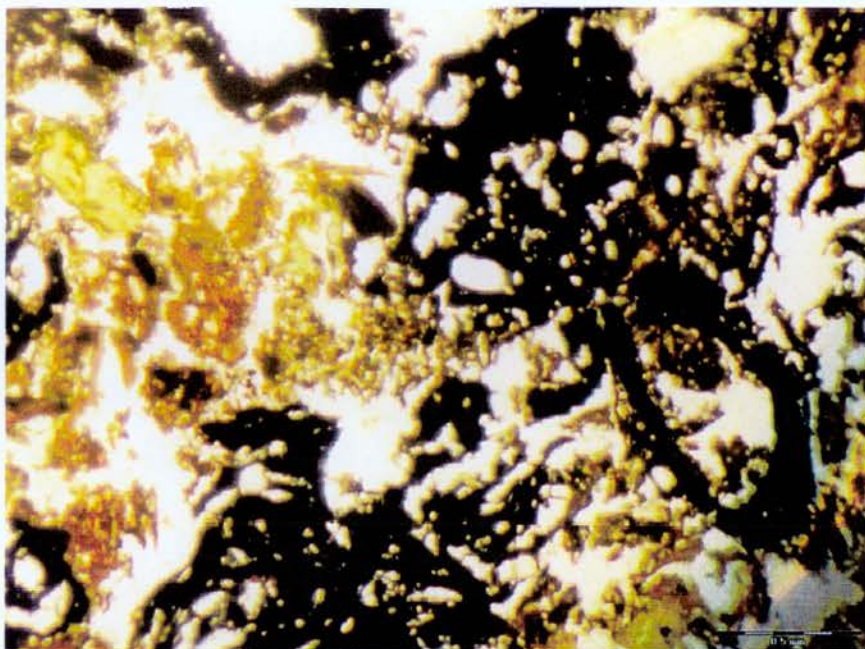
Plate 23: Reference Sample. Experimental fire hearth, Calanais Farm.
Peaty turf ash showing a higher charcoal fragment content (black) than
Plate 16, well humified peat. Also note the colour differences in the ashes.
PPL, x2.5.
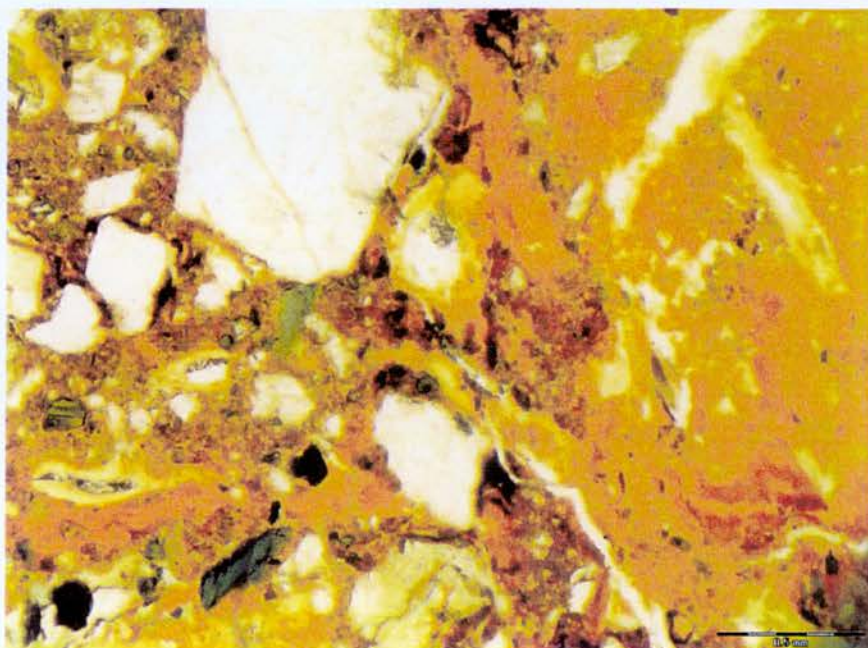
Plate 24: Reference Sample, Calanais Farm. Photograph of decaying plant remains
(Orange) within a well-humified peat matrix, with a massive microstructure.
These samples have a high mineral content, as evidenced from the
photograph.
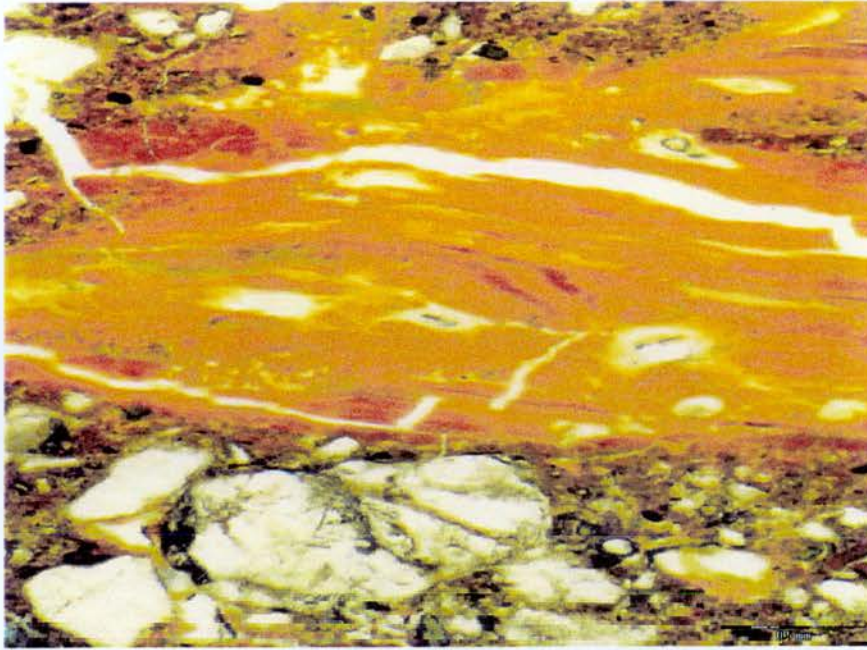
Plate 25: Reference Sample, Calanais Farm. Decaying plant remains in well humified Peat, with high mineral content, as seen at bottom of the photograph. PPL x2.5.
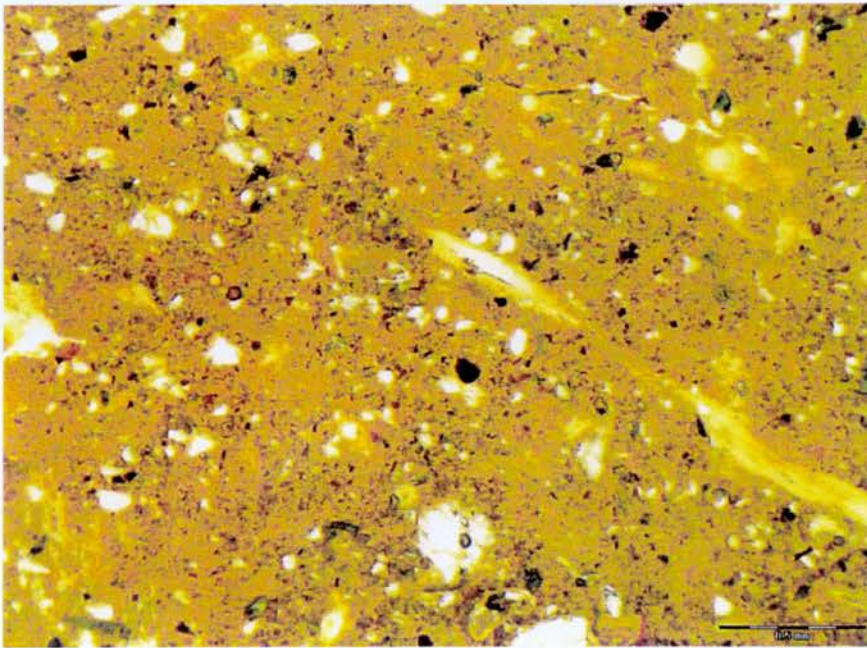
Plate 26: Reference Sample, Calanais Farm. Massive microstructure in well humified Peat. High mineral content. PPL, x2.5.
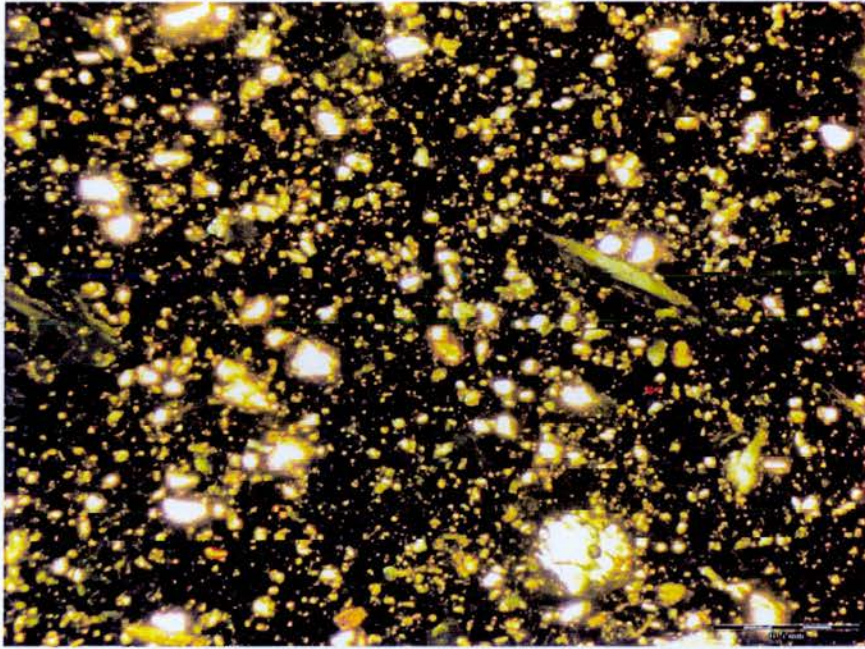
Plate 27: as Plate 26 in XPL. Organic material is isotropic (black), with birefringent quartz grains. XPL, x2.5.
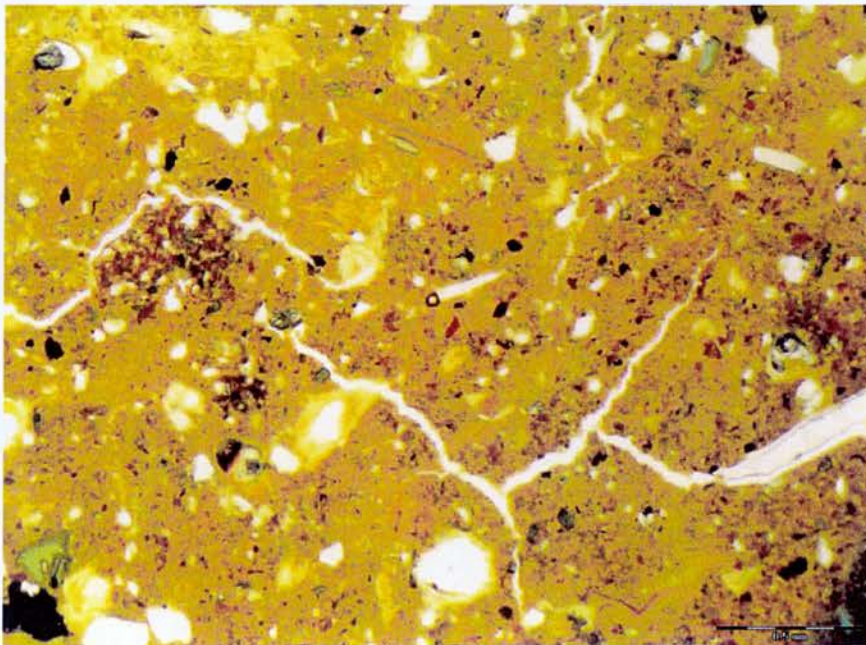

Plate 28: Reference sample, Calanais Farm. Massive and crack microstructure of well-humified peat. Green hornblende and white quartz grains visible. Well decomposed organic material. PPL, x2.5.
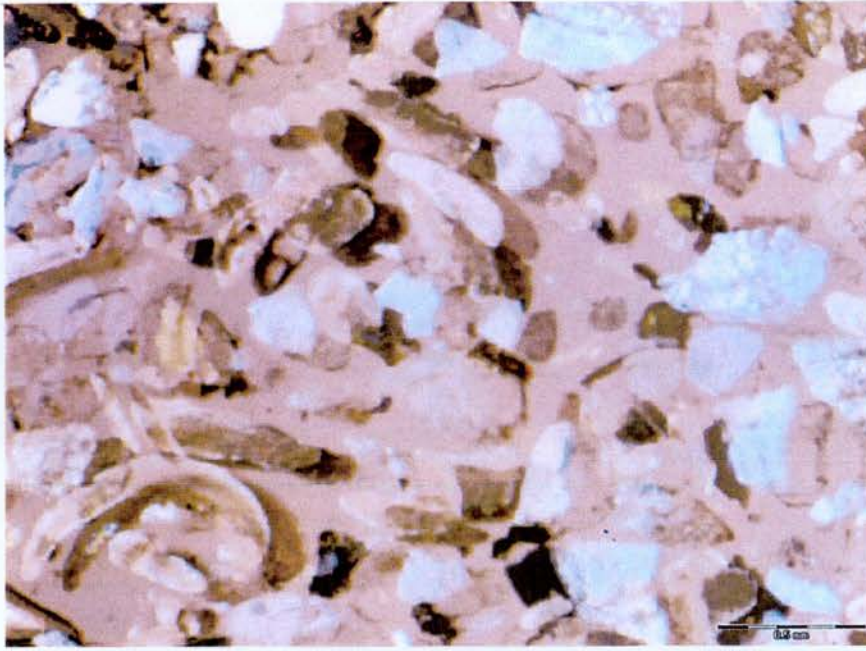
Plate 29: Reference Sample, Bostadh Beach. Single grain microstructure
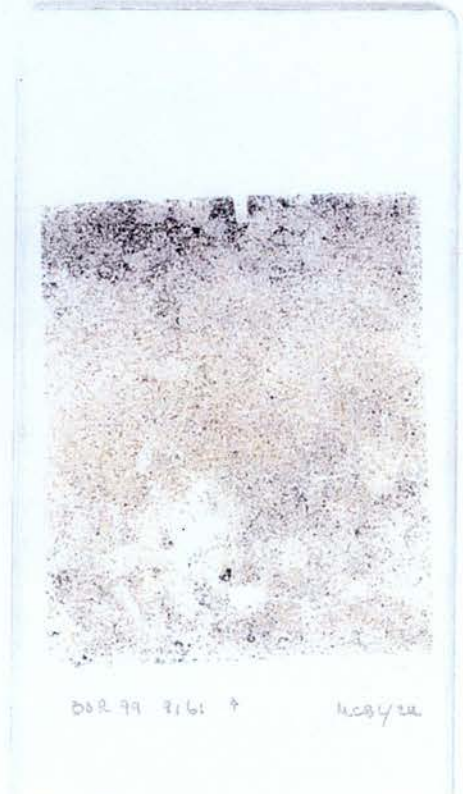With quartz, feldspar and carbonate grains. PPL, x10.

Plate 30: Thin sections of the floors at Bornais, South Uist. Real Size. Black areas are the charcoal formed deposits from roof collapse, with the lighter areas being sand that formed the original floor of the house.