A Study of West Coast Circular Structures Through Landscape Survey, Site Survey and Excavation:

Environmental Analysis

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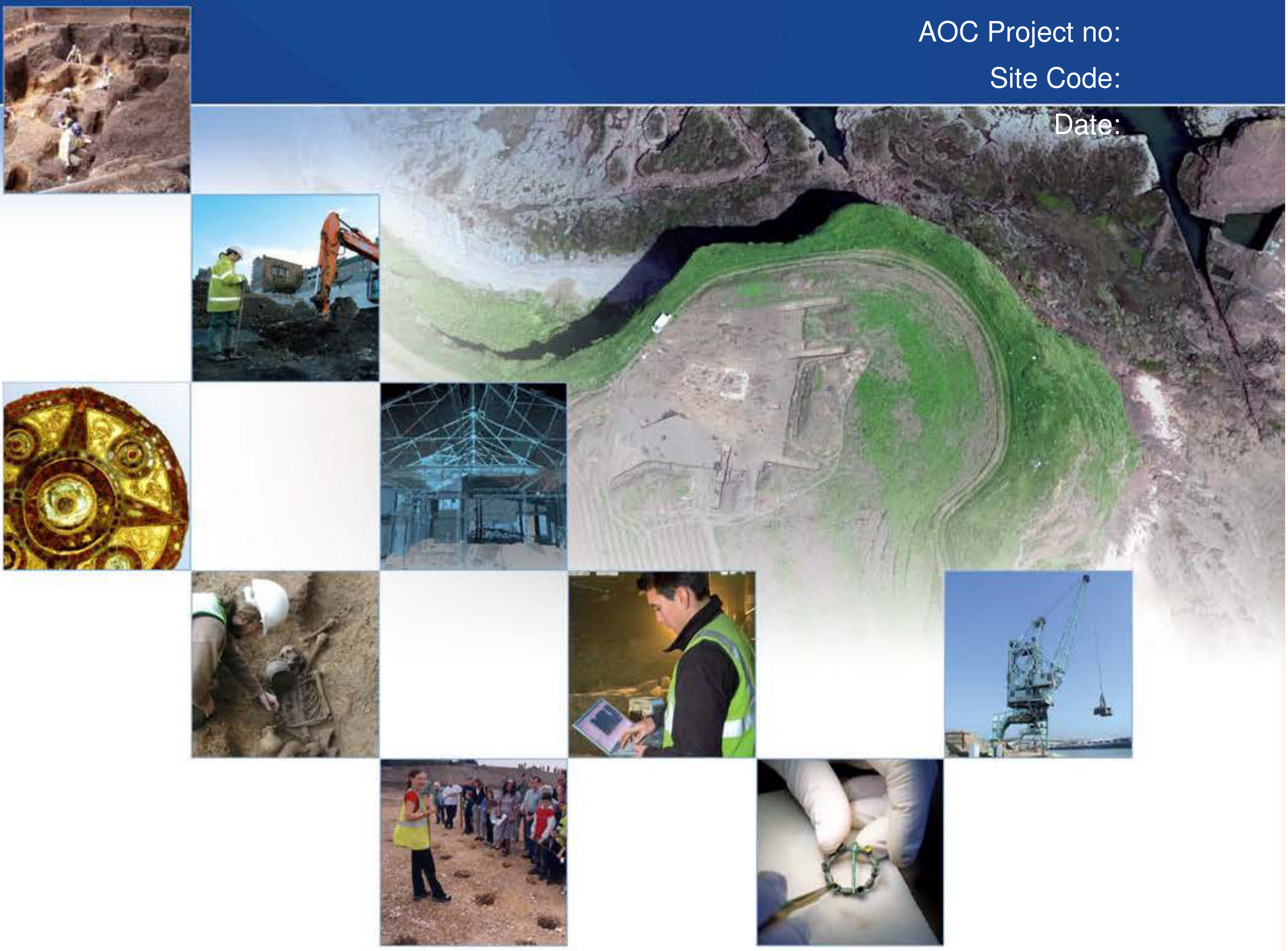

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A Study of West Coast Circular Structures Through Landscape Survey, Site Survey and Excavation: Environmental Analysis

On Behalf of:	
National Grid Reference (NGR):	
AOC Project No:	**60044**
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Abstract

Eleven bulk samples were collected from six sites in western Scotland form a series of round houses/hut circles/enclosures and submitted for environmental processing. These samples derived from occupation, hearth and pit features.

The environmental evidence was dominated by charcoal, retrieved both by hand and from the bulk samples. This material was analysed to identify evidence of occupational activity within features, ascertain what wood species were used for fuel and the composition of the woodland growing in the surrounding landscapes.

Factual data

Eleven bulk samples were submitted for environmental processing from six sites at Loch Raa, Achnahaird, Rue, Srathain, Auchtercairn 1 and Auchtercairn 2. The environmental assemblage recovered from these sites was comprised of carbonised wood of which 125 fragments larger than 4mm were identified to species. Charcoal fragments smaller than 4mm were not analysed. The wood species identified were alder (*Alnus glutinosa*), birch (*Betula* sp.), hazel (*Corylus avellana* L.) and pine (*Pinaceae* sp.). The charcoal assemblage contained two roundwood fragments and a single piece of bark, but there were no worked wood offcuts. The charcoal derived from a range of features such as hearths, occupation horizons and pits.

The only other environmental material recovered was five poorly preserved bone fragments from a single bulk sample taken from Rhue, Ullapool. The fragments did not exceed 10mm and none could be identified to either element or species.

Modern contamination was extensive in all samples and consisted of peat, roots, twigs, bracken fronds, heather leaves/stems, moss, seeds, insect eggs, insect remains, earth worm capsules and fibres. The close proximity of these features to the surface and the thickness of the covering vegetation may have affected the archaeological security of these contexts. The problem of modern root invasion within archaeological features was noted during excavation, but it was believed that the overall security of the small finds and charcoal has not suffered extensive re-working and is therefore reliable.

Methodology

The eleven bulk samples were processed in their entirety in laboratory conditions using a floatation method designed to retrieve environmental remains (cf. Kenward *et al*. 1980). The type of sediment was variable and depended on which area it came from. The samples described as occupation layers were mostly silty sediments and the burnt layers were ashy, none of which required any pre-treatment. The samples from Srathain were extremely compact and had to be soaked in warm water for 24 hours prior to processing. No charred or waterlogged macroplants were recovered.

The recovery of charcoal from Scottish sites tends to be limited and this ultimately affects how far the evidence can be interpreted and how it is used. In the absence of any other environmental material such as carbonised macro plant remains this has placed greater importance on the charcoal evidence in assisting with understanding the development of these sites and the surrounding landscapes. To ensure as much information as possible was obtained from this relatively small charcoal assemblage the conclusions presented in the discussion can only be described as interpretive assumptions. The interpretation of the charcoal evidence is therefore arbitrary and its main role will be to provide radiocarbon dates and be used to help identify fuel sources and the nature of the nearby landscape.

Results

Results are recorded in Tables 1, 2 and 3

The overall assemblage was dominated by birch which accounted for 57%, followed by alder 38%, hazel 3%, and pine 2%. The charcoal assemblage included large fragments along with two smaller pieces of roundwood and a single bark fragment. There was no evidence of worked wood within the assemblage, nor was there any evidence for the shaping or working of structural wood on any of these six sites. The charcoal assemblage was concentred in the enclosure at Auchtercairn 2 with 89 fragments identified from this site.

Discussion

ACHILTIBUIE AREA

Loch Raa Hut Circle, Achiltibuie

This hut circle was described as a domestic habitation and 11.4g of charcoal were recovered from trench 1 and 2. The charcoal appears to have originated from fuel debris associated with the hearths and the species were alder, birch and hazel which included two roundwood fragments. The presence of mixed wood species and roundwood is a strong indicator of fuel debris rather than in situ structural burning.

A single fragment from hearth [1.2] was poorly preserved and could not be identified to species. The morphological distortion affecting this charcoal fragment was distinctive in that the damage was either attributable to the burning process or to the nature of the wood itself. It is possible this wood was deliberately charred at an extremely high temperature for a specific purpose. Alternatively the wood could have been either partly decayed prior to charring or may represent another part of the tree such as a root or branch.

Achnahaird Hut Circle, Achiltibuie

This walled structure had undergone a period of abandonment before being reoccupied and a small assemblage of 0.8g of charcoal was recovered. A single fragment of alder was present in context [2.2] described as the collapse of the round house wall out with the structure. This single fragment is off little interpretive value. A further 4 unidentifiable fragments of charcoal were in context [2.3] in the abandonment phase. The preservation of these fragments was similar to the other unidentifiable charcoal fragment from the hut circle in Loch Raa.

ULLAPOOL AREA

Rhue Hut Circle, Ullapool

A small assemblage of 0.3g of birch were recovered by hand from contexts [1.3] and [2.3] located within the stone walled domestic structure and from along the extended entrance. This material probably derived from fuel debris which was subsequently trampled and re worked into the occupation horizons' within the hut circle. Four fragments of poorly preserved bone all of which were smaller than 10mm were recovered and none could be identified further. The bone fragments if contemporary with the hut circle are probably representative of food refuse discarded on the floor. Two fibres were also recovered which were clearly modern and were probably introduced accidently during excavation.

Srathain Hut Circle, Ullapool

These platform structures cut into the hill slope are not believed to represent domestic habitation or activities. This was confirmed by the near absence of any finds from the two bulk samples submitted for processing as only a single fragment of birch charcoal was retrieved from context [1.2]. These two bulk samples were described as a greasy/compact sediment and they proved the most difficult to process.

GAIRLOCH AREA

Auchtercairn 1 Hut Circle, Gairloch

This was described as a massive circular enclosure and 6g of birch fragments were collected from trench 1 which contained evidence of three levels of activity and intensive burning in the centre of the site. This site is not believed to have functioned as a domestic habitation and the charcoal recovered is likely to represent fuel debris.

Auchtercairn 2 Hut Circle, Gairloch

The original earth banked round-house was later replaced with a stone walled structure which included the later construction of a hearth within the building. The charcoal assemblage was concentrated in this hut circle with 48.8g of alder, birch, hazel, pine and a single bark fragment spread through out trenches 1 and 4. This charcoal was probably fuel debris which has subsequently become trampled and re-deposited within the occupation layers. If this charcoal relates to activities associated with the later hearth then this was after the stone built house was abandoned and was no longer primarily used as a domestic habitat.

Conclusion

The charcoal assemblage recovered from these six sites are all representative of mixed fuel debris as there is no evidence of any in situ structural burning.

The absence of any charred macroplants and burnt bone is surprising for those sites described as domestic structures. It is possible the occupants of the domestic buildings and sites regularly cleaned both the floors and hearths with the accumulative refuse disposed out with the living areas. Alternatively the presence of extensive modern contamination especially in the form of plant roots may have inadvertently led to the removal of smaller environmental finds. The recovery of small bone fragments from Rhue, Ullapool is inconclusive as this same site also contained modern fibers and it is unclear if these bone fragments are also intrusive.

The recovery of unidentifiable charcoal from both Loch Raa Hut Circle and Achnahaird Hut Circle situated in Achiltibuie suggests that either this region was deliberately burning things at an extremely high temperature or that they had to use decayed wood or other parts of the tree for fuel.

The composition of wood species found at these sites, alder, birch, hazel and pine, probably reflects the composition of woodland in the surrounding landscape. Birch and alder were the most common species present, reflecting their dominance in the landscape. Many of these sites appear to have been situated close to a water source and the damp ground conditions would have readily supported both birch and alder woodland, hence its dominance within the charcoal assemblage. The hazel species would have been components of this scrubby woodland. The small number of pine fragments within the assemblage is not unusual as due to the high resin content of this species it reduces to ash more readily than other wood species, as a consequence it is typically underrepresented within the archaeological record.

The charcoal assemblage from Loch Raa, Achnahaird, Rue, Srathain, Auchtercairn 1 and Auchtercairn 2 are representative of mixed fuel remains where birch and alder have clearly been favored. The charcoal assemblages from these six sites are typical of other finds recovered from similar sites in Scotland.

References

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Section 2: Appendix 1

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Table 1. Flot finds

Area	Site	Sample	Context	Trench	Feature	Sample Vol (l)	Flot (ml)	% sorted	Charcoal
Achiltibuie	Loch Raa	LR 05	1.3	1	Hearth	1.5	25	100	<4mm
Achiltibuie	Loch Raa	LR 07	1.5	1	Occ H	3.5	200	100	Yes
Gairloch	Auchtercairn 1	G1. 2	1.3	1	Ash	3	150	100	Yes
Gairloch	Auchtercairn 1	G1.5	1.4	1	Pit	1	30	100	<4mm
Gairloch	Auchtercairn 2	Acht 1.3	110	1	Occ H	1	110	100	Yes
Gairloch	Auchtercairn 2	Acht 1.4	1.11	1	Occ H	2	130	100	Yes
Gairloch	Auchtercairn 2	Acht 4.4	4.3	4	Occ H	1	250	100	Yes
Ullapool	Rhue	R 03	1.3	1	Occ H	3	65	100	<4mm
Ullapool	Rhue	R 04	1.4	1	Occ H	3	25	100	No
Ullapool	Srathain 1	S1.1	1.2	1	Occ H	1	110	100	Yes
Ullapool	Srathain 1	S1.5	2.3	2	Occ H	0.5	30	100	<4mm

Table 2. Retent finds

Area	Site	Sample	Context	Trench	Feature	Sample Vol (l)	Retent Vol (l)	% Sorted	Charcoal	Bone (g)	Fibre (g)
Achiltibuie	Loch Raa	LR 05	1.3	1	Hearth	1.5	0.08	100	<4mm		
Achiltibuie	Loch Raa	LR 07	1.5	1	Occ H	3.5	0.1	100	<4mm		
Gairloch	Auchtercairn 1	G1. 2	1.3	1	Ash	3	0.2	100	<4mm		
Gairloch	Auchtercairn 1	G1.5	1.4	1	Pit	1	0.2	100	<4mm		
Gairloch	Auchtercairn 2	Acht 1.3	1.11	1	Occ H	1	0.3	100	Yes		
Gairloch	Auchtercairn 2	Acht 1.4	1.11	1	Occ H	2	0.3	100	<4mm		
Gairloch	Auchtercairn 2	Acht 4.4	4.3	4	Occ H	1	0.05	100	<4mm		
Ullapool	Rhue	R 03	1.3	1	Occ H	3	1.2	100	<4mm	5 (0.03g)	1 (N/A)
Ullapool	Rhue	R 04	1.4	1	Occ H	3	1.1	100	<4mm		1 (N/A)
Ullapool	Srathain 1	S1.1	1.2	1	Occ H	1	0.2	100	<4mm		
Ullapool	Srathain 1	S1.5	2.3	2	Occ H	0.5	0.05	100	<4mm		

Key: Occ H=Occupation horizon, <4mm= smaller than 4mm not collected, weight given in grams in bracket, N/A too small too weigh

Table 3. Charcoal species

Area	Site	Sample	Context	Trench	Feature	Recovery	Latin name	Common name	No	RW	Total Weight (g)
Achiltibuie	Loch Raa	LR 2	1.2	1	Hearth	HD	Indet	Indet	1		6.1
Achiltibuie	Loch Raa	LR 6	1.3	1	Hearth	HD	*Alnus glutinosa*	Alder	1		
Achiltibuie	Loch Raa	LR 6	1.3	1	Hearth	HD	*Corylus avellana*	Hazel	1		0.2
Achiltibuie	Loch Raa	LR 7	1.5	1	Pit	B/S	*Betula sp*	Birch	6		
Achiltibuie	Loch Raa	LR 7	1.5	1	Pit	B/S	*Corylus avellana*	Hazel	1	Yes	2.1
Achiltibuie	Achnahaird	F 05	2.2	2	Wall outside structure	HD	*Alnus glutinosa*	Alder	1		0.08
Achiltibuie	Achnahaird	F 28	2.3	2	Abandonment phase	HD	Indet	Indet	4		0.8
Achiltibuie	Loch Raa	F LR 15	2.4	2	R/H Occ h	HD	*Alnus glutinosa*	Alder	1	Yes	0.8
Achiltibuie	Loch Raa	F LR 15	2.4	2	R/H Occ h	HD	*Betula* sp	Birch	3		2.2
Gairloch	Auchtercairn 1	1.2	1.3	1		RT	*Betula sp*	Birch	5		3.3
Gairloch	Auchtercairn 1	1.3	1.3	1	Ashy soil	HD	*Betula* sp	Birch	5		1.4
Gairloch	Auchtercairn 1	1.7	1.4	1	Ashy soil	HD	*Betula* sp	Birch	1		1.3
Gairloch	Auchtercairn 2	Acht 1.5	1.10	1	Occ H	HD	*Alnus glutinosa*	Alder	5		
Gairloch	Auchtercairn 2	Acht 1.5	1.10	1	Occ H	HD	*Betula* sp	Birch	3		
Gairloch	Auchtercairn 2	Acht 1.5	1.10	1	Occ H	HD	*Corylus avellana*	Hazel	1		
Gairloch	Auchtercairn 2	Acht 1.5	1.10	1	Occ H	HD	*Pinaceae* sp	Pine	1		2
Gairloch	Auchtercairn 2	Acht 1.3	1.11		Occ H	B/S	*Betula sp*	Birch	11		6.9
Gairloch	Auchtercairn 2	Acht 1.4	1.11	1	Occ H	B/S	*Betula sp*	Birch	3		5.5
Gairloch	Auchtercairn 2	Acht 1.6	1.11	1	Occ H	HD	*Alnus glutinosa*	Alder	1		
Gairloch	Auchtercairn 2	Acht 1.6	1.11	1	Occ H	HD	Indet	Bark	1		
Gairloch	Auchtercairn 2	Acht 1.6	1.11	1	Occ H	HD	*Betula sp*	Birch	23		

Gairloch	Auchtercairn 2	Acht 1.6	1.11	1	Occ H	HD	*Corylus avellana*	Hazel	1	13.4
Gairloch	Auchtercairn 2	Acht 4.4	4.3	4	Occ H	B/S	*Alnus glutinosa*	Alder	19	6.6
Gairloch	Auchtercairn 2	Acht 4.5	4.3	4	Occ H	HD	*Alnus glutinosa*	Alder	17	
Gairloch	Auchtercairn 2	Acht 4.5	4.3	4	Occ H	HD	*Betula sp*	Birch	2	
Gairloch	Auchtercairn 2	Acht 4.5	4.3	4	Occ H	HD	*Pinaceae* sp	Pine	1	14.4
Ullapool	Srathain 1	S1.1	1.2	1		B/S	*Betula sp*	Birch	1	0.6
Ullapool	Rue	F 05	1.3	1	Hearth	HD	*Betula* sp	Birch	2	0.1
Ullapool	Rue	F 04	2.3	2	Hearth	HD	*Betula* sp	Birch	3	0.2

Key: Occ H= Occupation horizon, HD=Hand recovered, B/S= Bulk sample, total weight of charcoal sample given in grams

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Wedig Project; Micromorphology Analysis Report

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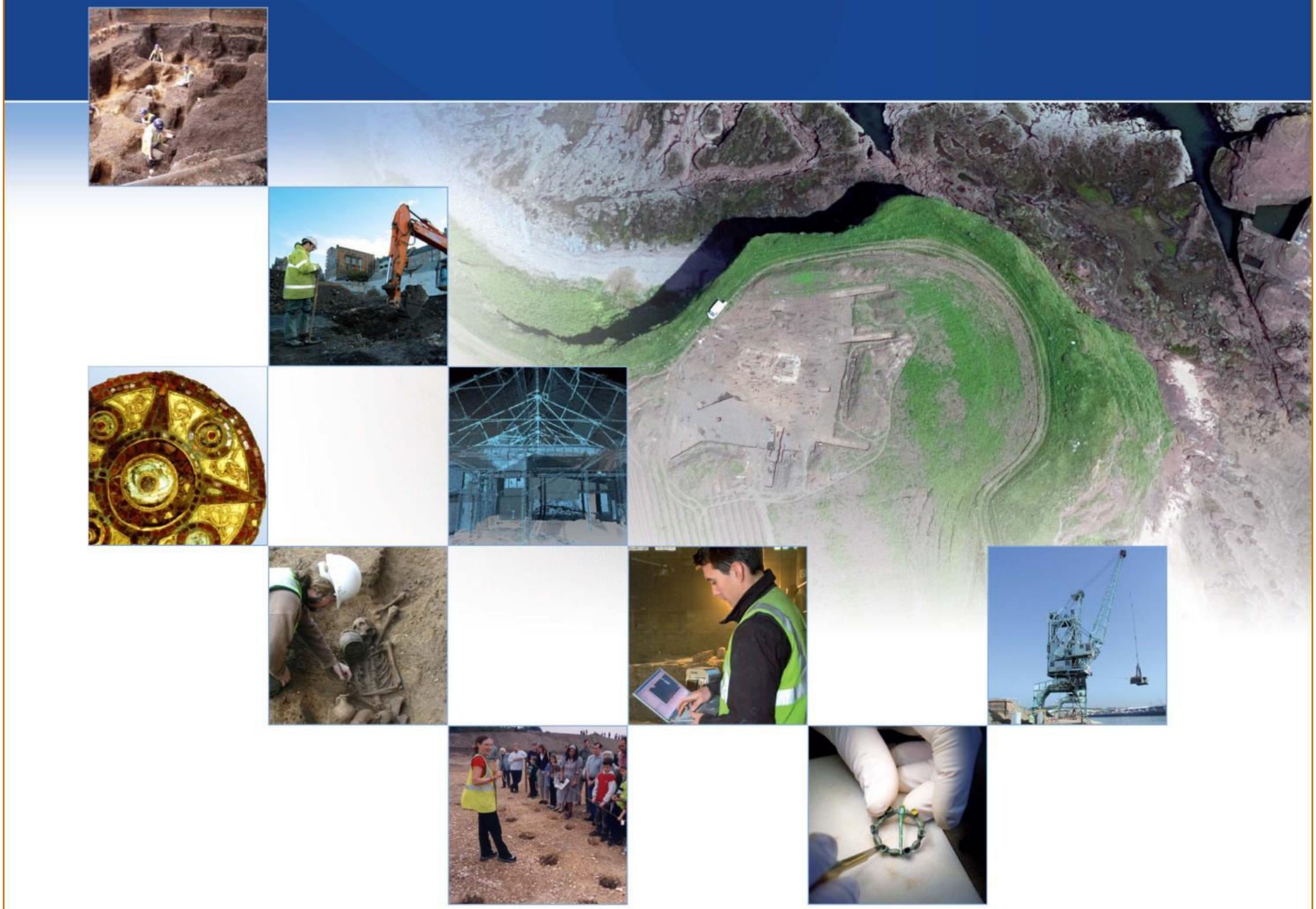

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Wedig Project: Micromorphology Analysis Report

On Behalf of: Wedig Project

National Grid References (NGR):	**NC 0213 1188** **NC 0230 1265** **NH 1057 9689** **NH 1269 9728** **NG 8077 7693**
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Prepared by: Lynne Roy

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Introduction

This report presents the results of micromorphological analysis of nine kubiena samples collected as part of the Wedig community archaeological project. The project aimed to allow a better understanding of circular structures in Wester Ross, through the survey, excavation and sampling at the sites of circular structures across Wester Ross (Wildgoose and Welti, 2012). Eight of the samples analysed were removed during the 2012 excavation season from across five sites; Loch Raa, Achnahaird, Rhue, Strathain and Achtercairn 2. The ninth sample was removed from Achtercairn 3 during a later phase of excavation in 2014. A tenth sample removed from Achtercairn 1 (Wedig 3) was not analysed due to difficulties encountered during processing.

The solid geology beneath the two sites at Achiltibuie (Loch Raa and Achnahaird) comprises reddish feldspathic sandstones and grits of the Torridonian strata. These rocks give rise to a drift geology that is characteristically reddish or pinkish with stony and loamy sand textures. Soils at both sites are peaty gleys or peaty podsols, often strongly gleyed above an iron pan and have either friable or an indurated B horizon immediately below the pan. Soils at Strathain are also derived from Torridonian strata but are more commonly developed on glacial till or colluvium; they are peaty gleys or peaty podzols (Futty and Towers 1982, 556-7).

The solid geology at Rhue comprises pebbly and gravelly sandstones of the Applecross Formation overlain by a superficial geology of glacial sands and gravel with common colluvial deposits. Soils are of the Torridon Association and consist of peaty gleys and peat with some peaty podzols and peaty rankers (Futty and Towers 1982, 115).

The soils at Achtercairn are developed on drifts derived from the Lewisian metasediments and hornblende-schists of the Loch Maree Group. Drifts are mainly brown or dark brown, stony and with loamy sand or sandy loam. Soils are of the Lochinver Association and are peaty gleys, peat and peaty rankers with some peaty podsols (Futty and Towers, 91-94).

Micromorphology has become an increasingly important analytical tool in understanding site formation processes (Simpson and Barret 1996) and the use of space (Matthews *et al.* 1997), which can be difficult to resolve at the macro scale. The occupation deposits and buried land surfaces excavated at each of the circular structures present an opportunity to differentiate between areas of occupation and abandonment and also allow these to be set in context with pedogenetic processes to which each site has been subject, both during and after its occupation.

Aims and objectives

The aims of the soil micromorphological analysis are summarised in the Data Structure Report (Wildgoose and Welti, 2012) and are to provide a more refined interpretation of the soil profile. For the purpose of the analysis of the nine samples that form the focus of this report the aims include:

i) The process of deposition
ii) The character of the material deposited
iii) Identification of occupation areas
ii) Identification and characterisation of hearth structures
iv) Identification of post-depositional processes.

Micromorphological analysis of Achtercairn 3 was undertaken with the additional aim of identifying any multiple events or activities within the micro layers (Welti, 2014 *pers comm.).*

Methodology

The samples were prepared for analysis using the methods of Murphy (1986) at the University of Stirling in the Department of Environmental Sciences. The thin sections have been described using the terminology of Bullock *et al* (1985) and Stoops (2003). The coarse/fine limit of 10µm is used for both the mineral and organic components.

Micromorphology is an analytical technique by which soils and sediments are made into thin transparent glass mounted slides (usually 30µm thick) which can be examined using a petrographic microscope. Interpretation of microstratigraphic sequences in thin section is based on internal and comparative analysis of the type, frequency, morphology and structural relationships of depositional components and boundaries in each sequence and their spatial, temporal and sociocultural contexts within settlements. Analysis of micromorphological soil features can identify elements relating to human activity which may not be identifiable during excavation and also allow these to be set in context with both the natural pedogenic and disturbance related processes to which an archaeological site is subject, both during and after its occupation.

When estimating abundance of fabric constituent the following terms (after Stops 2003; 49) have been used:

Abundance	**Area %**
Very dominant	>70
Dominant	50-70
Frequent	30-50
Common	15-30
Few	5-15
Very few	<5

Results

The results are summarised below in Table 1. A full description of the results is located in Appendix 1.

Loch Raa (Wedig 1)

Key: t=trace +=Very few, ++= Few, +++= Frequent/Common, ++++Dominant/Very Dominant

Pedofeatures t=trace (<1%) tt=rare (1-2%) ttt=occasional (2-5%) tttt many (5-10%)

Sample	Context	Coarse Mineral						Fine Mineral	Coarse Organic						Amorphous Fine Organic			Pedofeatures					Microstructure	Coarse Material arrangement	C/F related distribution
		Rock frags	Chlorite	Muscovite	Biotite	Feldspar	Quartz	Colour PPL Groundmass b-fabric	Charred	organ residues	(decomposed)	Plant tissues	(fresh)	Plant tissues	Yellow	Reddish brown	Black	Excremental	Impure/limpid clay coatings	Silty clay coatings/infill	Fe/Mn accumulations	Fe/Mn nodules			
T1 LR 1	1.3	tr				+	++++	Yellowish brown Heterogeneous Speckled b-fabric	++	+		tr		++	+++	+++	++	t			ttt	ttt	Complex. Massive with rare channel voids	Randomly oriented some clustering of coarse minerals. Poorly sorted (frequently sand sized)	Close porphyric
T1 LR 2	1.3	+	tr			++	++++	Very dark brown Heterogeneous Weakly speckled b-fabric	++	++		+		tr	++	+++	+++	tttt	t	t	tt	ttt	Complex. Intergrain microaggregate	Randomly oriented and arranged. Unsorted	Single spaced smooth enaulic
T1 LR 3	1.3/1.2	tr			+	+	++++	Yellowish to reddish brown Heterogeneous Undifferentiated	+	+		+	++	+++	+++	++++	+	tttt		t	tt	ttt	Complex. Massive with rare channel and chamber.	Randomly oriented and arranged. Unsorted	Open porphyric
T1 LR 4	1.2	++			++	++	++++	Yellowish brown Heterogeneous Speckled b-fabric	+++	+		++		+++	+++	++	++	tttt			tttt	ttt	Complex. Massive with few channel voids	Randomly oriented. Some clustering of coarse mineral and organic matter. Unsorted	Open porphyric
T3 LR 1	3.3				+	+	+++	Yellowish to reddish brown Heterogeneous Undifferentiated b-fabric	++	tr		+++		++	+++	+++	+++	tt	tt	ttt	tttt	tttt	Complex. Channel and chamber	Random and poorly sorted	Close porphyric
T3 LR 2	3.2				+	+++	++++	Yellowish to reddish brown Heterogeneous Undifferentiated b-fabric	++	+++		++		++	+++	+++	+	tt	tt	ttt	ttt	ttt	Complex. Channel and chamber	Random unsorted. Rare clustering of coarse organics towards top of layer	Close fine enaulic

Achnahaird (Wedig 4)

Sample	Context	Coarse Mineral						Fine Mineral	Coarse Organic				Amorphous Fine Organic			Pedofeatures					Microstructure	Coarse Material arrangement	C/F related distribution
		Quartz	Feldspar	Biotite	Muscovite	Chlorite	Rock frags	Colour PPL Groundmass b-fabric	Plant tissues (fresh)	Plant tissues (decomposed)	organ residues	Charred	Black	Reddish brown	Yellow	Fe/Mn nodules	Fe/Mn accumulations	Silty clay coatings/infill	Impure/limpid clay coatings	Excremental			
ACH T1.1	1.3	++++	+	+		+		Dark brown to black. Homogenous Undifferentiated b-fabric	+	++	+	t	++++	+++			tt			t	Massive	Random and unsorted	Chitonic
ACH T1.2	1.2	++++	+	+		+		Dark reddish brown to black Heterogeneous Undifferentiated b-fabric	+	++	+	+++	++++	+++	+	ttt	tttt	t		tr	Massive	Random and poorly sorted (exception black layer horizontal band see Appendix 1)	Close porphyric
ACH T1.3	1.2	++++	++	+			++	Yellowish to reddish brown Heterogeneous Undifferentiated b-fabric	++	+++	++	+++	++	++++	+					tr	Complex. Weakly developed moderate sub-angular structure with few large channels	Random orientation. Clustering/banding of coarse material. Moderately sorted (mainly medium sand sized)	Open porphyric
ACH T2.1	2.7	++++	+					Yellowish brown Slight birefringence	+	+	T		+++	+++	+++	ttt	tttt	ttt	t	tttt	Complex. Massive to bridged grain in places	Randomly arranged and oriented. Moderately sorted (mainly medium sand sized)	Gefuric
ACH T2.2	2.6	++++	++	+		+	+	Dark yellowish brown to black Heterogeneous Slightly speckled b-fabric	T		T	++	+++	+++		tr	t			tttt	Massive with few vughs. Excremental vermiform in places	Randomly arranged and oriented. Poorly sorted	Close porphyric
ACH T2.3	2.3	++++	+					Dark yellowish brown to black Heterogeneous Slightly speckled b-fabric		t		t	++	+++	++			tr		tttt	Massive with rare channels	Random and unsorted	Close porphyric

Sample	Context	Coarse Mineral						Fine Mineral	Coarse Organic				Amorphous Fine Organic			Pedofeatures					Microstructure	Coarse Material arrangement	C/F related distribution
		Quartz	Feldspar	Biotite	Muscovite	Chlorite	Rock frags	Colour PPL Groundmass b-fabric	Plant tissues (fresh)	Plant tissues (decomposed)	organ residues	Charred	Black	Reddish brown	Yellow	Fe/Mn nodules	Fe/Mn accumulations	Silty clay coatings/infill	Impure/limpid clay coatings	Excremental			
ACH T3.1 Fabric 1	3.5	++++	+++				t	Brown with patches of yellowish brown to reddish brown fabric Heterogeneous Undifferentiated b-fabric	tr	++		+	+	+	++	tt	tt	t		tt	Complex. Channel and chamber with patches of weakly developed sub-angular blocky. Patches of crumb/granular structure in more porous areas	Random orientation. Common clustering of part decomposed/fragmented blackened organic material. Poorly sorted	Close porphyric
ACH T3.1 Fabric 2	3.5	++++	+++				t	Brown to reddish brown. Heterogeneous Undifferentiated b-fabric	++	+++	+	+++	+++	+++	+++	tt	tt	t		tttt	Channel and chamber with patches of granular to crumb structure	Randomly oriented and distributed. Poorly sorted	Close porphyric
ACH T3.2	3.4	++++	+++				t	Dark yellowish brown to dark reddish brown. Heterogeneous Undifferentiated b-fabric	+	++	+	+++	++	+++	+++	tt	t			tttt	Complex channel and chamber to granular/crumb in more porous areas.	Randomly oriented. Some clustering of medium to coarse sand (possibly earthworm lines)	Porphyric
ACH T3.3	3.3	++++	+++				+	Yellowish brown Heterogeneous Undifferentiated b-fabric	t	++	t		++	++	++	ttt	tt			tttt	Complex Channel and chamber to granular crumb in more porous areas.	Randomly oriented. Decomposing plant materials occasionally clustered and commonly associated with granular/crumb microstructure	Close porphyric.

Rhue (Wedig 2)

Key: t=trace +=Very few, ++= Few, +++= Frequent/Common, ++++Dominant/Very Dominant

Pedofeatures t=trace (<1%) tt=rare (1-2%) ttt=occasional (2-5%) tttt many (5-10%)

Sample	Context	Coarse Mineral						Fine Mineral		Coarse Organic				Amorphous Fine Organic			Pedofeatures					Microstructure	Coarse Material arrangement	C/F related distribution
		Quartz	Feldspar	Biotite	Muscovite	Chlorite	Rock frags	Colour PPL	Groundmass b-fabric	Plant tissues (fresh)	Plant tissues (decomposed)	organ residues	Charred	Black	Reddish brown	Yellow	Fe/Mn nodules	Fe/Mn accumulations	Silty clay coatings/infill	Impure/limpid clay coatings	Excremental			
RHUE 1 1	1.3	t						Light yellowish brown to orange brown heterogeneous	Undifferentiated b-fabric	+++	++++	++	+++	+	+	++++		T	tttt		t	Complex. Weakly developed sub angular blocky, few platy or lenticular structure with few polyconcave voids	Frequent parallel orientation of elongate plant tissue. Banding of elongated plant tissue and charcoal	Porphyric (ranging from close to open)
RHUE 1 2	1.2	t						Orange to reddish brown. Heterogeneous	Undifferentiated b-fabric	+++	+++	++	+	+++	+++	++++	ttt	tttt	tt		tttt	Complex weakly developed sub angular with few channels. Few patches of granular structure esp. towards top where more porous.	Common parallel orientation of fibrous plant tissue but more frequently randomly oriented. Randomly distributed	Porphyric

Strathain (Wedig 5)

Sample	Context	Coarse Mineral						Fine Mineral	Coarse Organic				Amorphous Fine Organic			Pedofeatures					Microstructure	Coarse Material arrangement	C/F related distribution
		Rock frags	Chlorite	Muscovite	Biotite	Feldspar	Quartz	Colour PPL Groundmass b-fabric	Charredl	organ residues	Plant tissues (decomposed)	Plant tissues (fresh)	Yellow	Reddish brown	Black	Excremental	Impure/limpid clay coatings	Silty clay coatings/infill	Fe/Mn accumulations	Fe/Mn nodules			
RHUE 2 1	1.2/1.3?	+++		+++			++++	Yellowish brown Patchy and heterogeneous Undifferentiated b-fabric	+++	t	+++		+++	+	+++	+++	+++		ttt	ttt	Complex. Channel and chamber with occasional granular patches.	Randomly oriented some clustering of plant tissues and phytoliths	Porphyric (ranging from close to open)
RHUE 2 2	1.2	+	+	+++	++	+	++++	Very dark reddish brown to black Homogenous Undifferentiated b-fabric	++	+	+	+	+++	++	++++	tttt	ttt	t	ttt	t	Channel and chamber	Randomly oriented and arranged. Unsorted	Porphyric
RHUE 2 3	1.2	+		+			++++	Light yellowish to very dark brown Heterogeneous Undifferentiated	+	+	++++	++	+++	++++	+	tttt		tt	tttt	tttt	Complex. Medium separated sub angular. Channel and chamber and granular	Randomly oriented and arranged. Unsorted	Porphyric

Key: t=trace +=Very few, ++= Few, +++= Frequent/Common, ++++Dominant/Very Dominant
Pedofeatures t=trace (<1%) tt=rare (1-2%) ttt=occasional (2-5%) tttt many (5-10%)

Achtercairn 2 (Wedig 6)

Sample	Context	Coarse Mineral						Fine Mineral	Coarse Organic				Amorphous Fine Organic			Pedofeatures					Microstructure	Coarse Material arrangement	C/F related distribution
		Rock frags	Chlorite	Muscovite	Biotite	Feldspar	Quartz	Colour PPL Groundmass b-fabric	Charred	organ residues	Plant tissues (decomposed)	Plant tissues (fresh)	Yellow	Reddish brown	Black	Excremental	Impure/silty clay coatings	Clay coatings/infill	Fe/Mn accumulations	Fe/Mn nodules			
GAIR 2 1	1.11	+++	+++		+++	++	++++	Dark greyish brown to reddish yellow brown Heterogeneous Speckled b-fabric	++	+	++	t	+++	+++	++	t		tttt	t	ttt	Complex. Massive to very weakly developed sub angular blocky. Few channel voids	Randomly oriented and distributed. Unsorted	Close porphyric
GAIR 2 2	1.11	++	+++	++	+++	++	++++	Yellow to greyish Heterogeneous Speckled b-fabric	++	+	+++	t	+++	++	+	tttt		tttt	ttt	ttt	Complex. Massive with few channels and chambers. Very few granular structure (commonly within channels)	Randomly oriented. Frequently randomly distributed but few clusters of charred, organic and ash material. Poorly sorted	Close porphyric
GAIR 2 3	1.6	+	+	+	++	+++	++++	Orangish yellow Homogeneous Undifferentiated	+	t	+++	+	++++	+	+	t	t	tttt	tt	ttt	Complex. Weakly to moderately separated sub angular blocky. Common channels and chambers and rare granular (left hand of layer above large void)	Randomly oriented. Few clusters/ very weak bands of coarse minerals) Coarse mineral predominantly medium to coarse sand sized. Phytoliths and single cells are silt sized	Open porphyric

Key: t=trace +=Very few, ++= Few, +++= Frequent/Common, ++++Dominant/Very Dominant

Pedofeatures t=trace (<1%) tt=rare (1-2%) ttt=occasional (2-5%) tttt many (5-10%)

Achtercairn 3

Sample	Context	Coarse Mineral							Fine Mineral	Coarse Organic				Amorphous Fine Organic			Pedofeatures					Microstructure	Coarse Material arrangement	C/F related distribution
		Quartz	Feldspar	Biotite	Hornblende	Muscovite	Chlorite	Rock frags	Colour PPL Groundmass b-fabric	Plant tissues (fresh)	Plant tissues (decomposed)	organ residues	Charred	Black	Reddish brown	Yellow	Fe/Mn nodules	Fe/Mn accumulations	Clay coatings/infill	Textural	Excremental			
ACHT 3 1	5.3	+++	++	+++	+++	++	++	+++	Yellow to orange brown with some dark brown patches Heterogeneous Speckled b-fabric	t	++	+	+++	+	+++	+++	Ttt	ttt		ttt	tttt	Complex. Vughy to crumb in places with frequent channels and chambers	Randomly oriented and distributed. Rare clustering of charred material. Unsorted	Close porphyric
ACHT 3 2	5.3	++++	++	+++	+++	++	++	++	Yellow Heterogeneous Undifferentiated b-fabric	t	++	+	++	++	++	++	ttt	tt		tt	tt	Complex. Weakly sub-angular blocky with common channels and chambers.	Randomly oriented. Dominantly randomly distributed but few clusters of charred, material. Unsorted	Close porphyric
ACHT 3 3	5.3	++++	++	+++	+++	++	++	++	Dark reddish brown to orange brown. Heterogeneous Undifferentiated b-fabric	+	++	+	+++	+++	+++	+++	ttt	tt	ttt	ttt	ttt	Complex. Channel and chamber with vughs. Crumb to granular like in places where excremental features dominate	Randomly oriented and distributed. Unsorted	Close porphyric
ACHT 3 4	5.3/5.2	+++	+++	+++	++	++	+++	++	Yellowish brown to dark brown. Heterogeneous Speckled b-fabric	T	++	++	++	++	+++	+++	t		t	ttt	tttt	Complex. Channel and chamber with patches of crumb microstrcuture.	Randomly oriented and distributed. Unsorted	Close porphyric
ACHT 3 5	5.2	++++	+	++	++	+	++	+	Reddish brown Heterogeneous Speckled b-fabric			+++	+++	+++	+++	+++	Ttt			Tttt	tt	Complex. Massive with few channels and chambers	Randomly oriented and distributed. Poorly sorted (frequent fine to medium sized quartz)	Close porphyric

Interpretation and Discussion

Interpretation of the results is presented below by site, sample and layer number and from the base up, followed by a brief discussion.

The mineral and rock fragment suite present throughout the five samples from Achiltibuie (Loch Raa and Achnahaird) is typical for the area being dominated by quartz with few feldspars and very few other minerals (see Appendix 1 for full description). The sample from Strathain is similarly derived from Torridonian strata (Futty and Tower 1982, 115). Rock fragments where present and identifiable are often sandstone and of sedimentary origin. Mineral fragments are largely absent from the Rhue sample and restricted to rare quartz. The two samples removed from Achtercairn display a more diverse mineral composition than the others studied and this reflects the underlying drift geology which is derived from the Loch Maree Group (Futty and Towers 1982, 91-94). No erratics introduced by human occupation were observed in any of the samples.

Loch Raa: Sample LRT1

This sample was taken over the boundaries of contexts 1.2 and 1.3, a sequence of hearth deposits. When viewed at macro scale no boundaries are visible. However when viewed microscopically this samples comprises four distinct layers with zones of layer 3 appearing within layer 2. It is assumed that the upper (L4) and lower layers (L1) can be assigned to context 1.2 and 1.3 respectively but owing to the diffuse nature of the boundaries between the layers and the description of both contexts as 'patchy' (Wildgoose and Welti 2012) a context number cannot be certainly assigned to the two central layers. Both contexts 1.2 and 1.3 are interpreted as occupation horizons associated with a hearth feature.

Layer 1 (Context 1.3)

The lower part of context 1.3 (layer 1) is a compact dense (porosity 1-2%) sandy silt. The coarse to fine ratio (c/f ratio) is 40/60 with a high proportion of fine ash material as indicated by the speckled birefringence fabric (b-fabric). The matrix is predominantly yellowish brown in plane polarised light (PPL) and black brown in cross polarised light (XPL). Frequent black angular flecks (possibly micro charcoal) throughout the matrix give the layer a speckled heterogeneous appearance. Noted pedofeatures include occasional iron (Fe) and manganese (Mn) blackened rounded anorthic nodules indicative of some water saturation and incipient podsolisation (See Lindbo et al 2010) but the layer appears to otherwise have been subject to very limited post-depositional disturbance.

Amorphous reddish brown to black organic matter (possibly charred) dominates the organic matter, while larger fragments of charcoal with visible pores are few rising to frequent in the top left of the layer. The survival of charcoal indicates that this hearth deposit was subject to relatively low temperatures but the absence of cellular plant tissue material is indicative of temperatures high enough to combust the larger plant tissue fragments leaving only reddish and yellowish fine charred material. The larger charcoal fragments are angular indicating limited physical weathering or physical movement i.e. they are probably *in situ* and appear to be embedded within the fine ash groundmass. Experimental research into the micromophological properties of hearths undertaken by Miller et al (2008) showed embedding of coarse burned material to be a property of trampled hearths and indeed the compacted nature of this layer is also consistent with a trampled hearth.

The clear to sharp boundary between layer 1 and the overlying layer 2 is undulating and varies from clear (<60µm) to sharp in places indicative of a relatively abrupt change in use

Layer 2

Layer 2 is an unsorted fine sand with a complex intergrain microaggregate microstructure; occasionally crumb like in places with rugose porous excremental aggregates. The extensive post-depositional bioturbation experienced by this layer is indicated by the many excremental pedofeatures most frequently faecal pellets, (the by-product of small arthropods (Dawod and Fitzpatrick, 1992)) and is also reflected in the complexity of the microstructure and in the enaulic related distribution (See Stoops 2003, 42). This evidence for significant biological working contrasts with the layer 1 and is indicative that the boundary between layers 1 and 2 represents a change in the type and intensity of use of space. For layer 2 to have been so extensively reworked it is likely that it was exposed and/or located in neglected domestic space.

Iron and manganese accumulations and nodules are many and may be indicative of significant redox conditions (Lindbo et al 2010) caused by chemical weather and water saturation of the profile. It should be noted however, that iron and manganese formation is commonly observed within buried archaeological soils as an artefact of burial beneath structures as evidenced by the experimental earthwork at Overton Down (Macphail and Cruise, 1996) and Hazleton, Gloucestershire (Macphail 1990) and thus these features may in at least part result from burial beneath the hearth (layers 3 and 4) sediment.

The matrix is heterogeneous and speckled. It is very dark brown to black in PPL owing to a dominance of dark brown and blackened amorphous fine organic material with a very weakly speckled b-fabric indicative of fine ash within the matrix. Charcoal material is often fragmented and denuded indicative of trampling and/or of post-depositional physical weathering. The contents of layer 2, although reworked are thus indicative of general occupation debris incorporating some hearth waste as evidenced by the presence of charcoal and fine ash.

Layer 3

Layer 3 has a clear boundary with the underlying layer and by contrast is a much finer, moderately sorted silt deposit dominated by compacted amorphous reddish brown organic material mixed with fine ashy material. The presence of fine ash, burned bone fragment and possible burned peat fragments as well as charcoal fragments is indicative of the incorporation of domestic hearth waste. Excremental features and Fe/Mn nodules and accumulations are many, indicating significant biological and chemical weathering. Patches of layer 3 like material are present within layer 2 providing further indication of significant physical and biological mixing. The presence of woody organ residues and highly birefringent tissue residues towards the top of the layer is also indicative of mixing by modern root material.

Layer 3 thus bears several similarities to layer 2 and appears to represent general occupation and hearth debris which has been subject to significant post-depositional pedoturbation.

Layer 4 (Context 1.2)

Layer 4 has much in common with the compact material found in layer 1 and is consistent with trampled hearth material. It has a largely massive microstructure; it is very compact and dominated by fine ash material. Unlike the underlying layers, layer 4 has does not appear to have been subject to significant reworking by soil biota and excremental features are rare. The influence of other post-depositional processes specifically water action and compression during burial is evidenced by many Fe/Mn aggregates and nodules. Rock fragments are few but notable given their relative absence in underlying layers. There is some clustering of coarse mineral and charred matter which may have been caused by sweeping of hearth waste, a feature noted by Miller at al (2008) during their experimental work on micromorphological signatures of hearth features.

Discussion

The series of deposits represented in the Loch Raa sample thus present a mix of compacted hearth debris and reworked organic and charred sediments which have been much altered due to post-depositional pedoturbation. This complex layering of reworked and apparently unaltered material could be interpreted as representing changes of use within the hearth sequence and would be consistent with temporary abandonment of a hearth area (perhaps in favour of another nearby) leaving layers 2 and 3 in exposed or neglected domestic space perhaps as an area for dumping of hearth and organic waste which would have provided food for soil biota allowing them to remix the charred organic material. The compact hearth debris presented in layer 4 could thus tentatively be interpreted as representative of a change in the intensity use of this area perhaps back into use as a hearth.

Loch Raa: Sample LRT3

This sample was removed across two buried soil contexts located within the soil trench outwith (north of) the area of occupation. The context boundary is not visible within the sample when viewed at macro scale but is distinguishable microscopically although diffuse.

Layer 1 (Context 3.3)

Context 3.3 is a moderately sorted silt dominated by amorphous reddish brown organic matter. The layer has a complex channel and chamber microstructure with a porosity of up to 5%. Large channel voids dissect the layer and the presence of some bright orange woody organ residues within or in close association is indicative of post-depositional disturbance by root action. Excremental pedofeatures are rare and are concentrated in a single large channel void with an incomplete infilling of rounded excremental fabric each up to 400µm in diameter probably derived from earthworm channelling (see Kooistra and Pullman, 2010). Fe pedofeatures range from weakly impregnated, irregularly shaped, orthic impregnations of the groundmass in the form of nodules and hypo-coatings, to strongly impregnated anorthic nodules, pans and hypocoatings. There are also many channel voids with coatings or infillings of amorphous yellow clay indicative of translocation of fine organic material through the soil profile (Kuhn et al 2010). Anthropogenic indicators are limited to few charcoal fragments probably blown in from the nearby hut circle.

Layer 2 (Context 3.2)

Context 3.2 bears some similarities to context 3.2 and is similarly dominated by amorphous reddish brown organic matter. Fe pedofeatures are occasional and indicative of podsolisation although they tend to be more weakly impregnated and less frequent than those in the layer below, perhaps reflecting the higher position of context 3.2 in the soil profile (Fe pedofeatures tend to increase with depth (See Wilson et al 2013)). The enaulic related distribution, frequent channels and chambers associated with highly birefringent woody organ residues are indicative of a high degree of post-depositional mixing. Excremental features are rare and the post-depositional disturbance appears to have been caused mainly by root activity. Organic material is commonly blackened, frequently blackened towards the top of the slide where planar voids and fissures are indicative of shrink swell processes thus suggesting that layer 2 has been subject to changing hydrological regimes.

Discussion

Contexts 3.2 and 3.3 are thus typical of the peaty podsols found in this area (see above and Futty and Towers 1982). As discussed by Limbrey (1975; 137-41) the formation of humic-iron pans at the base of the profile coupled with high rainfall can cause saturation and the formation of acidic peats higher in the profile a process that appears to have occurred here. Unlike the archaeological examples from the Loch Raa hut circles, the buried soils appear to have undergone relatively little post-depositional mixing by soil biota but have experienced significant mixing by root activity as well as being subject to post depositional distortion by leaching and water saturation.

The question of when the podsolisation of these buried soils occurred is of some interest to the study of the wider landscape of Loch Raa and specifically to the settlement of the Loch Raa hut circle. Generally the impact of humans on the upland soil system is associated with accelerating soil development towards podsolisation, gleying and peat formation all of which have been evidenced in the buried soils from Loch Raa and thus could tentatively be interpreted as a signature of anthropogenic activity. However, podsolisation may already have been underway by the time of the settlement. For example at Kilphedir in the Strath of Kildonan, Sutherland, the floor of an excavated hut circle was found to have been established on a soil transitional between a podsol and podsol with an iron pan (Fairhurst et al, 1974) and iron pedofeatures noted within the Loch Raa samples are also indicative of incipient podsol formation. However, iron pan formation is often found directly below occupational surfaces (see above) as the subsoil becomes compacted and drainage is inhibited, representing the ‘reactive’ zone of occupation surfaces (Simpson et al 1998) thus any interpretation of the ‘natural’ soil on which any occupation surface was formed must be treated with great caution.

Achnahaird – Sample ACH T1

This sample was removed from within the Achnahaird hut circle close to a hearth feature and over the boundary of context 1.2 a hypothesised occupation horizon and 1.3 interpreted as representative of abandonment. When examined microscopically this sample comprised three distinct layers; layer 1 representing context 1.3 and layers 2 and 3 forming part of context 1.2.

Layer 1 (Context 1.3)

Layer 1 comprises moderately sorted sand dominated by medium sized sand grains. There are no anthropogenic indicators and pedofeatures are limited to Fe stained organic matter and rare coalesced aggregates of probable excremental origin. There are few plant tissue remains and organ residues, often highly birefringent and associated with channel voids indicating that they are associated with post-depositional mixing by root material. The layer has a chitonic related distribution with fine Fe stained material surrounding the quartz grains. Chitonic distributions are typical of sandy spodic horizons (Stoops 2003, 42). The moderate sorting of the mineral material, its sub-rounded nature and, the absence of rock fragments may indicate that this deposit is at least in part windblown perhaps sealing the occupation horizon following it’s abandonment. It has evidently undergone some limited post-depositional remixing as evidenced by iron staining, fine amorphous black material and, modern roots and rare excremental features.

Layer 2 (Context 1.2)

Layer 2 forms the lower part of context 1.2 and comprises compact poorly sorted sand with a massive microstructure and chitonic related distribution. This layer has developed on the windblown sand below and has a high proportion of coarse mineral material derived from the underlying layer. The fine fraction is dominated by very dark brown to black amorphous iron stained organic material. The composition of layer 2 is thus consistent with general occupation and the compacted dominantly heterogeneous nature of the groundmass is typical of floor deposits (see Goldberg and Macphail 2010, Milek 2012). The low concentrations of charcoal and charred organics coupled with the survival of plant tissue fragments suggest against a hearth deposit rather it appears to represent general occupation. The exception to this is a black lens 1-3mm thick aligned parallel to the top of the slide and located close to the top of layer. It is dominated by amorphous black material with common cellular charcoal as well as few plant tissues and organ residues. Preservation of cellular charcoal alongside fibrous plant tissues again suggest against burning *in situ* but the concentration of material coupled with its horizontal alignment is perhaps indicative of sweeping of hearth waste. Two part denuded bone fragments are located just below this lens and provide further possible evidence for domestic hearth waste.

The layer is commonly dissected by pseudomorphic voids indicating some mixing in of material from above. There are few bright orange tissue fragments in the layer as well as very few bright orange rounded organ fragments indicative of modern root action. Excremental pedofeatures are rare and post-depositional mixing has been limited.

Layer 3 (Context 1.2)

Layer 3 has a clear boundary with the underlying layer 2 and is a compact poorly sorted silt as reflected in the porphyric occasionally close porphyric related distribution. The coarse organic component is mixed including cellular charcoal, frequent single plant cells and few plant tissues. The fine material is dominated by reddish brown amorphous material with ash patches. Phytoliths are common and are indicative of grass ash. Pedofeatures are limited to rare anorthic Fe/Mn nodules. The absence of excremental features and preservation of well preserved plant tissues is indicative of relatively limited post-depositional mixing. The components of layer 2 are also consistent with compact floor material but the differences in structure may suggest a change in the balance of activities affecting this particular area. Clustering of coarse material may be indicative of some form of sweeping (Miler et al 2008) possibly of waste material.

Discussion

The micromorphological evidence from the sample from Achnahaird Trench1 is thus largely consistent with the field interpretation. Context 1.3 contains very few anthropogenic indicators and appears to represent a period of abandonment of the hut circle during which windblown sand encroached. Context 1.2 appears to represent general occupation incorporating a lens of charred hearth debris.

Achnahaird –ACH T2

This sample was removed from the boundary of three contexts (2.3), (2.6) and (2.7) which correspond to the layers identifiable microscopically. This sample has suffered some loss of sediment during processing.

Layer 1 (Context 2.7)

This layer was interpreted in the field as the natural sand dune upon which the hut circle was constructed. Micromorphological evidence is largely consistent with this interpretation being a poorly sorted medium sand, dominated by sub-rounded medium sized quartz grains consistent with a windblown sand deposit. The very few plant remains are fragmented or sub-rounded indicating that they have been subject to chemical or physical weathering. There are many spherical elliptical and coalesced excremental remains loosely packed and bridging the quartz grains giving the sediment a gefuric related distribution common to spodic horizons (Stoops 2003, 42). Iron and/or manganese accumulations and nodules indicate that the sediment has undergone podsolisation (Lindbo et al 2010) a process which may have been caused or accelerated by the subsequent construction of the hut circle (see Simpson et al 1998).

Layer 2 (Context 2.6)

This context represents the first phase of occupation developed upon the windblown sand. The layer is dominated by amorphous fine organic material which is responsible for the dark yellowish brown matrix colours. Plant tissues and organ residues are notably absent with the exception of a single woody root fragment. There are few cellular charcoal fragments and occasional patches of calcitic ash material indicative of human influence. The boundary between the two layers is diffuse and has probably been blurred by post-depositional mixing by soil biota, the activity of which is evidenced by the many loosely spherical aggregates and excrements. Indeed post-depositional mixing has created a much altered sediment with a complex microstructure varying from massive to vermiform to excremental in places. Despite this mixing the layer remains relatively compact with a dominantly porphyric related distribution.

Layer 3 (Context 2.3)

Context 2.3 was interpreted in the field as representative of the same abandonment represented by Context 1.3 (see ACH T1) and indeed the two layers show sufficient similarities micromorphologically to support this interpretation. The microstructure of 2.3 is also massive with local variation caused by the dominance of excremental material. Context 2.3 is a poorly sorted sand deposit in which the coarse mineral material dominates. The coarse mineral material is dominated by sub-angular to angular quartz and the physical weathering of grains noted in 1.3 appears to be absent. As with 1.3, the fine material of 2.3 is dominated by dark reddish brown amorphous organic material and the presence of many excremental features is indicative of significant post-depositional mixing by soil biota. Indeed this mixing is consistent with a sediment representing abandonment as it would have been exposed following deposition and open to mixing by biological and physical elements.

Discussion

Significant post-depositional mixing has thus altered and destroyed much of the sediment record within this sample but the sample has retained sufficient of its original structure to allow for differentiation between deposits and for the identification of a defined sequence of events from the initial sand dune surface through to occupation and a first phase of abandonment.

Achnahaird ACH T3

This sample was removed from a soil trench situated beneath lazy bed cultivation outwith the main occupation area. The whole sample has been subject to significant post-depositional pedoturbation as demonstrated by the observed channel and chamber and granular and crumb microstructures.

Layer 1 Context 3.5

Context 3.5 is a poorly sorted heterogeneous sand deposit. It has a complex microstructure which largely reflects differences in post-depositional mixing by soil biota with few to common channels and chambers and patches of granular structure in more porous areas towards the top of the layer. Plant tissue remains are very few, as are charred cellular fragments. Pedofeatures are dominated by excremental fabrics including infilled passage features with occasional Fe/Mn nodules and Fe impregnation indicative of incipient iron pan formation (see Lindbo et al 2010). Context 3.5 thus appears typical of a Bc transitional soil horizon with some Fe/Mn concretions. Organic and charred material is probably mixed in from above and the increase in coarse mineral content towards the base of the layer is further indicative of a transitional Bc horizon.

Layer 2 (Context3.4)

Context 3.4 is significantly more organic than the underlying layer with a much lower coarse mineral content. The layer is dominated by reddish brown amorphous organic material occasionally with cellular structure but more commonly heavily decomposed. The channel and chamber to granular microstructure attests to the extensive post-depositional pedoturbation and most pedofeatures are excremental in origin. The patches of granular structure are a mixture dominantly of enchytraeid and earthworm excrement (see Kooistra and Pullman, 2010). Essentially this layer has been almost entirely reworked by soil meso and microfauna and is an excremental fabric. Anthropogenic indicators are limited to few internally amorphous possible carbonised fragments.

Layer 3 (Context 3.3)

Context 3.3 displays a certain degree of similarity to context 3.5, having a much higher coarse mineral content than the intermittent layer and it is a moderately sorted sand deposit. As with context 3.5, context 3.4 has been subject to significant post-depositional disturbance and this is reflected in the channel and chamber rarely granular microstructure. However context 3.3 has not been as reworked as extensively as the intervening layer (Context 3.4) probably reflecting the reduction in organic matter content in this layer which would have resulted in a significant decrease in available food supply for micro and meso soil fauna. Organic matter is represented by modern roots and few internally amorphous reddish brown to black features. The majority of pedofeatures are of an excremental nature, although occasional amorphous yellow clay coatings to mineral grains and hypocoatings to voids were noted.

Discussion

The sequence of sediment layers represented in this slide thus appears to represent the transition from a sandy Bc horizon to an organic rich buried soil horizon which has been buried by a reworked sand deposit. Sediments within Achnahaird trench three have been extensively reworked as evidenced by very diffuse boundaries between each layer and frequent excremental fabrics and there are no features that can be confidently interpreted as directly linked to former cultivation of the buried soil horizon. Research by Davidson (2002, 1252) (see also Davidson and Carter, 1998) has demonstrated that outwith archaeological contexts, micromorphological features diagnostic of cultivation are rarely preserved and that soil fauna are able to rework former cultivated soils within decades. Although context 3.4 is buried beneath context 3.3, it is likely that 3.3 represents the gradual accumulation of sediment and as such has not prevented the reworking of 3.4 by soil fauna. The higher organic matter content and higher degree of excremental pedofeatures within context 3.4 is indicative of greater bioturbation than in the underlying and overlying layers, perhaps reflecting the addition of manure which will have had a positive effect on burrowing animals leading to the production of more excremental pedofeatures.

Rhue – RHUE 1

This sample was removed from across the boundary of two contexts located within the hut circle in close proximity to a hearth slab. Context 1.2 was described as a rich brown gritty soil with no stones and Context 1.3 was described as a black to brown greasy soil with no stones. Context 1.3 was hypothesised as a possible occupation horizon (Wildgoose and Welti 2012).

Layer 1 (Context 1.3)

Context 1.3 is a dominantly organic deposit with <1% coarse organic mineral material. The context is dominated by highly humified organic residues that have not been burnt, so they are not fuel ash. The high degree of humification has left limited structural information with which to identify the plants originally present and the context is dominated by amorphous yellow clay. Recognisable remains include epidermal and vascular tissues derived from herbaceous materials which are commonly most resistant to decomposition (see Fitzpatrick 1993). The elongate plant material is frequently wavy in appearance and is frequently aligned parallel to the top of the slide giving the layer a lenticular or platy appearance. Charcoal is common and is distributed into weak horizontal bands. The charcoal and bark and wood material within Context 1.3 has a curled appearance indicating that it has been compressed and lost its structure (Schweingruber 1982, 202) The relatively compact nature of the sediment is reflected in the frequently porphyric, commonly close porphyric related distribution. The subangular blocky to platy microstrcuture, compacted 'wavy' plant tissue and bark and partially infilled polyconcave voids all contribute to the low proposity of the layer and are indicative of compaction and/or trampling typical of floor deposits within occupied structures (Milek 2012)

The near absence of rock fragments and coarse mineral material is unusual for a deposit located within an hypothesised occupation horizon as occupation zones and floors are typically heterogeneous and mixed (see Macphail et al 2004; Goldberg and Macphail 2010) and whilst common charcoal provides clear evidence for anthropogenic activity, it is not associated with ash or other anthropogenic material and could thus have been swept, trampled, blown or washed into the deposit from nearby.

Layer 2 (Context 1.2)

As with Context 1.3, 1.2 is dominantly organic with very few angular medium sand sized quartz. Whilst plant material is commonly horizontally aligned it is more frequently randomly oriented than in Context 1.2 and the banding lenticular structure observed in 1.3 is notably absent. The layer is dominated by amorphous yellow organic material with few elongate plant tissue fragments and rare cellular charcoal. There are rare woody organ residues and woody epidermal structures with high birefringence indicative of modern root action. Much of the organic matter is blackened to dark reddish brown and internally amorphous and this coupled with frequent black flecks in the matrix give the groundmass a darker colour when compared with the underlying layer. One localised area towards the top of the layer contains possible vivianite, a compound which forms under reducing conditions when there is abundance of iron and phosphorous (Karkanas and Goldberg 2010, 535-6) which may be a result of abundance of phosphate rich dung and plant matter and is evidence for localised reducing conditions within the deposit. Channel voids occasionally contain excremental fabric. The porosity of the layer increases towards the top of the slide where rugous porous aggregates form a granular microstructure and are indicative of a higher degree of post-depositional disturbance than in the underlying layer.

Discussion

Contexts 1.3 and 1.2 thus comprise highly organic sediments subject to increasing post-depositional disturbance towards the top of the slide. The severe reworking of both layers by soil fauna is not surprising in such an organic deposit.

The function of contexts 1.2 and 1.3 within an occupation zone is intriguing. As discussed above, the near absence of coarse mineral material indicates that this is not a typical floor or occupation horizon. Stabling deposits from Early Medieval London Guildhall (Macphail and Goldberg 2006, 245) and Butser Ancient Farm (Macphail et al 2004) were found to be highly organic with fragments of layered plant material and excremental material not unlike the humified organic bands discussed above. Whilst the fecal spherulites which help to characterise such layers (Goldberg and Macphail 2010) are notably absent from Contexts 1.2 and 1.3, anthropological research into the micromorphology of known stabling deposits has shown that faecal spheruiltes are not always present (Milek 2012, 130). Indeed it is possible that the highly organic nature of the deposit inhibited the preservation of calcitic faecal spherulites. Research into stabling deposits by Milek (2012, 130-132) has also shown that whilst stabling deposits typically consist of readily identifiable herbaceous plant tissue and associated phytoliths embedded in amorphous organic matter, in deposits that have been reworked by soil fauna it is not possible to distinguish between plant tissues representing dung and those representing hay. It is possible therefore that the decomposed banded plant matter identified in contexts 1.3 and 1.2 represents the remnants of a banded stabling deposits where the finer boundaries have been blurred by post-depositional disturbance.

It is also possible that the compact plant matter represented in contexts 1.2 and 1.3 has been redeposited as a means of covering or resurfacing the floor a practice that is readily documented in anthropogenic (Milek 2012) and archaeological contexts (Courty 1992, Macphail and Goldberg 2010, Roy 2012), although the absence of a more heterogeneous occupation layer above to be compared with micromorphologically prevents any further testing of this theory.

A further possible interpretation lies with the possibility that this deposit is derived from the collapse or part collapse of a peat turf roof or wall into the structure following abandonment and has then subsequently undergone compaction and reworking by soil biota. Experimental research into collapsed turf by Macphail et al (2003) demonstrated preferential preservation of lignified material and charcoal and a predominantly porphyric related distributed both features identified within the samples from Rhue.

Strathain - RHUE 2

This sample was removed from within the platform and taken over a single context (1.2) which was hypothesised as a possible occupation horizon. When viewed microscopically this slide comprises three separate layers each of which is interpreted as part of context 1.2.

Layer 1 (Context 1.2)

Layer 1 is a very heterogeneous unsorted silt loam deposit characterised by the presence of large (gravel sized) sedimentary rock fragments and coarse sand sized minerals. The complex channel and chamber to granular microstructure and advanced decomposition of organic tissues is indicative of significant pos-depositional reworking. Anthropogenic indicators are limited to few to common cellular charcoal which increases in size and quantity towards the top of the layer. The diffuse nature of the boundary and increase in organic material towards the top of the layer are indicative that this layer represents a BC horizon or transitional zone between the lower coarse mixed material derived from the local natural through to a mixed anthropogenic deposit.

Layer 2 (Context 1.2)

Layer 2 is dominated by amorphous black material, with frequent reddish brown amorphous material which masks much of the groundmass and gives the layer a homogenous very dark brown to black appearance. It is possible that this amorphous black material is disaggregated amorphous charcoal and ash and representative of hearth debris which has subsequently been mixed with plant material and other occupation debris. However, the high degree of blackening and humification has left limited structural information with which to identify the plants originally present. Recognisable remains include elongated epidermal and vascular which are commonly most resistant to decomposition (Fitzpatrick 1993), indeed many of these tissues appear as elongate external cells or outer cases to empty or psedumorphic voids where the interior of the root or plant structure has been eaten by soil micro and mesofauna. The presence of few highly birefringent woody organ residues is indictaive of modern root action. As with the underlying layer, a complex channel and chamber microstructure attests to significant bioturbation and pedofeatures are dominated by many infilled passage features. The passage feature infillings are heterogeneous and similar in composition to the excremental fabric of the overlying layer 3.

Layer 3 (Context 1.3)

Layer 3 is an unsorted silt loam with a complex medium separated sub angular blocky microstructure with common accommodating planes and cracks and fissures. The compacted heterogeneous nature, fragmented nature of inclusions and microstructure are all consistent with a trampled deposit (See Macphail and Goldberg 2010). There are few charcoal fragments frequently fragmented and distributed throughout the matrix as well as small flecks of micro charcoal which contribute to the overall heterogeneity of the layer. The presence Fe/Mn nodules and accretions is indicative that this layer has also undergone oxidation and reduction and given the high organic matter content this is likely to have caused shrink swell forming the observed cracks and fissures.

As with the underlying layers of Context 1.2, layer 3 has also experienced significant bioturbation. This is evidenced by many channel features infilled with a yellowish brown silt excremental fabric. The presence of similar fabric pedofeatures with blurred boundaries with the groundmass is indicative of earlier passage features that have been reworked into the groundmass and there are rare patches of granular structure within more porous areas. Unlike in the layer above, where traces of epidermal structures are indicative that passage features were created by plant or root activity, the passage features in layer 3 are less defined and it is not always clear if they were created by a root or burrowing organism (see Fitzpatrick 1993).

Discussion

The three layers that comprise context 1.2 thus document the development of a very heterogeneous anthropogenic sediment which has been subject to numerous post-depositional processes from the probable trampling and compaction of the sediment during use of the structure through to the action of soil biota and plant activity and also changing hydrological regimes and acidification of the soil which have caused the formation of Fe/Mn pedofeatures.

Achtercairn 2 - GAIR 2

The Achtercairn sample was removed from across the boundaries of contexts 1.11 and 1.6 within the round house. When viewed microscopically this sample comprised three layers. Layers 1 and 2 corresponding to context 1.11 and layer 3 corresponding to Context 1.6.

Layer 1 (Context 1.11).

Layer 1 is a compact heterogeneous deposit comprising approximately 50% medium to coarse sand sized minerals. The mineral component is dominated by quartz but also comprises frequent chlorite and hornblende common biotites and few feldspars giving it a more diverse mineral range than most other samples studied as part of this project. The slightly speckled b-fabric and presence of fragmentary biogenic silica in the form of common elongate phytoliths associated with amorphous yellow to red organic matter are indicative of the presence of fine ash mixed into the martrix. Black angular flecks <50µm are distributed randomly throughout the matrix and probably represent micro charcoal. Identifiable plant tissues are rare and most coarse organic matter is fragmented and strongly decomposed (following Fitzpatrick 1993).

The massive to very weakly developed sub-angular structure reflects the compact nature of the deposit and highly fragmented nature of inclusions such as charcoal, plant tissues and rock fragments are consistent with a sediment that has been compacted and/or trampled (Milek 2012, 132; Macphail and Goldberg 2010). Amorphous fine yellow organic clay coatings/ partial infilling to voids occur in just over half of the few channel voids identified and are also consistent with a trampled deposit (see Fitzpatrick 1993). Rare woody organ residues attest to some modern root penetration. In contrast to most other sediments studied as part of this project, excremental features are rare and it is likely that the reduction in porosity caused by the compaction of the sediment would have made it more difficult for earthworms and other soil fauna to penetrate.

Layer 2 (Context 1.11)

As with the underlying layer, layer 2 is highly heterogeneous. The mineral component reflects that of the underlying layer but shows a slightly greater proportion of coarser material. As with the underlying layer, coarse organic matter is heavily decomposed and plant tissues are very few. The speckled b-fabric, common phytoliths and micro charcoal in the matrix are indicative of the presence of ash and fine charred material within the matrix. A weak band of charcoal and grey ash towards the top of the layer has a diffuse boundary with the surrounding groundmass but may represent remnants of hearth clear out or sweeping that has subsequently been mixed.

Fragmentary charcoal, rock fragments and plant tissue show similarities with the underlying layer and alongside many infilled planar and polyconcave voids are indicative of compaction by trampling (see above). In contrast to the underlying layer however, layer 2 has a complex massive to channel and chamber microstructure with very few patches of granular material increasing to few towards the top where porosity is greater. Layer 2 has thus been subject to significantly greater post-depositional disturbance than the underlying layer which probably reflects its location within the sediment profile and suggests that it was subject to greater exposure to biological, physical and chemical weathering following its deposition.

Layer 3 (Context 1.6)

Layer 3 is hypothesised as representative of abandonment (Wildgoose and Welti 2013). The boundary with the underlying layer is very diffuse and mixing between layers 2 and 3 is evidenced by the common patches of layer 2 type fabric distributed throughout the base of layer. Layer 3 is a compact poorly sorted orange/yellow clay which becomes increasingly homogenous in colour and composition towards the top of the slide. The coarse mineral fraction is significantly less than in the underlying layers and comprises less than 10% of the overall layer. Plant tissues and aggregated plant matter are rare and coarse organic matter is dominated by disaggregated plant cell material. Biogenic silica in the form of frequent equant, elongate and spiny phytoliths are frequent and evenly distributed throughout the layer. Anthropogenic aggregates are limited to very few angular part cellular charcoal and rare grey ashy material located towards the bottom of the layer.

The microstructure is complex and varies from weakly developed sub-angular blocky with common channels towards the base to channel and chamber with rare patches of granular structure. Towards the top of the layer is a cluster of channels infilled with very dark brown rounded excremental features and is indicative of mixing by soil fauna.

Discussion

The micromorphological evidence analysed in this slide is thus consistent with the hypothesised interpretation of a period of occupation followed by abandonment. Post-depositional reworking has blurred the boundaries between the contexts and limits interpretation regarding the function of the deposit. Nevertheless, Context 1.11 can be interpreted as a beaten/trampled material which represents the accumulation of general occupation debris whereas context 1.6 has been extensively reworked but is consistent with the interpretation of abandonment.

Achtercairn 3 – ACHT 3

This sample was removed from trench 5 which was excavated in March 2014 in an attempt to clarify the relationship between occupation phases within the structure. Sample ACHT 3 was removed from across the boundary of contexts 5.2 and 5.3. Context 5.3 was described as a black charcoal rich soil and 5.2 was described as a loose brown yellow crumbly soil containing small cobble stones, come charcoal pieces and numerous struck quartz flakes (Welti, 2014 *pers comm.)*. When viewed microscopically this sample is comprised of five layers separated by diffuse boundaries. Extensive biological reworking and the diffuse nature of boundaries makes it difficult to assign these layers confidently to a context but is assumed that layers 1-3 are part of context 5.3 and layer 5 is part of context 5.2

Layer 1 (Context 5.3).

Layer 1 is a porous heterogeneous deposit comprising approximately 50% medium to coarse sand sized minerals and common larger (5-10mm), metamorphic schist type, sub-rounded to sub-angular rock fragments. The mineral component comprises frequent quartz, chlorite and hornblende with common biotites and few feldspars. The b-fabric is slightly speckled; elongate and equant phytoliths are few. Black angular to sub-angular flecks 50-100µm are common and are distributed randomly throughout the matrix. Cellular charcoal is rare throughout the layer with the exception of a concentrated patch measuring c.7mm x 7mm towards the base of the slide where cellular charcoal and micro charcoal are common. In the centre of this area is a large (c.5 x 3mm) sub-angular blackened rock fragment surrounded by a partially reddened groundmass. It is possible that this rock fragment has been burned and blackened by heat which in turn has heated and reddened the surrounding sediment. Frequent sub-rounded to sub-angular internally amorphous black fragments (50-400µm) located in the groundmass surrounding the rock fragment may also be charred material.

Identifiable plant tissues are rare within this layer and restricted to irregular fibrous brown to reddish brown fragments with traces of elongate cells. Most coarse organic matter is fragmented and strongly decomposed (following Fitzpatrick 1993) and is largely represented by irregular internally amorphous patches of organic rich material.

The channel and chamber to crumb microstructure reflects the large number of organo-mineral excrements present and the extensive post-depositional bioturbation experienced by this layer is also indicated by the many excremental pedofeatures most frequently faecal pellets, (the by-product of small arthropods (Dawod and Fitzpatrick, 1992). Pedofeatures are largely excremental in origin with occasional fe/mn nodules also present. Layer 1 thus likely represents the general remains of occupation much altered and reworked by biological activity.

Layer 2 (Context 5.3).

Layer 2 has a diffuse boundary with the underlying layer and is distinguished from it by a slight change in porosity, mineral composition and microstructure. This layer is an unsorted fine sand with a complex weakly sub-angular blocky structure with few channels and chambers; occasionally crumb like in places with rugose porous excremental aggregates (although it is less porous than the underlying layer 1). The coarse mineral fraction accounts for approximately 60% of the layer and is dominantly comprised of medium to coarse sand sized minerals with fewer rock fragments than in the underlying layer. Quartz dominates the mineral fraction with frequent biotite, and hornblende with few chlorite and feldspars also present.

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The matrix is heterogeneous and speckled. It is yellow to dark brown in PPL owing to the frequency of yellow amorphous fine organic material within the matrix. There are few cellular charcoal fragments throughout the matrix. At the top of the layer is a cluster of burned material dominated by black amorphous fine material as well as internally amorphous black fragments (100-400µm). Coarse organic matter is largely comprised of irregular reddish brown stained areas. There are rare woody bright orange to red well preserved organ and tissue residues indicative of modern root penetration. Occasional impregnative dark brown pedofeatures with higher organic content are possibly heavily decomposed organic matter. Excremental pedofeatures are fewer than in the layer above reflecting a lesser degree of soil fauna activity within this layer.

The contents of layer 2 like those of layer 1, although reworked are thus indicative of general occupation debris incorporating some hearth waste as evidenced by the presence of charcoal.

Layer 3 (Context 5.3).

As with the underlying layer, layer 3 is highly heterogeneous. This layer is dark reddish to orange brown in PPL reflecting higher proportions of amorphous reddish brown organic matter in the matrix than present in the underlying layer. The mineral component reflects that of the underlying layer but displays a lesser proportion (40%) of coarse material. As with the underlying layer, coarse organic matter is heavily decomposed and plant tissues, organ residues and single cells are also very few. Although highly decomposed the coarse organic matter content of this layer is higher than in the underlying layers. The speckled b-fabric, common phytoliths and micro charcoal in the matrix are indicative of the presence of ash and fine charred material and also contribute to darker matrix colours than observed in the underlying layers.

Layer 3 has a porosity of c.15% and has a complex channel and chamber and crumb microstructure which reflects the large number of organo-mineral excrements present. This crumb structure coupled with the many excremental pedofeatures identified is indicative that layer 3 has been subject to significantly greater post-depositional disturbance than the underlying layer. Pedofeatures comprise occasional fe/mn nodules and accumulations, occasional irregular impregnative features are of probable organic origin. In the centre of the layer contained within a large channel void is a compact orange textural pedofeature measuring approximately 5,000µm. The feature is a well sorted silt with a massive microstructure with medium sand sized quartz inclusions and silt sized black punctuations (see also layer 5 below). Rare smaller patches (<1000µm) of this fabric are distributed randomly throughout the layer.

Layer 4 (Context 5.3/5.2?).

Layer 4 displays a certain degree of similarity to layer 2, having a higher coarse mineral content than the intermittent layer and containing less reddish brown amorphous fine organic material. The mineralcomposition of this layer reflects that of layer 2.

As with all of the underlying layers, layer 4 has been subject to significant post-depositional disturbance and this is reflected in the channel and chamber to crumb microstructure. Coarse organic material includes common single cells (20-50µm), few plant tissue residues and disaggregated cell clusters as well as few bright orange woody fragments of probable modern origin. Few internally amorphous reddish brown to black features are probably decomposed organic matter. There are frequent internally amorphous sub-angular to sub-rounded black fragments which along with few sub-angular charcoal fragments (100-400µm) make up the charred organic component.

The majority of pedofeatures are of an excremental nature, although traces of amorphous yellow clay coatings to mineral grains and hypocoatings to voids were also noted. Many textural pedofeatures in the form of fragments of layer 5 are present, occasionally located within the larger channel voids but often located within the general matrix. These pedofeatures frequently but not always have sharp to clear boundaries with the surrounding groundmass suggesting perhaps that they have been trampled in from the layer above rather than reworked by soil fauna. In some places the fragments have been partially reworked into the groundmass and the boundaries are more diffuse.

Layer 5 (Context 5.2).

As discussed above, fragments of layer 5 types fragment are mixed into layer 4 and also present in layer 3. In contrast to the other layers analysed in this slide, layer 5 is a compact deposit with low porosity and a massive microstructure.

Evidence for bioturbation includes few channels and chambers, rare excremental pedofeatures and traces of modern roots. Layer 5 is a poorly sorted silt deposit with a coarse mineral component dominated by sand sized quartz inclusions. Identifiable plant tissues are rare and most coarse organic matter is fragmented and strongly decomposed (following Fitzpatrick 1993) and comprises common reddish brown rounded internally amorphous features (possibly burned soil clasts) and common single cells and disaggregated groups of cells. Cellular charcoal is absent but there are common large internally amorphous black fragments (100-200µm) and frequent black punctuations <20µm.). Observed pedofeatures include many infilled passage features and occasional fe/mn nodules.

The massive microstructure, anthropogenic inclusions in the form of possible burned soil and charred material are consistent with a domestic floor deposit (see Golderg and Macphail 2010,264). Layer 5 also displays similarities to layer 1 (Context 1.11) of Achertcairn 2 which is also interpreted as compact floor deposit (see above).

Discussion

Micormophological analysis of contexts 5.2 and 5.3 has allowed for the identification of five discrete layers. All layers contain evidence for anthropogenic activity in the form of varying proportions of charred material including a possible heat blackened rock fragment in layer 1. Given their location within a roundhouse structure, these layers probably represent the gradual accumulation of occupation deposits. Layer 5 at the top of the sequence has a massive microstructure and is interpreted as a probable domestic floor surface bearing similarities to the floor surface observed in the thin section from Achtercairn 2 (see above).

Extensive biological reworking has produced a channel and chamber to crumb microstructure in all four remaining layers. The boundaries between the layers are diffuse and the mixing of the sediments by soil fauna and to a lesser extent soil flora has prevented the identification of the aimed for difference in use and activities across the sequence. The degree of biological reworking also differs throughout the layers and indeed is responsible for many of the observable characteristics and features of the sediments. Factors that determine soil fauna activity include food sources, moisture, pH, temperature and soil disturbance and in some instances are able to point to disturbance and or changing environmental conditions (see Kooistra and Pullamn, 2010). At Achtercairn 3 however the relatively high soil fauna activity across the four bottom layers prevents identification of such subtle changes. Nevertheless the observed slight differences in proportions of coarse mineral material, organic component and anthropogenic inclusions such as charred material could tentatively be used to infer changes in intensity and/or type of use within the structure over time.

Conclusion

By analysing and characterising the matrix of these deposits and comparing their results with the other excavated circular structures and with wider micromorphological and anthropological studies it has been possible to identify a range of anthropogenic and pedogenic site formation processes. At Loch Raa hut circle, limited post-depositional disturbance has allowed for identification of possible changes of use of space through the sequence. Although subject to significant pedoturbation, analysis of samples from Achnahaird has allowed for the possible differentiation of occupation and abandonment deposits.

Samples removed from the interiors of the hut circle at Achtercairn 2 although too biologically reworked to infer use of space, displayed a composition, heterogeneity and porosity consistent with compacted/trampled occupation horizons. The sample from Achtercairn 3 has also been subject to significant mixing by soil biota which has characterised and formed many of the noted microfabric types and pedofeatures observed. It has not been possible to identify the aimed for difference in use and activities occurring within this sequence but the identification of five discrete layers hints at changes in intensity of occupation which at the very least has affected organic matter content and the degree of post-depositional reworking. The final layer in the sequence comprises the remains of a probable compact floor surface.

Although not thought to be an occupied hut circle (Wildgoose and Welti 2012), the sample from Strathain produced evidence consistent with an anthropogenic deposit including a dense layer of amorphous black material which could be representative of hearth debris. As with the two Achtercairn deposits, the sediments at Strathain are too reworked to infer specific use.

The sample removed from Rhue, whilst also reworked retained fine laminations of organic matter and a near absence of mineral material raising a number of possibilities regarding interpretation ranging from a possible stabling deposit to the remains of a turf roof or wall collapse. Whilst the results of the micromorphological analysis at Rhue are inconclusive, they highlight the importance of micromorphology as a technique for identifying micro-scale structural properties that are not visible at the macro-scale and the implications this can have for the understanding of site formation processes.

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Appendix

Loch Raa

T1 LR Layer 1 (Context 1.3?)

C/F ratio:
40:60
Thickness:
1-25mm
Particle size and sorting:
Moderately sorted. Clay 15%, silt 55%, very fine sand 10%, fine sand 15%, medium sand 5%.
Coarse mineral:
Coarse mineral fraction comprises 35% of layer (c 70% of overall coarse fraction). Rock fragments are limited to two sub-angular sedimentary examples. Minerals and aggregates are dominantly sub-angular and commonly c200µm. Dominated by fine sand sized quartz, very few feldspars including microcline.
Rare elongate phytoliths.
Coarse organic:
Common sub-rounded to sub-angular reddish brown clasts average 200µm with amorphous/organic stained interiors. Rare rounded woody organ residue (e.g. one noted at bottom right of layer, probably woody modern root fragment c600µm. In close proximity to this is an elongate yellow tissue fragment c.100µm in length but with scarce remaining cell structure. Rare clusters of reddish brown cells c10µm in aggregated groups of up to 30 cells.
Few charcoal fragments average 150µm. Charcoal distribution is uneven and charcoal is more common towards top and left of layer where charcoal occurrence is frequent.
Coarse material arrangement:
Randomly oriented. Rare clustering of sub-angular sand sized mineral grains. Poorly sorted (frequently sand sized 100-200µm).
Fine organic:
Frequent fine yellow organic amorphous material gives matrix background colour with aggregates of fine amorphous reddish brown and black material contributing to a speckled appearance.
Groundmass:
Heterogeneous. Yellowish brown PPL, reddish brown, XPL. Speckled b-fabric caused by the presence/dominance of ash in the fine material.
Pedofeatures:
Occasional Fe impregnated organic matter and anorthic and orthic Fe/Mn nodules. Rare rounded excremental features.
Microstructure:
Complex massive structure with rare channel voids. Porosity 1-2%
C/F related distribution:
Close porphyric.
Boundary:
The boundary with the overlying layer is clear (<60µm) to sharp in places.

T1 LR Layer 2 (Context 1.3?)

C/F ratio:
60:40
Thickness:
20-60mm
Particle size and sorting:
Unsorted. Clay 15%, silt 30%, very fine sand 25%, fine sand 10%, medium sand 5%, coarse sand 5%.
Coarse mineral:
Coarse mineral fraction comprises 20% of layer (c 50% of overall coarse fraction). Very few sub-angular to sub-rounded rock fragments up to 2500µm variable mineral composition but of probable igneous origin. A single

fragment dominated by microcline is located in the centre of the layer and has been broken at one end and tapers towards the other showing possible anthropogenic influence. Mineral aggregates are mainly sand sized sub-rounded to sub-angular aggregates of quartz and feldspars. Mineral components is dominated by quartz with few feldspar and rare chlorite and ?hornblende.

Few phytoliths.

Coarse organic:

Approximately 30% of the whole layer is composed of very dark brown to black sub-rounded clasts which dominate the coarse organic component. They have no visible internal structure and are black in XPL.

Few bright orange rounded organ fragments avg 400µm (probably root fragments) distributed randomly through layer. Very few part decomposed bright orange elongate tissue fragments up to 3000µm in length. Rare reddish brown tissue fragments including two large fragments in centre of layer both c. 2000-3000µm diameter.

Few charcoal fragments 200-2000µm often part denuded but with cellular structure visible.

Coarse material arrangement:

Randomly oriented and arranged. Unsorted.

Fine organic:

Frequent amorphous dark brown/ reddish brown to black material dispersed through matrix.

Groundmass:

Heterogeneous. Very dark brown to black PPL, black, XPL. Undifferentiated b-fabric.

Pedofeatures:

Many Fe impregnated organic matter and occasional anorthic and orthic Fe/Mn nodules. Rare clay coatings and hypocoatings and rare part infillings to voids-amorphous yellow clay. Many spherical, elliptical and coalesced arthropod, mite and earthworm excrements.

Microstructure:

Complex intergrain microaggregate – rugose porous aggregates not always accommodating one another almost crumb like in places. Porosity 15% but up to 30% in places.

C/F related distribution:

Single spaced fine smooth enaulic

Boundary:

Undulating clear boundary above and below.

T1 LR Layer 3 (Context 1.3/1.2?)

Note: this layer occurs as a layer proper above layer 2 and below layer 4 but also as large patches (several mm across) and smaller patches throughout layer 2.

C/F ratio:

40:60

Thickness:

10-35mm

Particle size and sorting:

Moderately sorted. Clay 15%, silt 50%, very fine sand 20%, medium sand 15%.

Coarse mineral:

Coarse mineral fraction comprises 15% of layer (c 60% of overall coarse fraction). Rock fragments are rare disaggregated or sub-rounded quartz and feldspar ?sandstone fragments. Minerals and aggregates are dominantly quartz mixed with very few feldspars including microcline, plagioclase and very few biotite and possible olivine.

No phytoliths noted

Patch of calcitic ash c150µm in centre of layer proper.

Coarse organic:

Very few charcoal fragments average size 400µm with greater frequency towards upper layer. Frequent angular black flecks throughout the matrix up to 100µm possibly charred but no cellular structure. Few reddish brown rounded material 10-100µm. Very few elongate orange tissue fragments increasing in frequency towards top of layer. Rare rounded woody organ fragments rising to few towards the top of the layer.

At left edge of upper layer is a partly fragmented black aggregate c2000x3500µm. The interior is a mixture of black and bright red material intermixed with quartz and may be burned peat/fuel fragment.

Coarse material arrangement:

Randomly arranged and oriented. Unsorted.

Fine organic:

The layer is dominated by compacted amorphous reddish brown organic matter. Common fine yellow organic amorphous material

Groundmass:

Heterogeneous. Yellowish to reddish brown PPL, black, XPL. Undifferentiated b-fabric.

Pedofeatures:

Common Fe impregnated organic matter and anorthic and orthic Fe/Mn nodules sand sized avg 100µm. Few planar voids infilled with amorphous yellow clay. In lower zone (within layer 2) pseudomorph or channel from above is part infilled with layer 2 fabric. In layer proper a single large pseudomorph part infilled with decomposing plant material. Many spherical, ellipsoid and coalesced excremental features.

Microstructure:

Complex. Massive with rare channel and chamber. Porosity 1-5%

C/F related distribution:

Open porphyric

Boundary:

Clear <60µm.

T1 LR Layer 4 (Context 1.2?)

C/F ratio:

50:50

Thickness:

1-3mm

Particle size and sorting:

Moderately sorted. Clay 15%, silt 55%, very fine sand 10%, fine sand 15%, medium sand 5%.

Coarse mineral:

Coarse mineral fraction comprises 35% of layer (c 70% of overall coarse fraction).Few rock fragments of probable sedimentary origin. Minerals and aggregates are dominantly sub-angular. Mineral component is dominated by fine sand sized quartz, with few feldspars (very few microcline and ?orthopyroxene), few biotite.

Very few phytoliths.

Very few sub-rounded patches of highly birefringent calcitic material (possibly ash).

Coarse organic:

Common orange sub-rounded aggregates avg 80µm. Few single reddish brown cells and aggregates cells groups.

Rare reddish brown patches sub-rounded and composed of disaggregated cellular material distributed in clusters.

Common to frequent (in top left hand corner) charcoal fragments 200-1000µm.

Single possible charred bone fragment 600x1000µm

Single large (4000µm) root channel with part decomposed orange plant tissue, adjacent to another long 2000µm and organ fragments.

Coarse material arrangement:

Randomly oriented. Some clustering of coarse mineral and organic material. Unsorted

Fine organic:

Frequent fine yellow organic amorphous material gives matrix background colour with aggregates of fine amorphous reddish brown and black material contributing to a speckled appearance.

Groundmass:

Heterogeneous. Yellowish brown PPL, black, XPL. Speckled b-fabric possibly indicative of calcitic ash in matrix.

Pedofeatures:

Many Fe impregnated organic matter and many anorthic and orthic Fe/Mn nodules. Occasional rounded coalesced excremental fabrics.

Microstructure:
Complex massive structure with few channel voids. Porosity 1-2%.
C/F related distribution:
Open porphyric.
Boundary:
Diffuse.

T3 LR Layer 1 (Context 3.3)

C/F ratio:
40:60
Thickness:
22-28mm
Particle size and sorting:
Moderately sorted. Clay 20%, silt 60%, very fine sand 20%.
Coarse mineral:
Coarse mineral fraction comprises 10% of layer (c 35% of overall coarse fraction). Rock fragments are notably absent with the exception of rare disaggregated metamorphic quartz and feldspar fragment. Minerals and aggregates are dominantly sub-angular and commonly c200µm.
Rare elongate phytoliths associated with organic material and more common towards base of slide.
Common quartz. Very few biotite and feldspars.
Coarse organic:
The layer is dominated by amorphous reddish brown organic matter. Common single rounded reddish brown cells 5-10µm, few in aggregated groups. Very few sub-rounded dark brown clasts (average 200x600µm). A cluster of blackened sub-rounded fragments is located at the bottom of the slide. Cellular structure is partially visible and may be disaggregated charcoal although more likely to be Fe impregnated organic matter. Frequent angular black flecks throughout the matrix up to 100µm possibly charred but no cellular structure. Common reddish brown rounded material 10-100µm. Few reddish brown elongate material (no cellular structure) 50-500µm.
Coarse material arrangement:
Random and poorly sorted (frequently sand sized 100-200µm).
Fine organic:
Frequent amorphous dark brown/ reddish brown to black material dispersed through matrix. Common fine yellow organic amorphous material
Groundmass:
Heterogeneous. Yellowish to reddish brown PPL, black, XPL. Undifferentiated b-fabric.
Pedofeatures:
Many Fe impregnated organic matter and many anorthic and orthic Fe/Mn nodules. Common pseudomorphic voids, approximately 50% of which either have coatings, hypocoatings or are part infilled with amorphous many yellow clay. Rare excremental features mainly contained within a single large channel void containing an incomplete infilling rounded excremental fabric up to 400µm.
Microstructure:
Complex channel and chamber. Porosity up to 5%
C/F related distribution:
Close porphyric but variable and locally concave gefuric around excremental features)
Boundary:
The boundary with the overlying layer is diffuse (>60µm), uneven and not discernible with the naked eye. This layer is distinguished from the overlying layer by slight differences in hue and coarse component.

T3 LR 1 Layer 2 (Context 3.2):

C/F ratio:
50:50

Thickness:
30-40mm
Particle size and sorting:
Poorly sorted. Clay 20%, silt 50%, very fine sand 25%, fine sand 5%.
Coarse mineral:
10% of overall layer (20% of coarse fraction). Dominated by sub-angular quartz (85%) with undulose extinction (quartz arenite). Frequent singular to sub angular with high order interference colours). Approximately 10% feldspars (plagioclase and microcline). Very few biotite. Patch of sub-rounded aggregates located in top centre right of layer comprised of quartz, mica and plagioclase feldspars.
Rare phytoliths.
Coarse organic:
Dominated by homogenous dark reddish brown PPL isotropic XPL material with some internal sub-rounded dark reddish brown clasts visible internally. In the top right hand of the layer is a patch of cellular black to very dark brown organic material possibly charred but more likely to be Fe impregnated. A single part disaggregated charcoal fragment c.1000µm is located at the top centre of the layer. Single large fragment c3500µm is also located at the top centre of the layer. Frequent black flecks 10-50µm throughout the matrix. Few disaggregated blackened cellular plant material up to 2000µm.
Common circular root channels with birefringent woody organ residues indicative of modern root disturbance.
Coarse material arrangement:
Randomly distributed and unsorted, rare clustering of coarse minerals and coarse organics towards tops of layer.
Fine organic:
Common amorphous yellow, Frequent amorphous reddish brown. Blackened material/punctuations give groundmass speckled appearance.
Groundmass:
Heterogeneous 10YR 5/6 yellowish brown to dark reddish brown PPL isotropic XPL. Undifferentiated to weakly speckled b-fabric
Pedofeatures:
Occasional blackened Fe/Mn nodules both anorthic and orthic (variable fromc400µ-4000µm. Occasional pseudomoprhic voids some 20% have many coatings or hypocoatings of amorphous yellow clay. C50% have no infilling. commonly with clay coatings. Rare spherical excremental
Towards top left of slide below large planar voids is a patch of fabric dominated by planar voids and fissured aligned at 40^{o} in line with the large void. The groundmass of this material is dominated by blackened organic material (possibly compressed or subject to different hydrological regime below void). Located below an iron pan.
Microstructure:
Complex channel and chamber microstructure. Porosity locally variable but average c.15-20%
Related distribution:
Close fine enaulic.
Boundary:
Diffuse with Layer 1. See above.

ACH1 T1 Layer 1 (Context 1.3)

C/F ratio:
80:20
Thickness:
22-30mm
Particle size and sorting:
Moderately to well sorted. Clay 5%, silt 20%, very fine sand 10%, fine sand 5%, medium sand 60%.
Coarse mineral:
Coarse mineral fraction comprises 60% of layer (c 95% of overall coarse fraction). Rock fragments are notably absent. Mineral component is dominated by medium sand sized quartz, with rare chlorite and biotite.
Coarse organic:

Very few plant remains, comprising rare rounded orange organ fragments avg 400µm. Very few disaggregated tissue fragments sub-rounded to elongate 200-1000µm, bright orange in colour and part mixed into groundmass.
Single large irregular reddish brown to black fragment c.2000x2000µm closely associated with bright orange plant material located in centre of layer.

Coarse material arrangement:
Randomly oriented and arranged. Poorly sorted.

Fine organic:
Dominated by dark brown to black amorphous material with no birefringence.

Groundmass:
Heterogeneous. Yellowish brown PPL, black, XPL. Speckled b-fabric possibly indicative of calcitic ash in matrix.

Pedofeatures:
Many Fe impregnated organic matter. Rare coalesced aggregated of brown sub-rounded material of probable excremental origin.

Microstructure:
Massive. Porosity 1-2%

C/F related distribution:
Chitonic.

Boundary:
Diffuse.

ACH1 T1 Layer 2 (Context 1.2)

C/F ratio:
65:35

Thickness:
30-34mm

Particle size and sorting:
Poorly sorted. Clay 10%, silt 35%, very fine sand 10%, fine sand 5%, medium sand 40%.

Coarse mineral:
Coarse mineral fraction comprises 50% of layer (c 95% of overall coarse fraction). Rock fragments are notably absent. Mineral component is dominated by medium sand sized quartz, with rare chlorite and biotite.
Two part denuded bone fragments located just below the black lens at the top centre of the layer. The first measures 100x500µm and the second measures 250x500µm.

Coarse organic:
Few plant remains, comprising very few rounded orange organ fragments avg 400µm. Very few disaggregated tissue fragments sub-rounded to elongate.
At top left of the layer is a black lens 1-3mm thick aligned horizontally parallel with the top of the slide. It is clearly visible with the naked eye and is dominated by amorphous black material. Within the lens disaggregated cellular charcoal is common and is avg 500µm. The lens is commonly dissected by pseudomorphic voids indicating some mixing in of material from above. There are few bright orange tissue fragments in the layer as well as very few bright orange rounded organ fragments.
Patches of blackened organic material are common throughout the layer including two large patches both up 1cm diameter and associated with pseudomorphic voids.

Coarse material arrangement:
Randomly oriented and arranged. Poorly sorted.

Fine organic:
Dominated by dark brown to black amorphous material with no birefringence.

Groundmass:
Heterogeneous. Yellowish brown PPL, black, XPL. Speckled b-fabric possibly indicative of calcitic ash in matrix.

Pedofeatures:
Many Fe impregnated organic matter. Occasional Fe/Mn nodules. Occasional soil clasts. Rare channels infilled with amorphous yellow clay. Trace of brown coalesced possible excremental fabric.

Microstructure:
Massive. Porosity 1-2%
C/F related distribution:
Chitonic.
Boundary:
Diffuse with underlying layer. Clear (<60µm) above.

ACH1 T1 TR Layer 3 (Context 1.2)

C/F ratio:
40:60
Thickness:
7-17mm
Particle size and sorting:
Poorly sorted. Clay 20%, silt 50%, very fine sand 10%, medium sand 20%.
Coarse mineral:
Dominated by quartz with few feldspars (plagioclase, orthoclase, microcline). Few rock fragments probable sandstone fragments sub-rounded to sub-angular mostly medium to coarse sand sized. Minerals are clustered into patches and/or bands. No apparent preferred alignment, often close to voids but not exclusively so. Mineral material is firmly embedded within groundmass and does not appear within voids. Coarse mineral material also closely associated with charcoal clusters, suggesting a more general clustering of the coarser material.
Few phytoliths.
Rare patches of possible calcitic ash.
Coarse organic:
Common angular black flecks 10-50µm (possible fragmentary charcoal). Few cellular charcoal fragments 50-1000µm often part denuded.
Few pseudomorphic channel voids and chambers which contain fresh (orange) woody organ fragments of which there are few.
Frequent single reddish brown cells, common reddish brown elongate plant tissues quite heavily decomposed and with no cellular structure. Few rounded to sub-rounded irregular groups of round cells.
Rare elongate cellular tissue residues with some disappearance up to 4000µm.
At the top right side of the layer is a large (2000x4000µm) organ residue and groups of plant tissue with some disappearance.
Coarse material arrangement:
Coarse material is clustered and in places appears almost banded. No apparent preferred orientation or cause for clustering. Moderately sorted (mainly medium sand sized).
Fine organic:
Common amorphous yellow and reddish brown.
Groundmass:
Heterogeneous. Reddish brown at base gradually becoming yellower towards top (colour deepening towards base may be an artefact of slide preparation) PPL, black, XPL. Undifferentiated b-fabric.
Pedofeatures:
Rare rounded anorthic brown nodules (soil clasts from above?)
Microstructure:
Complex. Moderately sub-angular blocky with some large channel voids. Porosity up to 10% due to large channel voids but groundmass is very dense and compact and porosity locally <1%.
C/F related distribution:
Open porphyric
Boundary:
Clear <60µm.

ACH T2 Layer 1 (Context 2.7)

N.B frequent abrasive [powder and air bubbles in slide impairs interpretation of some areas.

C/F ratio:
70:30
Thickness:
11-25mm
Particle size and sorting:
Moderately sorted. Clay 5%, silt 20%, very fine sand 15%, medium sand 60%.
Coarse mineral:
Coarse mineral fraction comprises 60% of layer (c 95% of overall coarse fraction). Rock fragments are notably absent. Mineral component is dominated by medium sand sized quartz, with rare chlorite and biotite.
Coarse organic:
Frequent reddish brown rounded to sub rounded organic aggregates average 25µm with no internal structure ?excrement. Very few plant remains, comprising rare reddish to orange tissue residues 200-600µm. Grains are subrounded and weathered.
Coarse material arrangement:
Randomly oriented and arranged. Moderately sorted (mostly sand sized).
Fine organic:
Dominated by reddish brown to black amorphous material with no birefringence.
Groundmass:
Heterogeneous. Yellowish brown PPL, black, XPL. Undifferentiated b-fabric
Pedofeatures:
Many Fe/Mn accumulations. Many Fe/Mn nodules. Many spherical, elliptical and coalesced 10-100µm loosely packed and randomly distributed between quartz grains. Occasional amorphous yellow clay infillings of pore spaces possibly leached from nearby organics.
Microstructure:
Complex. Massive to bridged grain. Porosity 1-2%
C/F related distribution:
Gefuric.
Boundary:
Diffuse.

ACH1 T2 Layer 2 (Context 2.6)

C/F ratio:
60:40
Thickness:
35-50mm
Particle size and sorting:
Poorly sorted. Clay 10%, silt 30%, very fine sand 15%, fine sand 10%, medium sand 35%.
Coarse mineral:
Coarse mineral fraction comprises 55% of layer (c 70% of overall coarse fraction). Rock fragments are rare and of probable sedimentary origin. Mineral component is dominated by medium sand sized sub-angular to angular quartz, with few feldspar and rare chlorite and biotite.
Coarse organic:
Few cellular charcoal fragments 200-800µm. One fresh organ residue. Plant tissues and organ residues are otherwise notably absent.
Frequent porous spherical aggregates (see also pedofeatures below) and individual ellipsoid and spherical clasts 10-200µm, coalesced in places.
Coarse material arrangement:
Randomly oriented and arranged. Poorly sorted.

Fine organic:
Dominated by dark brown to black amorphous material bridging quartz grains. Common reddish brown amorphous material. Density and quantity of fine bridging material varies through layer.
Groundmass:
Heterogeneous. Dark yellowish brown to black PPL, black, XPL. Patch of Speckled b-fabric in centre of layer possibly indicative of calcitic ash.
Pedofeatures:
Many spherical, elliptical and coalesced excrements.
Microstructure:
Complex, varying from massive to vermiform excremental fabric in places. Porosity highly variable and much of slide material missing
C/F related distribution:
Close porphyric.
Boundary:
Diffuse.

ACH1 T2 Layer 3 (Context 2.3)

C/F ratio:
70:30
Thickness:
13-21mm
Particle size and sorting:
Poorly sorted. Clay 15%, silt 25%, very fine sand 20%, medium sand 45%, coarse sand 5%.
Coarse mineral:
Coarse mineral fraction comprises 65% of layer (c 80% of overall coarse fraction). No rock fragments. Mineral component is dominated by medium sand sized sub-angular to angular quartz, with few feldspar and rare chlorite and biotite.
Coarse organic:
Rare reddish brown to orange organ residues and plant tissues (fresh).
Common patches of coalescent irregular dark organic excrements individually c.30µm but patches up to 2000µm. In places the coalesced black/dark brown organic excremental material forms an enaulic coarse/fine distribution pattern with the quartz grains.
Coarse material arrangement:
Randomly oriented and arranged. Poorly sorted.
Fine organic:
Dominated by dark brown to black amorphous material bridging quartz grains. Common reddish brown amorphous material. Density and quantity of fine bridging material varies through layer.
Groundmass:
Heterogeneous. Yellowish brown to black PPL, black, XPL. Patch of Speckled b-fabric in centre of layer possibly indicative of calcitic ash patch.
Pedofeatures:
Many loosely packed porous spherical aggregates and organic excrements.
Trace of amorphous yellow coatings to channel voids.
Microstructure:
Massive with rare channels and patches of excremental fabric.
C/F related distribution:
Close porphyric.
Boundary:
Diffuse.

ACH2 T3 Layer 1.1 (Context 3.5)

This layer consists of two fabrics (1 and 2). Fabric 1 (below) is dominant but there are rare weakly to moderately impregnated patches of fabric 2 distributed randomly throughout the layer. A large patch of fabric 2 measuring 12mmx8mm is located in the lower left centre of the layer.

C/F ratio:
70:30
Thickness:
20-31mm
Particle size and sorting:
Poorly sorted sand. Clay 10%, silt 30%, very fine sand 20%, fine sand 20% medium sand 10%, coarse sand 10%.
Coarse mineral:
Coarse mineral fraction comprises 45-65% of layer (c 70% of overall coarse fraction). Rare coarse sand sized rock fragments of sedimentary origin. Mineral component is dominated by medium sand sized sub-angular to angular quartz, with few to common (occasionally frequent) feldspars (microcline, plagioclase and orthoclase).
Trace phytoliths.
Coarse organic:
Few plant tissue fragments in varying stages of decomposition ranging from very light yellow to dark reddish brown. Commonly elongate up to 4000µm. Plant tissues appear to be decomposing *in situ* rather than modern fresh roots penetrating from above.
One possible burned peat fragment.
Very few blackened/carbonised cellular fragments and small flecks in matrix.
Coarse material arrangement:
Randomly oriented. Dominantly randomly arranges but occasional clustering of part broken down blackened material. Poorly sorted.
Fine organic:
Very few dark brown to black amorphous material bridging quartz grains. Few reddish brown amorphous material. Density and quantity of fine bridging material varies through layer.
Groundmass:
Heterogeneous. Brown with patches of yellowish brown to reddish brown PPL, black, XPL. Undifferentiated b-fabric.
Pedofeatures:
Occasional reddish/orange brown staining of fine material, probably fine organic matter moderately impregnated.
Rare fe/mn blackened nodules sub-rounded 10-200µm –strongly impregnated
Rare fabric passage pedofeatures – passage features resulting from soil mesofauna.
Occasional moderate to strongly impregnated fabric pedofeatures irregular reddened organic matter material mostly orthic but possibly some anorthic (impregnated organic matter from above?)
Trace yellow organic clay around plant tissue remains and voids
Microstructure:
Complex. Channel and chamber with patches of crumb granular structure in more porous areas. Also patches of weakly developed sub-angular blocky where porosity <2%.
C/F related distribution:
Close porphyric.
Boundary:
Diffuse.

Fabric 2
C/F ratio:
70:30
Thickness:
12X8mm (and in smaller patches throughout fabric 1)
Particle size and sorting:

Poorly sorted sand. Clay 10%, silt 30%, very fine sand 20%, fine sand 20% medium sand 10%, coarse sand 10%.

Coarse mineral:

Coarse mineral fraction comprises 20% of layer (c 25% of overall coarse fraction). Rare coarse sand sized rock fragments of sedimentary origin. Mineral component is dominated by medium sand sized sub-angular to angular quartz, with few to common (occasionally frequent) feldspars (microcline, plagioclase and orthoclase).

Few phytoliths.

Coarse organic:

Common plant tissue fragments in varying stages of decomposition ranging from very light yellow to dark reddish brown. Commonly elongate up to 4000µm. Very few organ residues

Coarse material arrangement:

Randomly oriented and arranged. Poorly sorted.

Fine organic:

Frequent reddish brown to orange amorphous material. Common yellow and black amorphous.

Groundmass:

Heterogeneous. Brown to reddish brown PPL, black, XPL. Undifferentiated b-fabric.

Pedofeatures:

Occasional reddish/orange brown staining of fine material, probably fine organic matter moderately impregnated.

Microstructure:

Channel and chamber.

C/F related distribution:

Close porphyric.

Boundary:

Clear with fabric 1.

ACH2 T3 Layer 2 (Context 3.4)

C/F ratio:

60:40

Thickness:

13-25mm

Particle size and sorting:

Poorly sorted. Clay 10%, silt 45%, very fine sand 10%, fine sand 10%, medium sand 15%, coarse sand 5%.

Coarse mineral:

Coarse mineral fraction comprises 35% of layer (c 60% of overall coarse fraction). Rock fragments are rare and medium sand sized and of probable sedimentary origin. Mineral component is dominated by medium sand sized sub-angular to angular quartz, with common feldspars.

Few phytoliths (elongate, spiky and equant)

Coarse organic:

Very few plant tissue fragments commonly elongate and up to 2000µm.

Few black possibly carbonised fragments. They are dense with no cellular structure which impedes identification commonly elongate with average length of c. 600µm. Frequent black angular flecks throughout matrix may be carbonised organic matter.

Few single brown cells c10µm and very few collections of aggregated cells (up to 30).

Two organ fragments part decomposed

One pseudomorphic void with tissue residue at edges and part infilled with microfauna excrement.

A single large area of dense blackened material measuring 14mmx1mm is located in the lower right part of the layer. It is horizontally aligned below a large channel void and appears to consist of black (?Carbonised?) organic matter with reddish brown staining around mineral grains and voids.

Coarse material arrangement:

Randomly oriented. Dominantly randomly arranged but some clustering of coarse mineral material into weak bands – possibly as a result of earthworm action. Poorly sorted.

Fine organic:

Frequent reddish brown amorphous. Common amorphous yellow clay.
Groundmass:
Heterogeneous. Dark yellowish brown to dark reddish brown PPL, black, XPL. Undifferentiated b-fabric
Pedofeatures:
Many spherical, elliptical and coalesced excrements. Rugous porous aggregates in places.
Occasional moderately impregnated fabric pedofeatures part broken down. Possibly reworked organic matter?
Rare fe/mn nodules
Microstructure:
Complex, varying from channel and chamber to excremental fabric in places. Granular crumb structure in more porous areas. Channel voids are large and up to 5mm in width.
C/F related distribution:
Porphyric.
Boundary:
Diffuse.

ACH2 T3 Layer 3 (Context 3.3)

C/F ratio:
75:25
Thickness:
25-31mm
Particle size and sorting:
Moderately sorted medium sand. Clay 10%, silt 25%, very fine sand 10%, medium sand 50% coarse sand 5%.
Coarse mineral:
Coarse mineral fraction comprises 60% of layer (c 80% of overall coarse fraction). Large rock fragments are notably absent. Rare medium sand sized and of probable sedimentary origin. Mineral component is dominated by medium sand sized sub-angular to angular quartz, with undulose extinction. Frequent feldspars (Microcline and Plagioclase).
Very few phytoliths (elongate)
Coarse organic:
Rare part decomposed orange organ fragments.
Few dark reddish brown to black heavily decomposed organic matter fragments/patches in places so decomposed that they have become moderately impregnated fabric pedofeatures with mineral embedded and mixed in (c200-400µm).
Very few elongate yellow plant tissue fragments (Small up to 200µm) embedded/arranged around sand grains.
Very few elongate large (1000-4000µm) reddish brown plant tissue fragments.
Coarse material arrangement:
Randomly oriented. Dominantly randomly arranged but some clustering of decomposing plant material which is commonly associated with granular/crumb structure i.e. has encouraged soil biota action. Unsorted.
Fine organic:
Frequent black amorphous. Few reddish brown amorphous. Few amorphous yellow/orange clay.
Groundmass:
Heterogeneous (but of more even colour than underlying layers). Yellowish brown PPL, black, XPL. Undifferentiated b-fabric
Pedofeatures:
Occasional fe/mn nodules
Many excremental features, spherical, elliptical
Occasional amorphous yellow to orange clay coatings to mineral grains and hypocoatings to voids
Microstructure:
Complex channel and chamber with granular crumb structure in more porous areas.
C/F related distribution:
Close porphyric.

Boundary:
Diffuse and undulating.

Rhue

RHUE 1 Layer 1 (Context 1.3)

C/F ratio:
40:60
Thickness:
40-45mm
Particle size and sorting:
Poorly sorted. Clay 35%, silt 40%, fine sand 10%, medium sand 10% coarse sand 5%.
Coarse mineral:
Rock fragments and mineral aggregates notably absent. Trace coarse sand sized angular quartz undulose extinction. Coarse mineral is <2% of layer
Common phytoliths (elongate equant and rounded).
Coarse organic:
Frequent to dominant elongate horizontally aligned wavy light yellowish plant tissue. Cellular structure frequent but rarely intact and associated cells distributed through matrix adjacent to fragments.
Common single reddish brown cells (30µm) and rounded clusters of up to 100 cells (3000µm).
Frequent disaggregated single elongate cells and groups of cells.
Common reddish brown elongate part disaggregated fibrous plant tissue fragments, commonly associated with phytoliths and single plant cells.
Few reddish brown woody organ residues very few of which have high birefringence (probably modern roots).
Few brown compressed wavy woody material –?possibly bark? 200-1000µm.
Common charred plant material, commonly elongate, frequently cellular and up to 4000µm (avg c.200-600µm).
Rare denuded charred bark
Frequent angular black flecks with amorphous interior 2-50µm located close to larger charred organics- probably micro charcoal.
Coarse material arrangement:
Elongate plant tissues and charred organics are frequently oriented parallel to the top of the slide giving a lenticular structure to the layer. Distribution of elongated plant tissues and charred organic matter is weakly to moderately banded and appears to be aligned roughly along same lines as polyconcave voids – compression/trampling?
Towards the base of the layer the plant material appears to be interleaved with darker more heterogeneous groundmass with slightly less elongate yellow plant tissue.
Dominantly unsorted although coarse charcoal seems to be sorted into fragments often c.200-600µm in size.
There is a band of frequent fragmented denuded charcoal towards the top of layer.
Fine organic:
Dominant to very dominant yellow amorphous clay.
Very few black amorphous.
Very few reddish brown amorphous.
Groundmass:
Heterogeneous. Light yellowish brown to orange brown PPL, black, XPL. (layer is more reddish to orange in colour towards base, where higher occurrence of amorphous black material). Undifferentiated b-fabric
Pedofeatures:
Many infillings/part infillings of planar and polyconcave voids with amorphous yellow organic clay
Rare textural excremental pedofeatures.
Very few pseudomorphic voids with part disappeared plant tissue material
Microstructure:
Complex weakly developed sub angular blocky microstructure with few lenticular or platy bands. Few polyconcave voids.
C/F related distribution:
Porphyric.

Boundary:
Diffuse.

RHUE 1 Layer 2 (Context 1.2)

C/F ratio:
50:50
Thickness:
22-25mm
Particle size and sorting:
Poorly sorted. Clay 25%, silt 50%, fine sand 10%, medium sand 10% coarse sand 5%.
Coarse mineral:
Rock fragments and mineral aggregated notably absent. Trace coarse sand sized angular quartz undulose extinction. Coarse mineral is <3% of layer
Single sub-angular blue fragment 100µm near base of slide-possibly vivianite formed from decomposition of bone in reducing conditions?
Common phytoliths (elongate, equant, spiky and rounded) rarely articulated.
Coarse organic:
Common elongate yellow plant tissue 2000-6000µm, frequently disaggregated and with associated cells mixed into groundmass.
Common reddish brown fibrous, frequently associated with reddish brown disaggregated cells and close to reddish brown amorphous material.
Common single reddish brown cells c30µm.
Common single elongate reddish brown cells c50µm
Few organ residues, very few of which are highly birefringent woody fragments – probably modern roots.
Rare elongate tissue fragments dissecting groundmass – post depositional floralturbation.
Frequent blackened organic matter.
At the top of the layer is a band of yellow to reddish brown elongate fibrous plant tissue aligned parallel with the top of the slide.
Rare cellular charcoal <1000µm, few black fragments angular with amorphous interior possibly charred.
Coarse material arrangement:
Elongate plant tissues and charred organics are frequently oriented parallel to the top of the slide but less so than in previous layer. Coarse material dominantly randomly oriented and randomly distributed
Fine organic:
Dominant yellow amorphous clay.
Common black amorphous.
Frequent reddish brown amorphous.
Groundmass:
Heterogeneous. Orange to reddish brown PPL, black, XPL. Undifferentiated b-fabric
Pedofeatures:
Many fe/mn blackened aggregates
Occasional fe/mn nodules
Common pseudomorphic voids with part disappeared plant tissue material – woody edges remain, plant material eaten by micro fauna as demonstrated by occasional excremental fabric within roots.
Occasional excremental textural pedofeatures rising to many towards top of the slide where microstructure granular and sediment more porous.
Rare coatings to voids and rare partial infillings with yellow amorphous clay, rising to occasional towards the top of the layer.
Microstructure:
Complex weakly developed sub angular blocky microstructure with few channels. Rare to common patches of granular structure, more common towards top of layer where porosity greater.
C/F related distribution:

Porphyric.
Boundary:
Diffuse.

Strathain 1

RHUE 2 Layer 1 (Context 1.3/1.2?)

C/F ratio:
40:60
Thickness:
10-31mm
Particle size and sorting:
Unsorted. Clay 20%, silt 40%, very fine sand 15%, medium sand 20% coarse sand 5%.
Coarse mineral:
Coarse mineral fraction comprises 35% of layer (c 80% of overall coarse fraction). Approximately 25% of the layer is comprised of four large micaceous sandstone fragments, average 10mmx10mm. Dominant grains in the smaller rock fragments are quartz with very few iron oxide staining around grains. Smaller rock fragments can be classed as quartz arenites.
Mineral component is dominated by sub-angular to angular quartz, with undulose extinction. Frequent platy muscovite (in matrix as well as in rock fragments). Muscovite randomly oriented in matrix but commonly oriented at 25^{o} within larger rock fragments.
Common phytoliths (elongate with very few spiny).
Coarse organic:
Frequent light yellow part disaggregated plant tissues 10-200µm commonly associated with phytoliths.
Rare yellow very decomposed organ residues.
Common sub-angular to angular black fragments. Internal cracks and fissures but otherwise no structure, possibly charred?
Common cellular charcoal typically 100-600µm but occasionally up to 2000µm. Common small black flecks <10µm throughout matrix gives layer a speckled appearance. The quantity of charred material increases towards the top of the layer which has a darker colour and more frequent organic matter.
Coarse material arrangement:
Randomly oriented. Occasional clustering of decomposing plant material the top of the layer, plant tissues and phytoliths closely associated.
Unsorted.
Fine organic:
Frequent yellow amorphous Common black amorphous. Rare reddish brown amorphous.
Groundmass:
Heterogeneous. Yellowish brown to very dark brown PPL, black, XPL. Undifferentiated b-fabric
Pedofeatures:
Common small (20µm) blackened orthic nodules ?fe/mn nodules
Occasional rounded and rugous fabrics – probably excremental in origin.
Occasional staining and part infilling of voids with amorphous yellow clay
Microstructure:
Complex channel and chamber with occasional patches of granular structure (commonly granular towards the top of the layer).
C/F related distribution:
Porphyric.
Boundary:
Diffuse.

RHUE 2 Layer 2 (Context 1.2)

C/F ratio:
40:60
Thickness:
15-40mm
Particle size and sorting:
Unsorted. Clay 20%, silt 40%, very fine sand 10%, fine sand 10% medium sand 10% coarse sand 10%.
Coarse mineral:
Coarse mineral fraction comprises 35% of layer (c 70% of overall coarse fraction).
Very few micaceous sandstone and fine grained sandstone rock fragments. Generally much smaller than in the underlying layer averaging 250-1500µm. Excepting one large fragment dissected by the left hand edge of the slide and measuring 12x8mm.
Mineral component is dominated by sub-angular to angular quartz, with undulose extinction. Common platy muscovite. Few biotite, rare chlorite, rare feldspars.
Very few phytoliths (note this may be an artefact of visibility as dense black amorphous fine material masks most of layer; in areas where black material less dominant phytoliths are commonly visible).
Coarse organic:
Few bright orange to yellow part decomposed tissue fragments (no birefringence), Commonly elongate 500-2000µm.
Very few woody orange organ residues (highly birefringent)
Very few dark reddish brown to very dark brown/black tissue fragments merging with groundmass.
Rare patches of mashed up bright red and yellow plant tissues and organ residues associated with excremental fabrics (part digested by soil mesofauna?).
Few cellular charcoal, part embedded within black amorphous material with commonly diffuse edges.
Coarse material arrangement:
Randomly oriented and arranged.
Unsorted.
Fine organic:
Very dominant black amorphous mixed with mineral material (may be fine charred material but absence of structure and density makes identification difficult).
Common yellow amorphous.
Few reddish brown amorphous.
Groundmass:
Frequently homogenous (amorphous black) Few passage features infilled with yellowish brown fabric give overall more heterogeneous appearance. Very dark reddish brown to black PPL, black, XPL. Undifferentiated b-fabric
Pedofeatures:
Many infilled passage features, dominantly infilled with yellowish brown excremental fabric similar to layer 3 fabric.
Occasional amorphous yellow organic clay infillings/part infillings to passage features.
Occasional spherical features outwith passage features indicating mixing by soil microfauna as well as mesofauna.
Any fe/mn features masked by black amorphous material.
Microstructure:
Complex channel and chamber with channels and chambers accounting for 30% of layer
C/F related distribution:
Porphyric.
Boundary:
Diffuse.

RHUE 2 Layer 3 (Context 1.2)

C/F ratio:
35:65
Thickness:

12-26mm

Particle size and sorting:

Poorly sorted silt. Clay 20%, silt 50%, very fine sand 5%, fine sand 5% medium sand 15% coarse sand 5%.

Coarse mineral:

Coarse mineral fraction comprises 5% of layer (c 15% of overall coarse fraction).

Very few quartz sandstone concentrated towards base of layer. Additional rare coarse sand sized sandstone randomly distributed throughout matrix.

Mineral component is dominated by sub-angular to angular quartz, with undulose extinction. Very few platy muscovite.

Common phytoliths rising to frequent close to plant tissue remains.

Coarse organic:

Dominant fragmented reddish brown, yellow and black organic fragments average 25µm.

Frequent patches of reddish brown to yellow decomposing organic matter, cellular structure within is common but frequently disaggregated and part disappeared.

Common single reddish brown cells (c.25µm) and common aggregates of these cells in groups of up to 50.

Common patches of angular very dark reddish brown to black dense amorphous material up to 3000µm cracked and often have embedded charcoal fragments within. These fragments are similar to the overall fabric of layer 2 but without embedded quartz minerals.

Few cellular charcoal frequently disaggregated at edges.

Frequent small black flecks in matrix are possibly micro charcoal.

Few red to orange organ residues (20-1000µm) often with high birefringence (modern root fragments/bracken rhizomes) rising to common towards the top of the layer.

Coarse material arrangement:

Randomly oriented and arranged.

Unsorted.

Fine organic:

Dominant yellow amorphous

Frequent black amorphous

Few reddish brown amorphous

Groundmass:

Heterogeneous. Light yellowish brown to very dark brown PPL, black, XPL. Undifferentiated b-fabric

Pedofeatures:

Many excremental. Located at the boundary between layers 2 and 3 are c.30 rounded to sub-rounded mesofauna channels 200-1000µm.

Occasional infillings/part infillings of voids by amorphous yellow clay

Many fe/mn patches and concentrations around cracking shrinkage voids

Many black nodules fe/mn staining?

Many channels infilled with yellowish brown silt-backfilled by microfauna.

Many fe/mn impregnative pedofeatures.

Microstructure:

Complex medium separated sub-angular blocky with channel and chamber with common accommodating planes and intrapedal channels Common, cracks and fissures possibly shrinkage cracks due to drying? Rare patches of crumb to medium separated granular structure. Six large channel voids occupy c.25% of layer

C/F related distribution:

Porphyric.

Boundary:

Diffuse.

GAIR 2 Layer 1 (Context 1.11)

C/F ratio:

65:35

Thickness:
1-21mm
Particle size and sorting:
Unsorted. Clay 20%, silt 30%, very fine sand 10%, fine sand 10% medium sand 20% coarse sand 10%.
Coarse mineral:
Coarse mineral fraction comprises 50% of layer (c 65% of overall coarse fraction).
A single angular large (6x9mm) quartz arenite fragment is located at the base of the layer. Few other coarse sand sized rock fragments of sedimentary origin often partly disaggregated and starting to mix with groundmass.
Mineral component is dominated by sub-angular to sub-rounded quartz, with undulose extinction. Frequent chlorite, common biotite, few feldspars (microcline and plagioclase)
Common elongate phytoliths.
Coarse organic:
Few sub-rounded very dark reddish brown to black internally amorphous blackened organic matter large fragments (500-3000µm) commonly associated with smaller fragments mixed into groundmass.
Few oval brown part cellular plant structures with disappeared interior – probably cross-sections of woody roots (200-400µm).
Rare fibrous yellow elongate tissue fragments
Trace yellowish rounded organ residues
Rare orangey yellow organic accumulations internally amorphous but clear boundary with groundmass, heavily decomposed plant tissue.
Few large charcoal (1000-4000µm) cellular but frequently denuded and fragmented and not identifiable to species level. Few black angular flecks (<50µm) internally amorphous but probably charred.
Coarse material arrangement:
Randomly oriented and arranged.
Unsorted.
Fine organic:
Common yellow amorphous
Few black amorphous
Common reddish brown amorphous
Groundmass:
Heterogeneous. Dark greyish brown to reddish yellow brown PPL, black, XPL. Speckled b-fabric
Pedofeatures:
Many channel voids infilled or part infilled with amorphous yellow clay.
Occasional fe/mn nodules (50-100µm).
Rare patches fe/mn accumulations.
Very few pseudomorphic voids with traces of external epidermal structure and 'disappeared' insides.
Microstructure:
Complex massive to very weakly developed sub angular blocky microstructure with few channel voids.
C/F related distribution:
Close porphyric.
Boundary:
Diffuse.

GAIR 2 Layer 2 (Context 1.11)

C/F ratio:
60:40 – 70:30
Thickness:
15-35mm
Particle size and sorting:
Unsorted. Clay 15%, silt 30%, very fine sand 10%, fine sand 15% medium sand 20% coarse sand 10%.
Coarse mineral:

Coarse mineral fraction comprises 60% of layer (c 70% of overall coarse fraction).
Few other coarse sand sized rock fragments of sedimentary origin.
Mineral component is dominated by sub-angular to sub-rounded quartz, with undulose extinction. Common chlorite, frequent biotite, few feldspars (microcline and plagioclase), few muscovite.
Common (occasionally frequent) elongate, equant, spiny and rounded phytoliths.
Coarse organic:
Common reddish brown rounded cell aggregates >100 rounded cells average 100-600µm Frequent in top left corner of layer. Cell aggregates commonly dissected by channel voids indicating subject to post-depositional disturbance also commonly part 'disappeared' (eaten) in centre.
Very few elongate yellow to orange well decomposed tissue fragments (50-500µm).
Very few patches of reddish orange plant material part mixed with groundmass.
Rare reddish brown fibrous tissue, elongate but with no internal cellular structure. Frequently associated with other organic matter.
Plant material is black XPL (no birefringence indicating relatively well decomposed).
Common blackened organic matter
Few angular black fragments (50-600µm) no internal structure but angular fragmented nature indicative of charred material.
Coarse material arrangement:
Randomly oriented. Frequently randomly arranged but some clustering of charred material and organics especially towards the top of the layer. A weak band of charcoal rich ashy material is located at the top of the layer. It has a diffuse boundary with the surrounding groundmass and is distinguishable by higher ash and charcoal content alone.
Unsorted.
Fine organic:
Frequent yellow amorphous
Very few black amorphous
Few reddish brown amorphous
Groundmass:
Heterogeneous. Yellow to greyish brown PPL, black, XPL. Speckled b-fabric
Pedofeatures:
Very few pseudomorphic voids with epidermal structure part intact, elongate and rounded cross-sections of root material.
Occasional infilled channel voids cutting through groundmass and organic matter (post-depositional), often infilled with excremental material.
Many excremental features (mainly textural granular type with diffuse boundary with groundmass)
Many planar voids part infilled or coated with amorphous yellow organic clay.
Occasional to many fe/mn nodules
Occasional fe/mn impregnated features/accumulations.
Microstructure:
Complex massive with few channels and chambers very few patches of granular structure (within channels).
C/F related distribution:
Close porphyric.
Boundary:
Diffuse.

GAIR 2 Layer 3 (Context 1.6)

C/F ratio:
30:70
Thickness:
28-32mm
Particle size and sorting:

Poorly sorted. Clay 50%, silt 30%, fine sand 10% medium sand 5% coarse sand %%.
Coarse mineral:
Coarse mineral fraction comprises 10% of layer (c 30% of overall coarse fraction (excluding phytoliths)).
Very coarse sand sized rock fragments of sedimentary origin.
Mineral component is dominated by sub-angular to sub-rounded quartz, with undulose extinction. Common feldspars, few biotite, very few chlorite, very few muscovite.
Frequent (occasionally dominant) elongate, equant, spiny and rounded phytoliths. (very few are articulated)
Coarse organic:
Common single reddish brown rounded cells average 30µm
Common single reddish brown elongate cells average 15 x 50µm
Rare rounded reddish brown aggregates of cells up to 500µm
Rare elongate yellow and reddish brown tissue fragments 1 up to 2000µm
Rare birefringent (modern root) organ residues
Common sub rounded blackened organic matter – amorphous interior avg 30-500µm.
Very few angular part cellular charcoal fragments 20-600µm.
Coarse material arrangement:
Randomly oriented.
Few clusters/weak bands of coarse mineral material.
Clusters of coarse mineral material within patches of layer 2 type fabric.
Single plant cells and phytoliths (silt sized coarse fragments) have a very even distribution throughout the layer.
Fine organic:
Dominant yellow amorphous
Very few black amorphous
Very few reddish brown amorphous
Groundmass:
Dominantly homogenous Orangish yellow PPL, black, XPL. Undifferentiated b-fabric (exception is patches of layer 2 type fabric which are heterogeneous and have speckled b-Fabric)
Pedofeatures:
Rare pseudomorphic voids with epidermal structure part intact, rounded cross-sections of root material.
Occasional to many infilled channel voids infilled with amorphous yellow organic clay
Rare excremental features (mainly textural granular type with diffuse boundary with groundmass especially in top left of layers above planar void)
Rare channel voids with dusty silt coatings.
Occasional fe/mn nodules
Rare fe/mn impregnated features/accumulations.
Very few textural patches of layer 2 type material, diffuse (occasionally clear) boundary with groundmass
Microstructure:
Complex weakly to moderately developed sub angular blocky. Common channels and chambers dissecting groundmass. Rare patches of granular
C/F related distribution:
Open porphyric.
Boundary:
Diffuse.

ACHT 3 Layer 1 (Context 5.3)

C/F ratio:
70:30
Thickness:
9-20mm
Particle size and sorting:
Unsorted. Clay 10%, silt 25%, very fine sand 15%, fine sand 20% medium sand 5% coarse sand 20%.

Coarse mineral:
Coarse mineral fraction comprises 50% of layer (c 65-70% of overall coarse fraction).
Common metamorphic schist sub-rounded to sub-angular rock fragments 500µm – 1cm. Mineral aggregates and some of the smaller rock fragments are part disaggregated mixing into general groundmass – as sand sized particles.
A single angular fine grey fragment (200x600µm) probable flint – possible artificially struck?
Frequent quartz, hornblende and chlorite; common biotitie, few muscovite; few feldspars (plagioclase and orthoclase.
Few elongate and equant phytoliths.
Coarse organic:
Common very dark brown to black irregular to rounded nodules/clasts average c 200µm – blackened organic matter?
Very few reddish brown stained amorphous smooth patches c400µm formed around circular pseudomorphic? voids – probable of plant origin.
Few irregular fibrous brown to reddish brown fragments of probable plant matter with a clear boundary with groundmass. No discernible interior cell structure. Average c.4000µm
Common angular to sub-angular black flecks and oblong inclusions frequently 50-100µm but few up to 5000µm. They are internally amorphous but with dark reddish brown edges suggesting organic origin.
Common irregular patches of internally amorphous reddish brown organic material.
Rare reddish brown elongate plant tissue fragments and organ residues with epidermal and internal cell structure partially intact
With the exception of the clustered charred material described below, cellular charcoal is rare. Small black flecks and punctuations <10µm distributed throughout matrix may be micro-charcoal.
Left hand side of slide (6mm form the base) an area c 7mmx7mm has a greater proportion of charred material than the rest of the layer, The groundmass is the same as layer 1 and this area is distinguished by a higher concentration of cellular and amorphous charred black material. Cellular charcoal is common and frequently measures 600-1400µm. Frequent sub-rounded to angular black features (50-400µm) In the centre of this areas is a sub-angular rock fragment (5 x 3mm), mineral appears metamorphic in origin approximately half of the fragment is dense black material – heat blackened stone? The groundmass surrounding the fragment is of a redder colour than elsewhere in the layer and possibly heat reddened. Phytoliths are common in this area (few throughout layer).
Coarse material arrangement:
Randomly oriented and arranged. Clustering of charred materials at left hand side of slide (see above)
Unsorted.
Fine organic:
Common yellow amorphous
Few black amorphous
Common reddish brown amorphous
Groundmass:
Heterogeneous. Yellow or orange brown PPL, black, XPL. Speckled b-fabric
Pedofeatures:
Many rounded porous rugose aggregates of probable excremental origin. Rare rounded dark brown fecal pellets in channel voids.
Occasional fe/mn nodules (50-100µm)
Occasional dark brown (PPL) reddish brown (XPL) impregnative fabric clear to sharp boundary with groundmass and irregular outline. Most common at the base of the unit
Very few possible pseudomorphic voids with traces of external reddish brown structure.
Rare patches fe/mn accumulations.
Microstructure:
Complex. Vughy to crumb in places with many channels and chambers.
C/F related distribution:
Close porphyric.
Boundary:

Diffuse.

ACHT 3 Layer 2 (Context 5.3)

C/F ratio:
65:35
Thickness:
5-14mm
Particle size and sorting:
Unsorted. Clay 10%, silt 30%, fine sand 45% medium sand 10% coarse sand and gravel 5%.
Coarse mineral:
Coarse mineral fraction comprises 50% of layer (c 70-75% of overall coarse fraction).
Few metamorphic schist sub-rounded to sub-angular rock fragments 500µm – 5000µm.
Common medium sand sized angular mineral grains – dominantly quartz.
Dominant quartz. Frequent quartz, hornblende and chlorite. Common biotitie, few muscovite. Few feldspars (plagioclase and orthoclase.
Few to common (in places) elongate phytoliths.
Coarse organic:
Few dark red rounded patches of probable decomposed organic matter.
Few very dark brown to black irregular blackened organic matter patches.
Rare red birefringent organ fragments and cross sections of probable modern root material and bracken rhizomes.
Few cellular charcoal clustered at the centre top of the layer.
Few internally amorphous (probable charred) black fragments c.100-400µm average.
Few angular black flecks c.10-50µm scattered randomly through the matrix possibly micro charcoal.
Coarse material arrangement:
Randomly oriented and arranged. Clustering of charred materials at the centre top of the layer (see above)
Unsorted.
Fine organic:
Frequent yellow amorphous
Few black amorphous
Few reddish brown amorphous
Groundmass:
Heterogeneous. Yellow brown PPL, dark greyish brown, XPL. Undifferentiated b-fabric
Pedofeatures:
Occasional patches of moderately impregnated brown fabric with higher organic matter content than surrounding groundmass
Occasional rounded black internally amorphous nodules average 50-100µm fe/mn nodules.
Rare textural – brown patches, irregular welded aggregates – may be related to soil micro fauna.
Rare fine brown silt coatings to mineral aggregates.
Rare round/elliptical brown nodules in or near passage features 10-50µm
Rare pseudomorphic voids.
Microstructure:
Complex. Massive with many channels and chambers.
C/F related distribution:
Close porphyric.
Boundary:
Diffuse.

ACHT 3 Layer 3 (Context 5.3)

C/F ratio:
60:40
Thickness:

23-26mm
Particle size and sorting:
Unsorted. Clay 15%, silt 35%, fine sand 30%, medium sand 15% coarse sand and gravel 5%.
Coarse mineral:
Coarse mineral fraction comprises 40% of layer (c 60% of overall coarse fraction).
Few metamorphic schist sub-rounded to sub-angular rock coarse sand to gravel sized rock fragments. Mineral aggregates and some of the smaller rock fragments are part disaggregated mixing into general groundmass – as sand sized particles.
Large (1000x5000µm) angular flint fragment – possibly worked?
Frequent quartz, hornblende and chlorite. Common biotitie, few muscovite. Few feldspars (plagioclase and orthoclase.
Common elongate phytoliths.
Coarse organic:
Common black organic punctuations
Very few plant tissue fragments and organ residues within pseudomorphic voids.
Very few orange elongated tissue fragments and organ residues.
Rare round reddish brown clusters of c.30 cells c 400µm diameter.
Very few large angular charcoal fragments 200-2000µm.
At the boundary between layers 3 and 4 is a large (4,500 x 2,000µm) angular piece if cellular charcoal.
At the base of the layer is a patch of charred material 15 x 8 mm mixed in with the groundmass but dominantly (c.70%) black amorphous material. A single outlying cellular charcoal piece is associated with the amorphous black material.
Coarse material arrangement:
Randomly oriented and arranged. Clustering of charred materials at base of layer (see above)
Unsorted.
Fine organic:
Frequent yellow amorphous
Common black amorphous
Frequent reddish brown amorphous
Groundmass:
Heterogeneous. Dark reddish brown to orange brown PPL, black, XPL. Undifferentiated b-fabric
Pedofeatures:
Occasional pseudomorphic voids.
Occasional rounded black nodules – possible fe/mn features/blackened organic matter.
Many rounded aggregates make up groundmass – excremental fabric in places.
Occasional round faecal pellets within channel voids.
Occasional reddish brown irregular impregnative features possible very decomposed organic matter.
In the centre of the layer, an area c5000µm is comprised of dense orange groundmass – c,.70% silt with medium sand sized quartz inclusions and black punctuations. Diffuse to clear boundary with surrounding groundmass. It is possible that this textural pedofeature is a fragment of floor surface or building material mixed in from above. Rare smaller textural patches of this material up to 1000µm are distributed rarely and randomly through the layer.
Microstructure:
Complex. Channels and chamber with vughs to crumb like, granular in places where excremental fabric dominates.
C/F related distribution:
Close porphyric
Boundary:
Diffuse.

ACHT 3 Layer 4 (Context 5.3/5.2)

C/F ratio:
70:30

Thickness:
11-16mm
Particle size and sorting:
Unsorted. Clay 15%, silt 35%, fine sand 20%, medium sand 10% coarse sand and gravel 10%.
Coarse mineral:
Coarse mineral fraction comprises 50% of layer (c 70% of overall coarse fraction).
Few metamorphic schist sub-angular rock fragments; four large fragments measure 5-10mm but mostly have average measurement of 500-1000µm.
Frequent very fine to fine sand sized quartz. Common biotite, feldspar, chlorite. Few chlorite and muscovite.
Common elongate and equant phytoliths (rarely articulated).
Coarse organic:
Frequent internally amorphous sub-angular to sub-rounded black organic fragments and punctuations (20-100µm).
Common single cell residues (10-50µm).
Few plant tissue residues and disaggregated cells.
Few bright orange woody and fibrous tissue fragments and organ residues – birefringent possibly modern roots?
Few dark reddish brown rounded features with internal cells within an otherwise amorphous interior. Also, few reddish brown rounded areas with amorphous interior.
Few sub-angular cellular charcoal 100-400µm.
Very few bright red irregular fabrics with smooth amorphous interior containing few traces of elongate cells and frequent phytoliths- heavily decomposed plant tissue?
Coarse material arrangement:
Randomly oriented and arranged. Unsorted.
Fine organic:
Frequent yellow amorphous
Few black amorphous
Common reddish brown amorphous
Groundmass:
Heterogeneous. Yellowish brown to dark brown PPL, black, to very dark reddish brown XPL. Speckled b-fabric.
Pedofeatures:
Trace pseudomorphic voids.
Occasional rounded black nodules – possible fe/mn features/blackened organic matter.
Many rounded aggregates make groundmass – excremental in places.
Occasional reddish brown irregular impregnative features possible very decomposed organic matter.
Occasional patches of dense yellow fabric (layer 5 type) within channel voids and vughs. Groundmass significantly different from surrounding exhibiting massive microstructure, lower organic matter content and frequent sand sized quartz material similar to layer 5 and that observed in void space in layer 3.
Microstructure:
Complex. Frequent channels and chamber to crumb like, granular in places where excremental fabric dominates.
C/F related distribution:
Close porphyric
Boundary:
Variable – dominantly diffuse but occasional sharp boundary with layer 5 fabric in areas where faunalturbation lese extensive.

ACHT 3 Layer 5 (Context 5.2)

C/F ratio:
60:40
Thickness:
1-6mm
Particle size and sorting:
Poorly sorted silt. Clay 15%, silt 45%, fine sand 20%, medium sand 15% coarse sand and gravel 5%.

Coarse mineral:
Coarse mineral fraction comprises 50% of layer (c 80% of overall coarse fraction).
Very few sub-angular rock fragments up to 1000µm metamorphic in origin.
Dominant medium and fine sand sized quartz quartz. Few hornblende, biottie and chlorite.
Common elongate phytoliths.
Coarse organic:
Frequent black organic fragments and punctuations (<20µm)
Common sub-angular black fragments (100-200µm) internally amorphous
Common rounded internally amorphous reddish brown organic matter (100-300µm)
Common single cells and disaggregated cell material.
Coarse material arrangement:
Randomly oriented and arranged.
Poorly sorted (Frequent fine to medium sand sized quartz inclusions)
Fine organic:
Dominant yellow amorphous
Common black amorphous
Frequent reddish brown amorphous
Groundmass:
Homogenous. Reddish brown PPL, black, XPL. Speckled b-fabric
Pedofeatures:
Occasional rounded black nodules – possible fe/mn features/blackened organic matter.
Many passage features resulting from bioturbation by soil fauna. These appear as channels infilled with yellow excremental fabric (porous rugose aggregates)
Microstructure:
Massive with few channels and chambers.
C/F related distribution:
Close porphyric
Boundary:
Clear to sharp with layer 4 excepting some areas where excremental features apparent and boundary is diffuse.

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Achnahaird Buffer 7.1

Sample ref	Horizon	Ph	Conductivity	Dissolved solids
Achd T3	H7	6.25	198	94
Achd T3	H6	5.26	28	16
Achd T3	H5	5.33	23	11
Achd T3	H4	5.8	50	24
Achd T3	H3	4.89	51	24
Achd T3	H2	4.39	104	51
Achd T3	H1	4.17	220	89

Achtercairn 2 Buffer 7.1

Sample ref	Horizon	Ph	Conductivity	Dissolved solids
Acht 2 T4	H4	4.92	73	35
Acht 2 T4	H3	4.84	359	184
Acht 2 T4	H2	4.37	31	
Acht 2 T4	H1	4.3	354	173

Gairloch 1 Achtercairn 1 Buffer 7.1

Sample ref	Horizon	Ph	Conductivity	Dissolved solids
Gair 1 T3	H4	5.6	153	81
Gair 1 T3	H3	5.54	139	68
Gair 1 T3	H2	5.83	222	113
Gair 1 T3	H1	4.28	432	256

Loch Raa Buffer 7.1

Sample ref	Horizon	Ph	Conductivity	Dissolved solids
Loch Raa T3	4	5.35	146	74
Loch Raa T3	3	4.74	70	36
Loch Raa T3	2	4.55	186	96
Loch Raa T3	1	4.68	334	165

Rhue Buffer 7.1

Sample ref	Horizon	Ph	Conductivity	Dissolved solids
Rhue T3	H4	5.05	88	44
Rhue T3	H3	5.1	38	20
Rhue T3	H2	4.14	227	100
Rhue T3	H1	4.14	409	207

Srathain Buffer 7.1

Sample ref	Horizon	Ph	Conductivity	Dissolved solids
SRA T4	H1	4.35	652	471
SRA T4	H2	4.39	97	39
SRA T4	H3a	4.03	215	109
SRA T4	H3b	4.7	19	10

Name BI

Date 2nd Feb 2013

Sample Ref	Horizon	mc	m(c+s)	ms gm	m(c+s)h	msh gm	L gm	LOI %
Rhue T3	H2	11.86	13.63	1.77	12.63	1	0.77	43.5
Rhue T3	H3	11.86	17.44	5.58	17.1	0.34	5.25	6.1
Rhue T3	H4	12.19	16.57	4.38	16.23	3.94	0.44	10
Gair 1- T3	H2	10.93	14.48	3.55	11.69	2.79	0.76	21.4
Gair 1- T3	H3	12.19	19.33	7.14	17.36	1.97	5.17	72.4
Gair 1- T3	H4	11.86	16.62	4.76	14.6	2.02	2.74	57.6
Sra-T4	H1	11.86	13.2	1.34	12.21	0.99	0.35	26.1
Sra-T4	H2	12.19	14.96	2.77	14.32	0.64	2.13	76.8
Sra-T4	H3a	12.19	15.47	3.28	15.17	0.3	2.98	90.9
Sra-T4	H3b	10.93	14.99	4.06	14.86	0.13	3.93	96.7
Acht 2-T3	H1	10.93	11.31	0.38	10.94	0.37	0.01	97.4
Acht 2-T3	H2	11.86	12.68	0.82	11.95	0.73	0.09	10.9
Acht 2-T3	H3	12.19	14.68	2.49	12.61	2.07	0.42	16.8
Acht 2-T3	H4	10.93	14.57	3.64	14.28	0.29	3.35	92
Loch Raa-T3	H1	11.87	14.01	2.14	12.72	1.29	0.85	39.7
Loch Raa-T3	H2	10.91	15.05	4.14	12.8	2.25	1.89	45.7
Loch Raa-T3	H3	12.19	15.93	3.74	15.68	0.25	3.49	93.3
Loch Raa-T3	H4	11.86	15.39	3.53	15.07	0.32	3.21	90.1
Achd-T3	H1	12.19	12.95	0.76	12.39	0.56	0.2	26.3
Achd-T3	H2	11.87	14.53	2.66	14.12	0.41	2.25	84.5
Achd-T3	H3	10.95	13.38	2.43	13.1	0.28	2.15	88.4
Achd-T3	H4	12.19	14.76	2.57	14.44	0.32	2.25	87.5
Achd-T3	H5	11.86	15	3.14	14.85	0.15	2.99	95.2
Achd-T3	H6	10.91	13.41	2.5	13.18	0.23	2.27	90.8
Achd-T3	H7	12.19	16.78	4.59	16.71	0.07	4.52	98.5

Loch Raa, 22nd March 2012		
H1 Brown		7.5YR 1.7/3/1 Smooth and Sticky, Silty Clay Loam
H2 Black (burnt)		5Y 1.7/2/1 Soapy, Silty Clay Loam
H3 Brown Stoney		10YR 1.7/3/2 Gritty, Clay Loam
H4 Yellowy Brown		10YR 1.7/4/4 Loamy Sand
Rhue, 16th May 2012		
H1 Very Dark Brown		7.5YR 1.7/1 Loam
H2 Very dark Brown		7.5YR 2/1 Sandy Clay Loam (peaty)
H3 Less dark Brown		10YR 2/2 Sandy Clay Loam, Stony layer
H4 Dark Brpwn mixed with yellowish soil		10YR 2/2 and 5/6 Sandy Clay loam (gravelly)
Gairloch 1, 17th June 2012		
H1 Brown with yellowish tinge, lots of fibrous roots		7.5YR 4/3 Silt Loam (organic soil)
H2 Dark Brown charcoal flecks and mineral flecks		7.5YR 3/3 Sandy Loam
H3 Dark Brown Reddish Tinge		7.5YR 3/4 Loamy Sand
H4 Olive with flecks of coarse stone / gravel		5Y 5/6 Peaty Gley with Mottling
Achnahaird, 29th August 2012		
H1 Very dark Brown		7.5YR Very Rooty, Silt Loam
H2 Very dark Brown		10YR 1.7/2/2 Less Rooty, Silty Clay Loam
H3 Very Dark Brown		7.5YR 1.7/3/1 Few Fibres, Silt Loam, Sandy
H4 Nearly Black		7.5YR 1.7/2/1 Few Fibres, Loam
H5 Very Dark Brown		10YR 1.7/2/2 Loamy Sand, Sandy
H6 Black, Old land surface?		10YR 1.7/2/1 Sandy Loam
H7 Brown with a reddish tinge		7.5YR 1.7/4/4 Sand
Srathain, 24th September 2012		
H1 Brownish Black		7.5YR 1.7/2/2 Loamy Sand, Is it peat?
H2 Brownish Black		10YR 1.7/2/2 Loamy Sand?
H3a Black		7.5YR 1.7/1 Loamy Sand
H3b Greyish Olive		5Y 1.7/4/2 Sand
Gairloch 2, 23rd October 2012		
H1 Brownish Black		7.5Y 1.7/3/1 Mostly Root, Not Possible to Analyse
H2 Black		7.5YR 1.7/2/1 Very Rooty Clay Loam (peaty)
H3 Brownish Black		7.5YR 1.7/2/1 Clay Loam, Very Rooty (peaty)
H4 Brownish grey		7.5YR 1.7/4/3 Clay

Pollen Analysis from Achtercairn 2 & 3, Gairloch, Wester Ross, Highlands

Dr Scott Timpany
ORCA Marine

1. Introduction

Key-hole excavation of a hut circle at Achtercairn 2, Gairloch, Wester Ross (NG 8077 7693) was undertaken through the Wedig Project in 2012 (Wildgoose and Welti, 2012). Trench 1 and two testpits (Trenches 2 and 3) were undertaken at the site of roundhouse Achtercairn 2. Trench 1 was placed north to south across the hut, while Trenches 2 and 3 were located 10m to the north east and 10m to the west of the roundhouse. A small number of finds were retrieved from Trench 1, which included a broken sandstone rubber, a pebble hammer and a quartz flake (Wildgoose and Welti, 2012). A radiocarbon date taken from birch charcoal recovered from the lower hearth has provided a Late Bronze Age date for the roundhouse of 896-799 cal BC (GU-30616; 2679±29 BP). A further circular stone setting, Achtercairn 3, was recorded approximately 40m downslope of the roundhouse and a further small trench (trench 4) was put in to investigate this feature (Wildgoose and Welti, 2012). This trench was extended to Trenches 5 and 6. (See illus 15 in main report text). Trench 7 was later dug in line with Trench 5, separated by a 50cm baulk. Radiocarbon dating of alder charcoal retrieved from a cobbled area, within Achtercairn 3 has shown this stone circle feature to be earlier than the Achtercairn 2 roundhouse, dating to 3633-3376 cal BC (GU-30617; 4719±30 BP) placing activity in the Late Neolithic period. A further radiocarbon date of alder charcoal has recently been obtained from beneath the 'wall' of the stone circle and provided a Middle Bronze Age date of 1736-1528 cal BC (GU-34311; 3341±35 BP) suggesting its construction took place in this period.

As part of the excavation a kubiena tin (8 x 5cm) sample (ACHT2) was taken through organic deposits within Trench 3 of Achtercairn 2 at the contact point between Contexts 3.3 and 3.4. A further sequence of kubiena tins (ACHT3.0-3.4) was taken through loam deposits 7.1 to 7.3 within Trench 7 of Achtercairn 3. The kubiena tin sample from Achtercairn 2 and two of the kubiena tin samples from (ACHT3.1 and 3.2) have been sub-sampled to provide material for pollen analysis. It is hoped this analysis will provide information on the environment of the hut circle during its lifetime and any evidence of how people interacted with this environment. All samples have been analysed for pollen, non-pollen palynomorphs (NPPs; includes fungal spores, animal hair and wood detritus) and microscopic charcoal.

2. Aims and Objectives of the work

The main objective of the analysis was to investigate the landscape around the two hut circles and to investigate any evidence of human-environmental interaction.

The key aims to achieve this objective are:

- To establish the presence and state of preservation of any pollen grains, NPPs and microscopic charcoal within the spot-samples.
- To reconstruct the local environment during the use of the hut circles.
- To investigate for any evidence of human-environmental interaction, such as farming, woodland clearance, burning events etc.

3. Methods

3.1 Pollen Analysis

A total of 15 samples of c. 2g wet weight were sub-sampled from the kubiena tins and prepared for pollen, non-pollen palynomorphs (NPPs) and microscopic charcoal analyses using the procedure described by Barber (1976). In order to remove mineral matter, the organic component of each sample was separated using a density flotation method, which also aids in concentrating the pollen from each level (Nakagawa et al, 1998). At least 500 total land pollen (TLP) grains were counted for each sub-sample; being grains of trees, shrubs, dwarf shrubs and herbs, excluding aquatics. Where pollen was found to be especially degraded and sparse a count of 300 TLP was employed; namely for levels 25cm and 27cm from ACHT3.1. Pollen was identified using key reference texts such as Moore et al (1991) and when needed through comparison with modern reference material from a collection housed in Orkney College UHI. Cereal-type pollen identification was made using the identification keys from Fægri et al. (1989), Moore et al. (1991) and was differentiated from wild grass pollen based on grain size, pore and annulus diameter and surface sculpturing (Andersen, 1979). Pollen preservation was recorded following Cushing (1967) and each pollen grain was classified as broken, corroded, crumpled or degraded. Pollen grains that had no remaining distinguishing features were categorised as unidentified. NPPs were recorded during routine pollen counting and they were identified using the descriptions and photomicrographs of van Geel (1976), van Geel et al (1989; 2003) and van Geel and Aptroot (2006). Microscopic charcoal was routinely counted during pollen analysis and has been divided into three size categories (<21µm; 21-50µm and >50µm) in order to distinguish between fire events taking place close to and some distance from the site; the larger microscopic charcoal fragments being closest to the site. Microscopic charcoal fragments where enough structure survived have been identified as either wood or grass charcoal and these counts added to the pollen diagrams.

The pollen and non-pollen palynomorph diagrams are shown in Illustrations 1 and 2. Plant nomenclature follows Stace (2010). Summary curves for trees, shrubs (constituting arboreal pollen, AP), dwarf shrubs and herbs (non-arboreal pollen, NAP) are shown. NPP terminology follows the type system devised by van Geel (1976) and uses the laboratory code as prefix (HdV), followed by the type number. NPP types not listed by van Geel have been given an OC prefix. The pollen data is expressed as percentages of total land pollen (TLP). Rare pollen types are denoted by a +, where + is one grain, ++ is two grains and +++ is three grains. NPPs are expressed as percentages of total land pollen plus NPPs. The pollen diagrams have been constructed using Tilia and Tilia.graph version 1.7.16 (Grimm, 2011). The pollen diagrams have been zoned using the sediment context for the purpose of this report.

3.2 Radiocarbon Dating

A 2g radiocarbon dating sample of peat was taken at 3cm from the sedimentary sequence in the kubiena tin sample recovered from Achtercairn 2. The sample was taken from this level following analysis of the pollen in order to date the appearance of cereal pollen in the assemblage.

4. Results

4.1 Stratigraphy

The stratigraphy of the sedimentary sequence within the Kubiena tin samples was recorded during sub-sampling (Tables 1 and 2).

4.1.1 Achtercairn 2

The contact point between the two stratigraphic units 3.3 and 3.4 was visible at 6cm showing there to be a sharp transition between the two sediment types. The basal context (3.4) was a minerogenic horizon of brown slightly peaty silt. Inclusions of brown-grey silt and coarse sand, suggest erosion episodes possibly associated with slope wash (colluvium), leading to observable accumulation of silt within the deposit. This unit was overlain by a dark brown, slightly silty, peat with visible monocotyledon plant fragments (e.g. grasses and sedges). The presence of silt and coarse sand within this layer again indicate periods of probable slope wash accumulating within the peat. The high minerogenic and organic nature of the two deposits has been shown from the Loss on Ignition analysis undertaken on these two sediment layers (see Local Soil testing Results, Prof B Ing, Appendix 3).

Context Number	Stratigraphic Description	Corresponding Pollen Levels
3.3	Dark brown, slightly silty, monocotyledon peat with occasional coarse sand inclusions.	1-6cm
3.4	Brown slightly peaty silt with light brown-grey silt inclusions and occasional coarse sand inclusions.	6-8cm

Table 1 – Stratigraphic sequence from Kubiena Sample taken from Trench 3

4.1.2 Achtercairn 3

The sedimentary sequence from Trench 7 was a sequence of minerogenic layers. The sampled part of the sequence from the two kubiena tins (ACHT3.1 and 3.2) showed a brown clayey loam that was observed to have an increase in clay fraction moving vertically upwards through the sediment column (Table 2). The upper unit of the sequence (7.1) contained occasional root fragments from the overlying vegetation cover.

Context Number	Stratigraphic Description	Corresponding Pollen Levels
7.1	Brown clayey loam, with occasional penetrating root fragments.	1-18cm
7.2	Brown slightly clayey loam.	18-30cm

Table 2 – Stratigraphic sequence from Kubiena Samples taken from Trench 7

4.2 Pollen and NPP results

The results of the pollen analysis are presented in Illustration 1 and are discussed below by Sequence and Context (Zone).

4.2.1 Achtercairn 2

4.2.1.1 Zone 1; Context 3.4

Zone 1 (Context 3.4) corresponds to levels 6-8cm in the pollen sequence (Table 1 and Illus. 1). The pollen assemblage from this zone consists largely of arboreal and shrub pollen, which together account for approximately 90% TLP. In particular this sum is contributed to mainly by birch (*Betula* sp.) and hazel (*Corylus avellana*) pollen, which make up around 60% and 30% TLP, respectively. Small values of oak (*Quercus* sp.) and alder (*Alnus glutinosa*) pollen are present indicating the presence of these trees in the landscape. There is some suggestion for the existence of heathland through the recording of heather (*Calluna vulgaris*) pollen, which contributes to around 2% TLP. The majority of herbaceous pollen present is represented by grass (Poaceae) pollen at around 5% TLP, with a range of other taxa present as rare types, including marsh marigold (*Caltha palustris*-type), butter cups (Ranunculaceae), devils-bit scabious (*Succisa pratensis*), nettles (*Urtica*-type) and marsh violet (*Viola palustris*-type). The spore assemblage consists mainly of ferns (*Pteropsida* (monolete) indet.) with polypoidy (*Polypodium*), sphagnum (*Sphagnum*) and bracken (*Pteridium*) present as rare types. The NPP assemblage also contains rare-types with no type being present in any significant number and includes HdV-16C, HdV-52 (animal hairs), HdV-55A/B (Sordaria type) and HdV-118 (globose microfossils). Microscopic charcoal for this zone is present across all fractions but highest at the 1-21µm fraction, suggesting burning is taking place but within the wider area of the roundhouse. A decrease in burning is also seen from the base to the top of this zone. The small number of Lycopodium spores counted from these levels demonstrates the high abundance of pollen observed for these levels, while the small values of corroded, crumpled, broken, concealed and unknown (pollen too degraded to positively identify) indicates pollen grains were also well preserved. The number of degraded grains is around 10% TLP and suggests that biological degradation (e.g. bacterial attack) is the main factor hindering preservation.

4.2.1.2 Zone 2; Context 3.3

Zone 2 (Context 3.3) corresponds to levels 1-6cm in the pollen sequence (Table 1 and Illus. 1). This zone is again dominated by birch and hazel pollen which make up to 70% and 30% TLP, respectively at their highest peaks in this zone (at 5cm for birch and 3cm for hazel). These values are seen to gradually fall to the end of the zone where birch accounts for 42% TLP and hazel accounts for 16% TLP. Other tree and shrub taxa are present at smaller percentages and rare types such as oak, alder, willow (*Salix* sp.) and ivy (Hedera helix). The top of the zone also sees the first appearance of pine (*Pinus* sp.) and elm (*Ulmus* sp.) pollen. Heather pollen values increase significantly in this zone from around 2% TLP at the base of the zone to 20% TLP at the top of the zone. Accompanying the rise in heather is the increased appearance of crowberry (*Empetrum*) and heaths (*Erica*-type) pollen. There is a slight increase also in grass pollen within this zone, which increases from around 5% TLP at the base of the zone to 9% at the top of the zone. There are also significant increases in the pollen of sedges (Cyperaceae), meadowsweet (*Filipendula*), cinquefoils (*Potentilla*) and star saxifrage (*Saxifraga stellaris*), which all form continuous curves for parts of this zone. A range of other herbaceous pollen also appears as rare types within this zone including pinks (*Dianthus*-type), Michaelmas daisies (*Aster*-type), ribwort plantain (Plantago lanceolata), chicory (*Cichorum intybus*-type) and hogweed (*Heracleum sphondylium*-type). Cereal pollen in the form of barley (*Hordeum*-type) pollen appears for the first time at 3cm and then continues to be present in the above levels. The spore assemblage is again dominated by ferns but there is also an increase in bracken values recorded in the upper part of the zone. Other spore types in the form of sphagnum, polypoidy and buckler-ferns (*Dryopteris*) are also present. Accompanying the rise in heather pollen is a rise in the curve of HdV-10 (*Conidia*), suggesting a local presence of heather around the hut circle. There are peaks also in the values of HdV-52 and HdV-16C, while from 4cm upwards there is a continuous curve in the values of HdV-181. In the upper part of the zone are the first appearances of HdV-1 (*Gelasinospora* spp.) and HdV-3B (*Pleospora* spp.), which are both indicative of local burning. This is also indicated by a large rise in the values of microscopic charcoal particularly at the 1-21µm and 21-50µm cross fractions, suggesting a significant increase in burning activity from 3cm upwards. Charcoal retaining enough structure to be identifiable as wood microscopic charcoal was present at 4 and 5cm, with that at 5cm identifiable as hazel wood. The percentages of degraded, broken and corroded pollen grains present, together with Lycopodium spores are all low indicating there was good pollen preservation and abundance. There is a slight increase in the numbers of crumpled grains indicating some mechanical damage of pollen grains, which may be a reflection of sediment mixing through erosional episodes of hill wash material moving downslope into the peat as suggested by the stratigraphic record.

4.2.2 Achtercairn 3

4.2.2.1 Zone 1; Context 7.2

Zone 1 (Context 7.2) corresponds to levels 18-27cm in the pollen sequence (Table 2 and Illus. 2). The pollen assemblage within this zone changes fairly abruptly between 23 and 25cm, from a landscape with some scrub woodland cover, to open heath environment. At 25-27cm the pollen assemblage comprises of arboreal and shrub pollen contributing 55-60% TLP; the main taxa being birch, alder and hazel, with oak and pine only represented as rare types. From 18-24cm the combined arboreal and shrub pollen has fallen to make up only 7-10% TLP. A rise is also recorded in dwarf shrub pollen at 24cm, dominated by an increase in heather pollen, contributing approximately 20-40% TLP for the remainder of this zone. A local presence of heather close to the sampling site is demonstrated by the large values of HdV-10 throughout the zone. Grass pollen remains consistent throughout the zone with values of around 25% TLP and is the largest contributor to the herbaceous pollen sum, which comprises between 35-52% TLP within this pollen zone (Illus. 2). Together with grass pollen there are also significant quantities of sedges, ribwort plantain, chicory, Michaelmas-daisies (*Aster*-type), bog myrtle (*Myrica gale*), cinquefoils and marsh valerian (*Valeriana dioica*). Other herbaceous pollen, present as rare types include vetches (*Vicia*-type), meadowsweet, cowbane (*Cicuta virosa*-type), mint (*Mentha*-type) and devil's bit scabious. Cereal pollen is present at 23-24cm and at 19cm with the appearance of barley-type pollen. The spore assemblage is largely made up of ferns and bracken, with polypoidy, marsh fern (*Thelypteris palustris*) and parsley fern (*Cryptogramma crispa*) present as rare types. There is a rich NPP assemblage for this zone containing significant amounts of a number of taxa including HdV-16A, HdV-52A, HdV-55A/B (*Sordaria* spp.), HdV-112 (*Cercophera* sp.), HdV-181 and HdV-350. There are high values of microscopic charcoal across all fraction sizes in this zone, with a steady decline from 27cm to 23cm, with values then increasing before decreasing again. The high microscopic charcoal values indicate burning activity taking place within the local and wider area of Achtercairn 3. The high values for *Lycopodium* spores in the bottom two levels (26-27cm) reflects the paucity of pollen grains on the slides, with only 300 TLP recorded for these basal layers. These two levels also have the highest numbers of degraded grains with smaller values of crumpled and broken grains, suggesting degradation of pollen has been caused by biological damage rather than mechanical. The number of degraded grains and the number of *Lycopodium* spores can be seen to decrease vertically up the sediment column, indicating grains are better preserved and more abundant in the levels closer to the surface. This increased level of preservation mirrors the increased clay content in the loam suggesting there is a greater level of waterlogging in these sediments aiding the preservation of the pollen grains.

4.2.2.2 Zone 2; Context 7.1

Zone 2 (Context 7.1) corresponds to levels 17-18cm in the pollen sequence (Illus. 2 and Table 2). The pollen assemblage within this zone reflects a similar landscape to the previous zone with no major changes in vegetation taking place. Arboreal pollen (tree and shrubs) makes up around 20% of TLP in this zone, while dwarf shrubs, largely consisting of heather and heaths (*Erica*-type) contributes approximately 40% TLP, with herbaceous pollen adding the final 40% TLP (Illus. 2). There is an absence of pine pollen within this zone, while there is an appearance of ash (*Fraxinus excelsior*) pollen. Alder pollen decreases slightly from the previous zone, with hazel pollen showing a slight rise; oak and birch pollen values remain the same. The herbaceous pollen assemblage is again dominated by grass pollen, with significant values of sedge, ribwort plantain, chicory, Michaelmas-daisies and star saxifrage. Other herbaceous pollen present as rare types within this zone include meadowsweet, vetches, alpine saxifrage (Saxifraga nivallis), nettles, chamomiles (Anthemis-type), devils-bit scabious and mugwort (*Artemisia*-type). Cereal pollen is again present in this zone with the recording of barley-type pollen in rare quantities at 17cm. The spore assemblage again consists mainly of ferns, bracken and sphagnum, with polypoidy occurring as a rare type. The NPP assemblage is dominated by HdV-10 spores indicating that there is a local presence of heather close to the sampling site. A number of other NPP's are also present in the assemblage with continuous curves from the previous zone for types such as HdV-16A, HdV-52C, HdV-55A/B, HdV-112, HdV-350 and HdV-422. A number of other types are also present as rare types including HdV-1, HdV-4 (*Anthrostomella fuegiana*), HdV-123 and HdV-205 (possible *Sordaria* spp.). Microscopic charcoal values remain high across all fraction sizes, rising slightly from the end of Zone 1, suggesting burning activity took place close to the sampling site. The lower value of *Lycopodium* spores in this zone continues from that previously and indicates a greater abundance of pollen in this level. There is a slight decrease in the number of degraded pollen grains in this level, with small rises in the numbers of crumpled and broken grains; corroded grains only occurring in rare values. These categories for pollen preservation indicate that pollen continues to be better preserved in the upper levels of the sediment column and that biological damage is the main form of degradation.

4.3 Radiocarbon dating results

All radiocarbon dates have been calibrated using the University of Oxford Radiocarbon Accelerator Unit calibration program OxCal 4.1.7 (Bronk Ramsey 2010) and are presented in the text using the 2σ calibrated age ranges. The radiocarbon date obtained from the Achtercairn 2 sequence provided a post medieval date for the cultivation activity of cal AD 1485-1649 (GU-35220; 313±30 BP). This date indicates that the pollen sequence represents vegetational changes within the late medieval to post medieval period rather than relating to activity corresponding with the archaeology.

5. Discussion

5.1 Achtercairn 3; possible Late Neolithic to Early Bronze Age date

There are no radiocarbon dates available for the pollen assemblage analysed for Achtercairn 3, therefore it is not known for certain what the chronology is for the vegetational information garnered from the pollen analysis. The kubiena tin sequence (KT1-4) from Trench 4, associated with the stone enclosure extends from c. 2cm to 30cm (with the pollen sequence presented here covering 17-27cm). The stone wall of Achtercairn 3 was encountered close to the surface within Phase 2 of T5 correlating to Context 7.1 of the sediment profile. This phase of activity has been radiocarbon dated from alder charcoal underlying the stone 'wall' to 1736-1528 cal BC, placing activity in the Middle Bronze Age. Underlying this is a previous phase of activity (Phases 1a and 1b) represented by a cobbled area within a stone setting, which corresponds with Context 7.1 of the sediment profile. Alder charcoal from the cobbled area has provided a Late Neolithic date for this activity of 3633-3376 cal BC. Therefore it is likely that the pollen sequence from Achtercairn 3 (Illus. 1), sampled mainly from the Phase 1 sediments, with one level from those of Phase 2 relates to the Late Neolithic to Early Bronze Age period.

The pollen sequence from Achtercairn 3 reflects a fairly open environment of initial scrub woodland cover followed by a more open heath environment; as such the pollen catchment is likely to provide information on both the local and more widespread vegetational changes. Although the pollen levels have been taken contiguously through the sediment sequence, it is not clear what the sediment accumulation rate is for the two sampled contexts as they are likely to have formed at various rates over the Phase 1 and Phase 2 periods; compared to the potentially steadier rate of accumulation of organic sediments such as peats. Therefore a general chronology has been used based on the radiocarbon dates information for the two phases in the interpretation of the sequence.

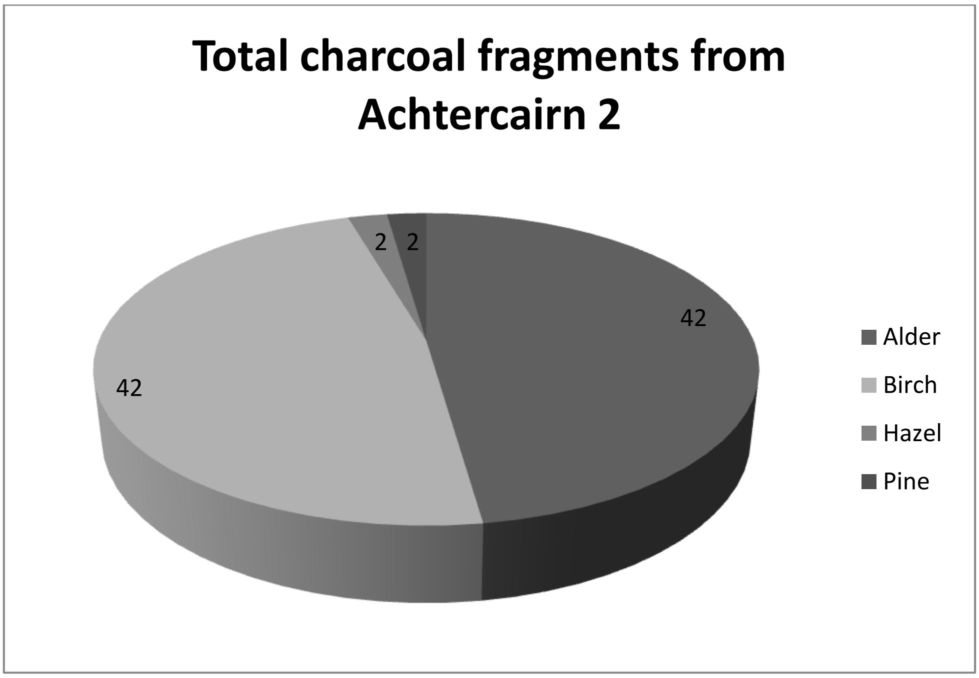
Arboreal and shrub pollen values are highest in the basal two levels (25 and 27cm) where probable scrub woodland of birch and hazel was growing on the slopes of the hillside and/or on areas of mire within the landscape. Alder is also shown to have had a significance presence in the landscape in these levels and is likely to have been growing in the wetter locations of this landscape, such as fringing burns or may have been growing on wetter parts of the mire similar to birch and hazel (Rodwell, 1991). There is some evidence for the presence of oak in the wider landscape with rare pollen values of this taxon recorded (Illus. 1). A local tree presence is also signalled in the NPP record from the presence of dead wood indicators such as *Bactrodesmium obovatum*, which is related to decaying wood of deciduous trees (van Geel *et al*, 1981) present on the woodland floor. The pollen assemblage indicates a largely open environment during this phase with high values of grass pollen (c. 20-25% TLP), together with appearances of other grassland taxa such as devil's-bit scabious, campions (*Silene*-type) and Michaelmas-daisies. Damp ground indicators are also present including, sedges, cowbane and hog's fennel suggesting these taxa were growing within wet woodland areas or in wetter areas of marsh/mire (Clapham *et al*, 1962; Stace, 2010). The basal pollen assemblage from Achtercairn 3 reveals a more open landscape of scrub and wet woodland, together with heath and grassland then is suggested by other Late Neolithic pollen sequences from across the region. For example at Badentarbet, Highlands, higher values of birch, alder and hazel pollen are present with tree and shrub pollen making up 75-85% TLP during the Neolithic to Middle Bronze Age period (Bunting and Tipping, 1997).

The pockets of scrub and wet woodland signalled inn the pollen record at Achtercairn 3 are depleted even more between 24 to 23cm when there is a marked decrease in the values of birch, hazel and alder pollen (Illus. 1). A slight rise is seen in the pollen values of oak, which increases from a rare type to begin a continuous pollen curve. It is likely that this rise in oak pollen reflects an increase in pollen into the catchment due to the decline in other arboreal pollen rather than an actual increase in the number of oak trees in the landscape. Similarly following this decline in overall arboreal pollen there are also appearances of elm, pine and willow pollen. This decline in tree pollen is accompanied by a rise in heather pollen, which increases from 5% to 35% TLP from 25 to 23cm (Illus. 1). The high values of HdV-10 spores, which relates to fungi that grows on the roots of heather (van Geel, 1976; van Geel and Middeldorp, 1988) in the pollen assemblage indicates that heather was present locally at the pollen sampling location prior to this increase in heather pollen, indicating the pollen reflects a more widespread rise in heather across the landscape. There are also increases in the representation of other heath vegetation accompanying the rise in heather such as heaths, bog myrtle and crowberry. The NPP assemblage also indicates the occurrence of other potential vegetation, within the heath communities. HdV-16A, HdV-16B and HdV-16C are present as both rare values and as continuous curves and indicate the presence of purple moor grass (*Molinea caerulea*), while the occurrence of HdV-18 suggests the presence of cottongrass (*Eriophorum vaginatum*) communities (van Geel, 1976; van Geel and Middeldorp, 1988). Increased values of HdV-120 are also recorded during the period of heathland cover and it is likely this spore also relates to the *Conidia* family (Pals *et al*, 1980) and thus related to a local presence of heather. This rise in heather and establishment of heathland vegetation appears to take place earlier than in other pollen studies across the region, which have been recorded across varying time periods, for example at Loch Maree, Wester Ross this rise in heather (to c. 20% TLP) took place at around 1900 BP, whilst at Badentarbet, Highlands a similar rise was dated as occurring at approximately 940-730 BP (Birks, 1972; Bunting and Tipping, 1997). However, it does occur at a similar period as that recorded at Loch Clair, where a heather rise took place sometime between 3410 to 2750 BP (Pennington *et al*, 1972).

At the same time as the decline in trees and rise in heather takes place there is a rise in disturbance indicators such as ribwort plantain, which can be seen to have a sharp increase from 25 to 23cm and then maintains a steady presence in the pollen assemblage of c. 8-15% TLP. Other disturbance indicators seen to rise during this phase include chicory, plantain sp. (*Plantago* sp.) and Michaelmas-daisies (Behre, 1981). All of these taxa are also associated with arable land and it is during this phase that the first cereal pollen is recorded in the assemblage with the appearance of barley-type pollen at 24cm and 23cm. Cereal pollen is absent in the previous studies from Wester Ross, which may be due to these studies having taken place at a distance too far from settlements and agricultural activity to have picked up such signals in the pollen record. The presence of cereal pollen and other arable taxa occurring at the same level as the decline in tree pollen implies that the woodland in this location may have been deliberately felled by people to create areas for arable farming. The large microscopic charcoal values across all size fractions indicates burning activity was taking place near to Achtercairn 3 as well as in the wider landscape and is thought to be representative of anthropogenic activity rather than natural causes. Local burning activity is also signalled by the presence of burning indicators HdV-1 and HdV-3B in the NPP record van Geel 1976; Innes and Blackford, 2003), the latter particularly prominent between 27-23cm (Illus. 1).

That wood was being burnt is evident from microscopic charcoal with enough structure preserved to be able to identify as wood charcoal (e.g. surviving scalariform plates) recorded in the pollen record at 25-24cm (Illus. 1). The microscopic wood charcoal was able to be identified as birch/alder and hazel therefore suggesting that some of the woodland was either felled by burning or that felled wood was used as wood fuel. The identification of alder charcoal in both the charcoal spread associated with the Late Neolithic cobbled surface and charcoal recovered from under the 'wall' of the stone circle at Achtercairn 3 would imply that the felled wood was used for wood fuel and that these reduced areas of woodland were returned to as a source for fuel in the Middle Bronze Age. This continuation of burning activity is also implied by the microscopic charcoal record, with values remaining high across all fraction sizes throughout the pollen sequence of Zone 1 (Context 7.2) and into Zone 2 (Context 7.1) (Illus. 1).

Charcoal identifications from the Late Bronze Age roundhouse Achtercairn 2 would suggest that these areas of scrub and wet woodland survived into this period. The charcoal fragments showed an assemblage comprised mainly of alder and birch, together with smaller numbers of hazel and pine (Illus. 3) (Robertson, 2013). A fragments of alder charcoal from this assemblage produced a radiocarbon date of 896-799 cal BC (GU-30616) for this phase of burning activity. The charcoal assemblage reveals a data set slightly at odds with that of the pollen data from Achtercairn 3. Both assemblages indicate a presence of birch and alder in the landscape; however the charcoal assemblage shows hazel was hardly used as a fuel source suggesting that there may have been a further decline in hazel in the landscape or else birch and alder were deliberately preferred to hazel as fuel sources. Pine is only present in small amounts in both assemblages suggesting it was probably scarce within the immediate landscape.



Illus. 3 – Charcoal identifications after data produced by Robertson (2013)

There is evidence for the presence of grazing animals throughout the pollen sequence suggesting the keeping of livestock in the area around Achtercairn 3. From 26cm upwards through the profile there is evidence of animal dung from the consistent presence of dung related fungal spores HdV-55A/B and HdV-112, together with appearances of HdV-52A and HdV-52C (animal hairs) (van Geel, 1976; van Geel *et al*, 2003). HdV-55A/B has also been linked to the presence of decaying wood (van Geel, 1976); however given the decline in arboreal pollen and the low representation of other dead wood indicators in the assemblage it is more likely this instance to be related to animal dung. A small number of grazing indicators are also present in the pollen assemblage, such as cinquefoils which form a continuous curve from 24cm (Illus. 1). Bracken has also been linked to grazing (Innes and

Blackford, 2003) but is consistently present throughout the pollen sequence with no peaks occurring at the same time as increases in the NPP dung indicator assemblage, suggesting it is more likely to be a constituent of the heath vegetation; although this does not rule out the grazing of livestock on these areas.

Evidence for arable activity recommences in the upper part of the pollen sequence, with the reappearance of barley-type pollen at 19cm and at 17cm across the top of Context 7.2 and base of Context 7.1 (Illus. 1). Despite the absence of cereal pollen between 23-19cm, this only corresponds to one level of pollen (21cm) and it may be that this lacuna in cultivation activity is a reflection of the pollen levels counted rather than an absence altogether of arable activity during this period. The identification of barley-type pollen across Late Neolithic and Early Bronze Age contexts, suggests it is likely to represent the cultivation of naked barley (*Hordeum vulgare var nudum*), charred grains of which have been recovered from sites of these periods across Scotland (e.g. Bishop *et al*, 2009; Timpany, 2014). The continued high values of ribwort plantain, together with chicory, Michaelmas-daisies and plantain sp. suggest the presence of arable land throughout this period. Other arable pollen indicators are also present including buttercups, carrot family (*Apiaceae* sp.) and chamomiles (Clapham *et al*, 1962; Stace, 2010). It appears likely that arable activity, together with the keeping of livestock took place from around 25-24cm to 17cm in the Achtercairn 3 sequence.

5.2 Achtercairn 2; c. cal AD 1485-1649

The pollen assemblage from Achtercairn 2 has been dated to the post-medieval period from a radiocarbon date of the peat at 3cm providing a date of cal AD 1485-1649. Therefore the pollen assemblage does not relate to the archaeology of the roundhouse. Despite this the pollen is nonetheless interesting as it provides landscape information for a period of which there is little existing pollen information.

The overall pollen catchment for this sequence is likely to be quite small, given the sediments are accumulating near a scrub woodland environment for the majority of the sequence. It has been suggested that the catchment area for such sequences is that of tens of metres rather than hundreds (Mitchell, 1988). The woodland canopy will also act as a filter for pollen and thus during periods of high arboreal (trees and shrubs) pollen counts the pollen signal from the catchment will again be quite local (Tauber, 1965; Odgaard, 1999). Therefore the pollen signal is dominated by local scrub woodland taxa and in particular those of birch and hazel, which may be over-represented as they are known abundant pollen producers (Birks and Birks, 1980; Bennett and Birks, 1990).

The overall pollen assemblage from Achtercairn 2 shows that birch-hazel scrub woodland was already well-established in the landscape prior to the commencement of this pollen sequence and therefore must have recovered significantly since the Middle Bronze Age assemblage of Achtercairn 3. As noted above, both of these tree types are abundant pollen producers and therefore the high pollen values of these taxa may to some extent mask vegetation changes that are taking place in the wider environment. However, as we are mainly interested in the local environment around the Achtercairn 2 hut circle then this information should still be relevant for this study. A local presence for these two tree types is also signalled by the presence of HdV-114 (scalariform plates) recorded in both zones (Illus. 2), which were identifiable as birch/alder (more likely birch based on the pollen evidence) and hazel. HdV-114 indicates that wood debris, such as dead wood from these tree types was present on the sampling site, decaying into the sediment (Pals *et al*, 1980; Schweingruber, 1990).

The tree and shrub pollen data also indicates that oak and alder both had a significant presence in the landscape (allowing for over-representation) and may have been present locally. Alder would again have been present in the wetter areas, such as fringing the burn, to the north west of the hut circle that runs down to the bay. Willow is also likely to have been present within this wetter area and may also be under-represented in the pollen assemblage due to it being insect-pollinated (Moore *et al*, 1991). It is within this location around the burn that other vegetation signalled in the pollen diagram were also growing such as stream-side plants like starry saxifrage, golden saxifrage (*Chrysosplenium*-type), hog's fennel (*Peucedanum palustre*-type) and alpine saxifrage (Clapham et al, 1962; Stace, 2010).

Despite the large arboreal and shrub pollen values the scrub-woodland was probably quite open and this is signalled by the range of herbaceous pollen types present (Illus. 2). The field layer for this woodland is seen to have been quite wet, particularly during Zone 1 as it grew on the peaty silt layer and this is indicated by the presence of herbaceous taxa, which grow in marsh and wet woodland environments such as cowbane, ragged robin (*Lychnis*-type) and marsh marigold (Clapham et al, 1962; Stace, 2010), which are confined to this layer. The continued presence of damp ground and wet wood indicators within Zone 2 suggests that although ground conditions were probably drier than in Zone 1 they would still have been wet during the transition and formation of the monocotyledon peat. These taxa include St John's wort (*Hypericum* sp.), cinquefoils, marsh violet, devils-bit scabious and meadowsweet, together with ferns (Clapham et al, 1962; Stace, 2010). This form of open, wet scrub woodland is a common feature from other pollen studies that have been undertaken in the region, such as at Loch Maree and Loch Claire, Wester Ross (Birks, 1972; Pennington *et al*, 1972) and Badentarbet, Highlands (Bunting and Tipping, 1997).

A distinctive feature of the pollen assemblage in Zone 2 is the rise of heather pollen from 6cm onwards (Illus. 1) indicating the spread and development of heathland in the area. An increased presence of crowberry, heaths and bog myrtle are also indicative of the development of this vegetation community (Clapham *et al*, 1962; Stace, 2010). The rise in heather pollen is accompanied by a rise in the number of HdV-10 spores, which again relates local growth of heather at the sampling site (van Geel, 1976; van Geel and Middeldorp, 1988). The appearance of HdV-20 within Zone 2 is also suggestive of a local presence of heather (van Geel, 1976; Kuhry, 1985). An increase in the presence of Types HdV-16A, HdV-16B and HdV-16C may also indicate an increased presence in purple moor grass, whilst the presence of cottongrass is inferred from the occurrence of HdV-18 both are associated with heathland communities (van Geel, 1976; van Geel and Middeldorp, 1988).

Towards the top of Zone 2 at 3cm there is a decline in tree pollen notably that of birch, together with alder, while there is a slight rise in the pollen of hazel, together with an overall increase in the pollen of herbaceous taxa (Illus. 2). This suggests that there has been a reduction in the amount of scrubland in the area and increase in more open ground together with that of heathland. It is at this point in the pollen diagram that evidence for human-environmental interaction within the landscape appears. The decline in arboreal pollen is accompanied by a cross-fraction rise in microscopic charcoal, particularly within the 1-21µm fraction. This increase in burning activity around the site is reflected by the appearance of NPP types HdV-1 and HdV-3B, which have been linked to localised dry conditions caused by burning (van Geel 1976; Innes and Blackford, 2003). The appearance of cow-wheats (*Melampyrum*-type), a herb that is also associated with dry conditions provides another indicator for local conflagration events (Simmons, 1996). An anthropogenic cause for this burning activity appears to be extremely likely given that it is during this phase of activity that disturbance indicators such as mugwort, chamomiles and ribwort plantain (Behre, 1981). It is from this level that cereal pollen is also present with the occurrence of barley-type pollen, accompanied by a slight rise in the pollen of grasses (Illus. 2). The barley-type pollen within this phase of activity it likely to represent hulled barley (*Hordeum vulgare*) of either the 2-row or 6-row variety (the latter including Bere barley), which has been evidenced as being cultivated in post-medieval assemblages from Scotland (e.g. Timpany and Haston, 2011). There is evidence of cereal cultivation more regionally within the post-medieval period from the study at Badentarbet, Highlands with agricultural activity taking place in a largely open landscape of grassland (including arable land) and heath, although still fringed by scrub woodland of birch, alder and hazel (Bunting and Tipping, 1997). A field system present on the first edition of the OS 6-inch map for this area from 1881 to the north of the roundhouse (RCAHMS, 1996) indicates agricultural farming was practiced during the later post-medieval period in this landscape and highlights the possibility of similar field systems being in use previous to this. Additional Shieling huts and farm boundaries have also been mapped in this area during the course of the field investigations.

There is some indication for the presence of grazing animals around the area of Achtercairn 2 throughout the period covered by the pollen assemblage from the presence of animal hairs (Hdv-52) observed within the pollen levels (van Geel, 1976), which are seen to peak at 3cm; during the period of increased anthropogenic activity. Unfortunately no fungal spores associated with dung were recorded from these levels, but herbaceous taxa that have been linked to grazing activity such as cinquefoils and bracken both increase during this period, while others such as devils-bit scabious are an ever-present in the assemblage (Innes and Blackford, 2003). There is a slight increase in the presence of nitrophilous taxa such as nettles towards the top of the zone, which may also signal a presence in dung (Stace, 2010). An increase in eutrophic conditions locally is signalled by the recorded rise in HdV-181 within the NPP assemblage (van Geel *et al*, 1983), which may again be associated with an increased animal presence; this type may also indicate the presence of shallow pools of stagnant water, although there is an absence of aquatic pollen evidence for such pools. Therefore there is some tentative evidence for the presence of livestock around Achtercairn 2, during the period of increased burning and cultivation activity.

6. Conclusions

- Pollen analysis of the kubiena tin sub-samples has shown that pollen is present in all levels, with pollen preservation being generally good and abundant within the Achtercairn 2 sequence but within the Achtercairn 3 sequence becomes more degraded and sparse in the lower levels of the sequence, which are less waterlogged than those above.
- The pollen assemblage from Achtercairn 3 corresponds with two phases of archaeological activity. Phase 1 of Early Neolithic date associated with a cobbled surface and burning activity and Phase 2 of Middle Bronze Age date associated with the circular stone 'wall'.
- The pollen assemblage from Achtercairn 3 shows an initial landscape of scrub woodland and grassland with some heath is replaced abruptly by heath and grassland communities following the decline of the woodland.
- The appearance of cereal pollen and high values of microscopic charcoal corresponding with the decline in woodland at Achtercairn 3 suggests deliberate removal of woodland by people for arable activities. Macroscopic charcoal suggests wood from the felled trees was used for fuel.
- The NPP assemblage for Achtercairn 3 indicates that livestock was also present from the occurrence of dun-related fungi and animal hairs.
- The Achtercairn 2 sequence was dated to the post-medieval period, much later than was expected.
- The pollen assemblage at Achtercairn 2 is dominated by that of birch and hazel, which may be over-represented leading to the masking of more subtle vegetation changes in the landscape and indicates the recovery of woodland in this area following the demise recorded in the Achtercairn 3 sequence.
- Anthropogenic activity is observed in the pollen record from 3cm onwards within the Achtercairn 2 sequence, signalled through an increase in burning activity, some loss of woodland and the appearance of cereal pollen, which indicates the cultivation of hulled barley.

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Achtercairn, Gairloch 2, Pollen Diagram

Analyst: S. Timpany

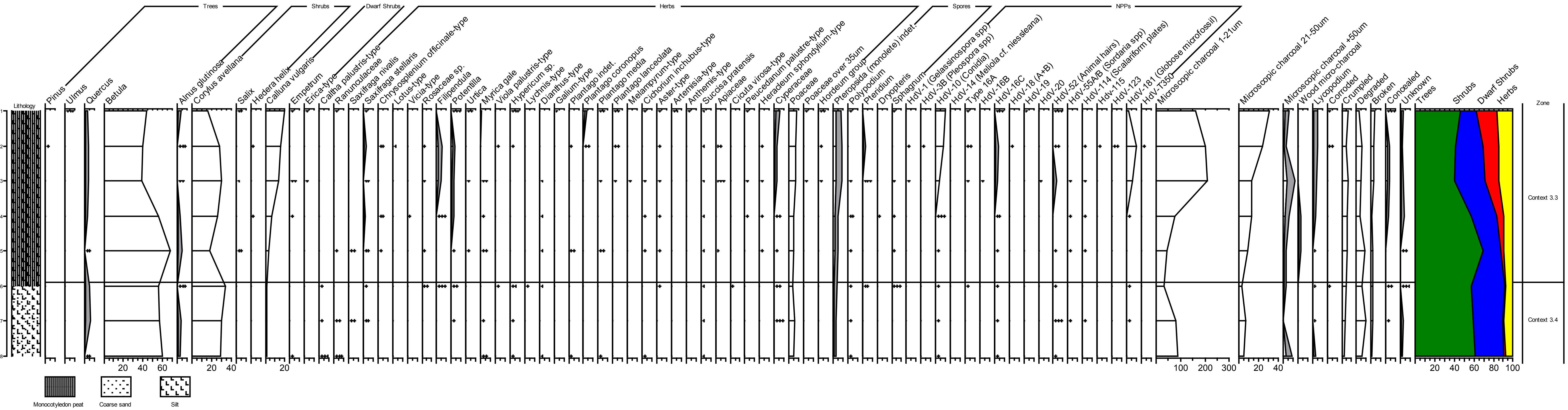

Illustration 2 - Achtercairn 3, Gairloch, Pollen Diagram
Analyst - Dr Scott Timpany

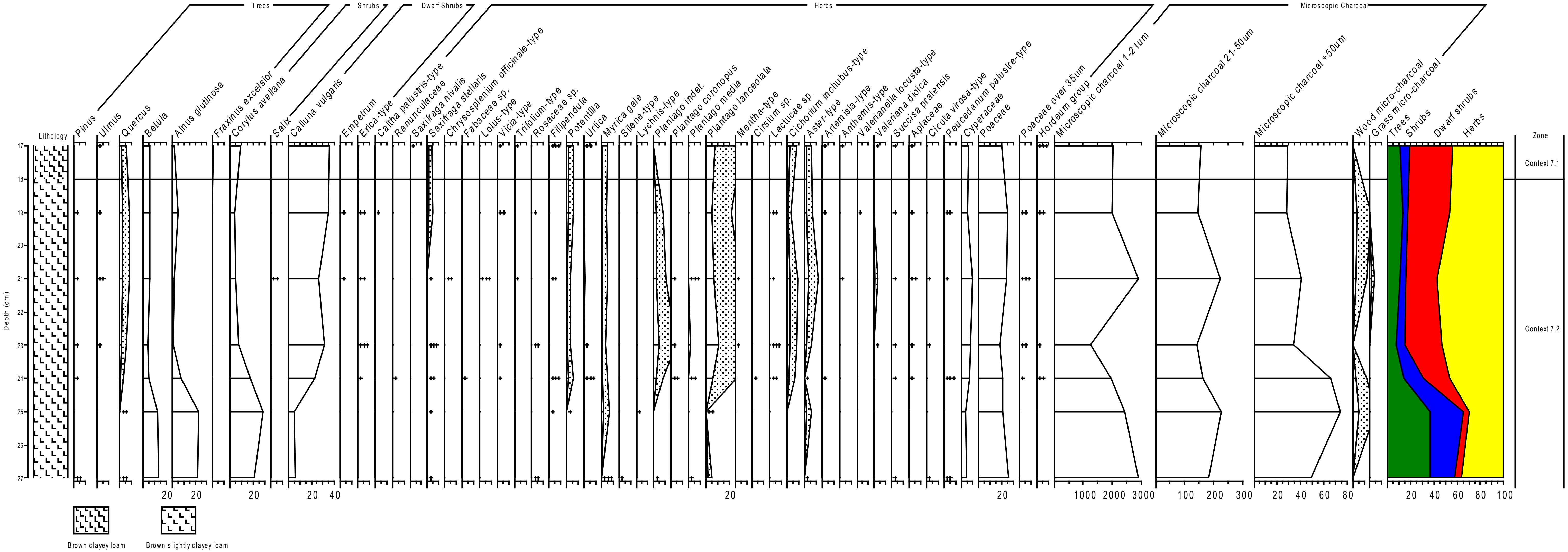

Illustration 2 - Achtercairn 3, Gairloch, Pollen Diagram

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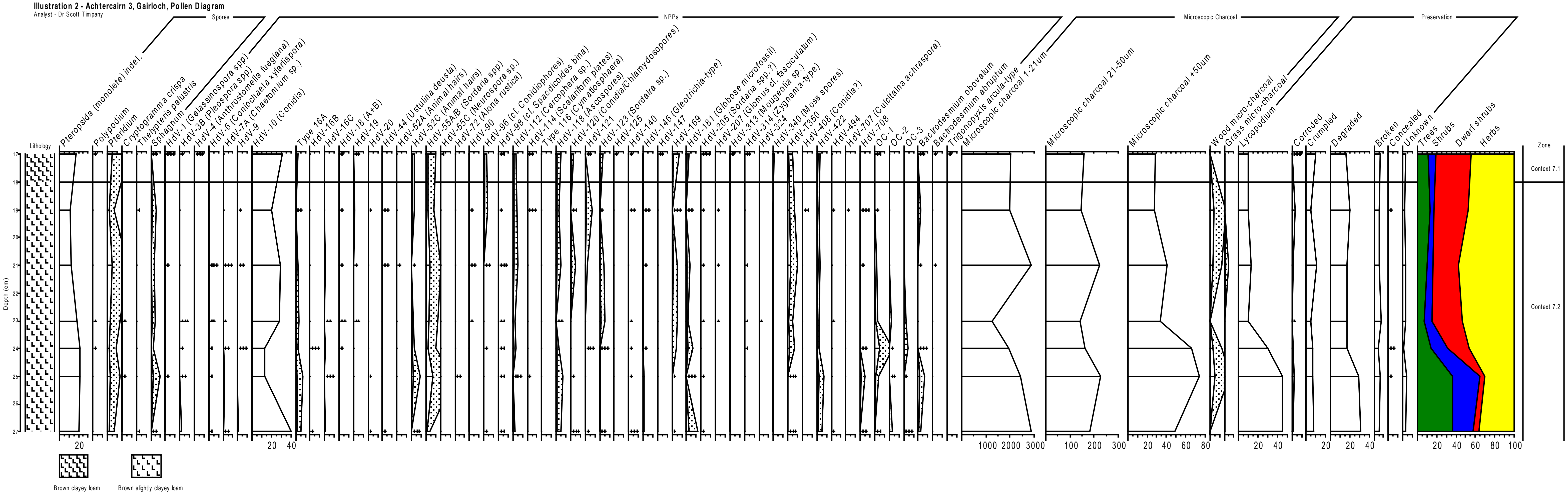

Assessing the effectiveness of multi-element analysis techniques in identifying past human activity at an Iron Age roundhouse in Wester Ross

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Signed ____

Sophie Curran

22/04/2013

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Abstract

Until recently, archaeology has based the identification of human occupation almost entirely on physical remains and artefact recovery, with a lesser focus on soil element concentrations. The enrichment of certain trace elements can be preserved in soils for long periods of time, serving as indicators of past human activity. Multi-element analysis techniques such as ICP- AES (inductively coupled plasma atomic emission spectroscopy) can determine the concentrations of up to 60 individual elements to trace levels of parts per million. Along with ethnographic and environmental data, this technique can help identify and determine site function or space use within archaeological structures. Studies from the literature focus primarily on comparisons between known context sites and historical records in order to accurately access the ability of ICP-AES. In this project, soil samples and site environmental information was collected from an Iron Age roundhouse in Wester Ross in order to provide an insight into site activity during its occupation, allowing for a better understanding of the people who lived there. Patterns of element enhancement across the site were identified for phosphorus (P), magnesium (Mg), manganese (Mn), boron (B), copper (Cu), cadmium (Ca), sodium (Na), aluminium (Al), chromium (Cr) and iron (Fe). Although enhancement does occur, there are no consistent trends between element signatures and their distribution, to accurately determine site activity. This study proves multi element analysis is effective at determining chemical elements however, it has not provided any additional information out with that of traditional archaeological techniques to help identify roundhouse function.

Contents

Introduction

Background to multi-element analysis

Humanity's inquisitive nature has driven the need to explore and understand the history of past societies. The purpose of archaeology is to find, preserve and examine human evidence throughout time, with an emphasis on artefact discovery (Shanks, 2013). These artefacts often take the form of structural remains, bones, tools, jewellery, weapons and pottery, which have been used in: building; food consumption and preparation; defence and weapons; ceremony and ritual (Jones, 1993). Artefact 'finds' are, and always will be, a fundamental aspect of archaeology (Schlezinger and Howes., 2000). However, movement towards more sophisticated analysis and procedural rigour, with a greater emphasis placed on quantitative analysis, probability sampling and the involvement of many inter-disciplinary arenas is now apparent (Dunnell, 1978). The development of soil science has brought new scope to examining archaeological sites, as precise data on soil chemistry and its characteristics is now obtainable. Multi-element soil analysis techniques are now an integrated part of modern archaeology used to aid the identification of interested prehistoric sites (Wilson et *al*., 2008; Middleton, 2010; Milek and Roberts, 2012; Drix *et al.,* 2013). In this study a multi-analytical approach including archaeological, magnetic and geochemical prospection was selected to study an Iron Age structure in Northwest Scotland.

Human occupation can significantly alter local environments over time and evidence of this may still be found in the physical stratal and chemical signatures of soils. Thus, archaeological habitation sites are likely to have been chemically altered by humans from that of the original natural soils (Misarti *et al.*, 2010). Chemical signatures of former land use can remain well preserved in soils and sediments in environments such as floodplains, caves, lakes and soils (Cook *et al*., 2006).The relationship between soil chemistry and archaeology is described by Oonk *et al*.(2009) as the 'enrichment and depletion of specific elements in the soil through the act of human occupation and activities'.

The discovery was first made by Olaf Arrhenius, who noted elevated phosphorus (P) in soils indicated human occupation as its widespread occurrence in plant tissue, bones, faeces, urine, and ash made for easy detection (Arrhenius, 1929; Middleton, 2004). Phosphorus (P) analysis techniques became common (as its distribution could be mapped across areas) helping to aid the identification of human activity on archaeological sites (Provan, 1971; Conway, 1983; Schlezinger and Howes, 2000). Only in the 1960's was more emphasis placed on analysing a wider range of chemical characterisations due to an improvement in extraction techniques (Cook &Heizer, 1962; Middleton, 2004). A greater interest is now placed on elements such as copper, iron, mercury, manganese, nickel, lead and zinc (Bintliff *et al,* 1990; Entwisel *et al,* 1998; Wells *et al*., 2004).

Multi-element analysis techniques, including inductively coupled plasma atomic emission spectroscopy (ICP-AES), inductively coupled plasma mass spectrometry (ICP-MS) and X-Ray fluorescence (XRF), are relatively quick and cost-effective practices that analyse a suite of chemical elements. Their purpose in archaeology is to locate and define sites (prospection) or to clarify more specific functions of sub-areas such as floor plans, agricultural land, and byres (Middleton, 2004; Wilson *et al*., 2007). Many factors contribute to the selection of an analytical method, these involve: Sampling logistics, number of samples to be measures, concentrations of samples to be measured, cost of analysis, time required to generate results or the precision and accuracy require in within each sample (Alloway, 2013).

The overall presence of accumulated elements in soils is important. However, it is the distinction between one site and another which provides information connects the site use and function. Element analysis techniques allow for a large suite of elements to be analysed from a small sample of soil (0.25g) resulting in only minor site disturbance. The equivalent procedure undertaken to retrieve site information includes numerous costly explorative test pits, which drain time and resources, often with little data in return (Misarti *et* a*l*., 2010).Excavations are intrusive practices which result in permanent soil change and physical damage. However it should be noted that in some cases, a key aim of archaeological investigations is to limit site disturbance. Often it is unfeasible to test pit in some sites and so multi-element analysis could provide vital information that cannot otherwise be collected (Misarti *et al.*, 2010).Barbra (1992) analysed the small scale range of chemical elements which produced positive detection results individually. However this technique required tremendous effort, and so ICP-AES analysis development is a positive contribution to archaeological site studies as it can deliver similar results in a fraction of the time.

For multi-element analysis to show any noteworthy results, certain criteria must first be met. Initially, soil content must have been influenced by human existence, resulting in a marked increase in element concentrations above the natural background level. Of the altered soil, the elements must then remain fixed over an extensive period of time in order to be identified (Entwistle *et al*., 1998). The preservation of chemical elements in the soil is dependent on soil type and associated soil processes, underlying geology, site use and post depositional material. If the soil conditions are favourable the deposition of elements from domestic, agricultural or industrial capacities may be preserved, as well as material deposits that have been purposefully or unintentionally placed within the soils (Wilson *et al.,* 2009).Anthropogenic loading of the soil may have been influenced by the remains of food, hearth ashes, byres, domestic residues, industrial processes, craftwork and manuring (Wilson *et al*., 2009). A host of elements including Phosphorus (P), Magnesium (Mg) Lead (Pb), Mercury (Hg), Potassium (K) Calcium (Ca), Cadmium (Cd), Strontium (Sr), Titanium (Ti), Thorium (Th), Zinc (Zn) can all be found in elevated levels within archaeological soils.

Previous archaeological applications of multi-element analysis

An attempt to isolate chemical enrichment and chemical variation in soils to determine anthropogenic activity has occurred at many sites around the world (Griffith, 1981; Misarti *et al*., 2010; Parnell *et al*., 2002; Entwistle *et al.,* 2000; Wilson *et al.*, 2005, 2008; Marwick., 2005). Griffith, (1981) studied soil samples of a former 17th century Indian village at Ontario, Canada. Through chemical analysis he identified a significant distinction between site areas, enabling site function to be determined. In this study elevated phosphorus (P) and exchangeable magnesium (Mg) allowed for a better soil element distinction to be made between former paths and pits, post moulds and longhouses. Parnell *et al.* (2002) also found alongside P and Mg, barium (Ba) and manganese (Mn) could be associated with waste disposal areas such as byres. In addition, craft production areas could be associated with mercury (Hg) and lead (Pb). Elevated levels of gold (Au) have been found in an ancient Mayan settlement (Cook *et al*., 2006). At Greaulin on Isle of Skye, Scotland (Entwistle *et al*, 2000) a study on former habitation sites showed elevated levels of potassium (K) was often associated with occupation, through general use and build-up of material. Thorium (Th) and rubidium (Rb) were strongly associated with habitation areas, while calcium (Ca) and strontium (Sr) were associated with field areas due to the discarding of bone from fish waste or shell sand material (Parnell *et al.,* 2002). Studies by Wilson *et al* (2005, 2007) on the known use of abandoned farm sites across the UK revealed that a number of chemical elements are required to determine an activity or function, as it cannot be accurately defined by one element alone.

Archaeological sites around the world have revealed anomalous chemical element levels that may in fact represent historic anthropogenic activity. Nevertheless, their source may also have formed in a number of ways out-with human influences. The use of results from multi-element analysis and chemical element interpretation to answer important archaeological questions has raised strong concerns. The interaction of element loading within soils over time is relatively unknown, especially with regard to anthropogenic inputs (Entwistle *et al*., 1998, 2000). Chemical element interpretation becomes ambiguous and complex when there is no historic site information available charting the land use through time. Additionally, it is difficult to define soil baseline element levels and natural soil composition in order to discover anthropogenic activity impacts (Matschullat *et al*., 2000). This is because soils are characterised by regional variability, which means a valid generalisation on soil background levels cannot be standardised to fit all soils around the world. In order to define the natural geochemical background levels, a distinction must be made between the natural-compound and anthropogenic inputs (Matschullat *et al*., 2000)

Furthermore, local environmental conditions, topography, soil type, micro climate, vegetation and fertiliser application are all factors that affect the residence time of elements in the soil. There are a great number of geochemical processes which occur within the soil that may alter the retention of chemical elements: adsorption, ion exchange, occlusion, isomorphic substitution, chelation and precipitation reactions, along with factors such as climate, pH, grain and pore size can all contribute towards the reduced preservation of information in archaeological soils (Oonk *et al*.,2009).

The misinterpretation of data can occur due to both sample error and analytical error. At present, geochemistry is limited in understanding how and when these factors take precedence. Additionally, information may be masked during multi-element analysis processes such as ICP-AES. Phosphorus (P) for example, comes in the form of adsorbed P phases, P precipitates and organic P which could individually hold information of archaeological significance (Oonk *et al*., 2009). ICP-AES often, but not always measures total P phases which could hide the true value of ancient inputs into the soil, resulting in sample misinterpretation. Further research is needed in chemical sequential extraction and element interactions to understand mineralogy and chemical composition processes. However, multi-element analysis remains a valuable tool to better our understanding of archaeological sites, particularly when structural remains are no longer visible or present. It provides an opportunity to gain quantitative data to represent the nature of archaeological sites in addition to artefacts and environmental data.

The land and climate in the Scottish Iron Age

The climate in the Iron Age would have been similar to what is currently experienced in Scotland today, if a little warmer. Two stages of vegetation removal occurred, first in the Neolithic period and then during the Bronze Age when extensive tree cover was cleared for building space, agricultural land and use as a fuel source, which ultimately diminished tree cover. Tipping (1997) states that even before the invasion of the Romans in Scotland there were extensive tree clearances in the north - proof that significant clearance had occurred. The Iron Age landscape must be viewed with the Western Isles and Northern Scotland as the central hub of activity - similar to the modern equivalent of Glasgow - as the sea and island landscape was perfect for their daily activities (Harding, 2004). Farming would have been undertaken near to a roundhouse building and proof of this can still be seen in the landscape today. However, the full extent of farming activity is unknown at present even through the use of pollen analysis (Tipping, 1994).

Scottish Iron Age roundhouses

A hut circle, more recently referred to as a roundhouse, is an architectural structure built during the Bronze Age (2450BC-600BC) and Iron Age (700BC-450 AD), in a time of great structural expansion (Armit, 2006). The Scottish Iron Age differs to that of England and Wales as no exact date can be applied across the whole country. Literature suggests a staggered regional change occurred (Piggot, 1966 and Armit, 1997). Hingley (1992) selected an end date of 200AD as it coincides with the known presence of the Romans - even though it is well documented they did not reach Northern Scotland. This date has been artificially placed in connection with the Roman interlude and so the term 'long' Iron Age is often used (Harding, 2004). Table1 highlights the approximated chronological length of the Bronze Age and Iron Age. Defining this period also poses difficulties, as remaining early iron artefacts are limited, with suggestions that iron works would not have been practised alongside settlement areas (Harding, 2004). Similarly, the lack of burial evidence makes it hard to reconstruct simple characteristics of people and their communities (Armit, 1990).

Table1. Approximate Chronology of Scottish Bronze and Iron Age used in this study (ScARF)

Label	Chronological Span
Bronze Age	2450BC-600BC
Early Iron Age	700BC-100 BC
Middle Iron Age	200BC- AD 400
Late Iron Age	AD 300 – 900

A roundhouse encompasses a wide range of circular building styles, including 'simple' comparatively modest roundhouses and more 'complex' Brochs, Wheelhouses, Duns and Crannogs. Archaeologists have expressed extensive interest in these though a focus on the latter 'complex' structures has been more prominent. This is possibly due to their visibility in the landscape and their unique architecture (Armit, 2005). The building of roundhouses is thought to have been influenced by the availability of raw materials, as structures in the West of Scotland were often stone built (evidence remaining), whereas, turf built houses are found in the east and remain difficult to identify. This is due to the intensifying use of agricultural practices, which has removed a large portion of evidence (Armit, 1990). The buildings have a circular or sub-circular shape with a raised bank of soil formed with stones or turf, and range between 4m and 20m in length, sometimes with one or two stone facings. Building designs vary from house to house, but often consist of a thatched roof with the support of large timber posts. Most, but not all, roundhouse entrances face towards the east or south east, and in some cases this would not have been the optimal location for sunlight or protection from the wind.

Roundhouse function

A roundhouse may have been used in a number of ways for habitation, industrial, domestic or ritual purposes. Figure1 is an artist's impression of structural appearance, organisation areas and daily activities. Residence in a roundhouse was first thought to have occurred over a long period of time. However, in a number of excavations evidence of abandonment was noted alongside extensions and repairs (Cowley, 2003, 2009; Halliday, 1999). Abandonment was not uncommon as an abundance of building materials led to the construction of new structures rather than repairing older ones. Furthermore, evidence of seasonal residence has been found on high pasture ground and is thought buildings would only have been occupied for part of the year, as winter conditions would make the site inaccessible (Crone, 2000).

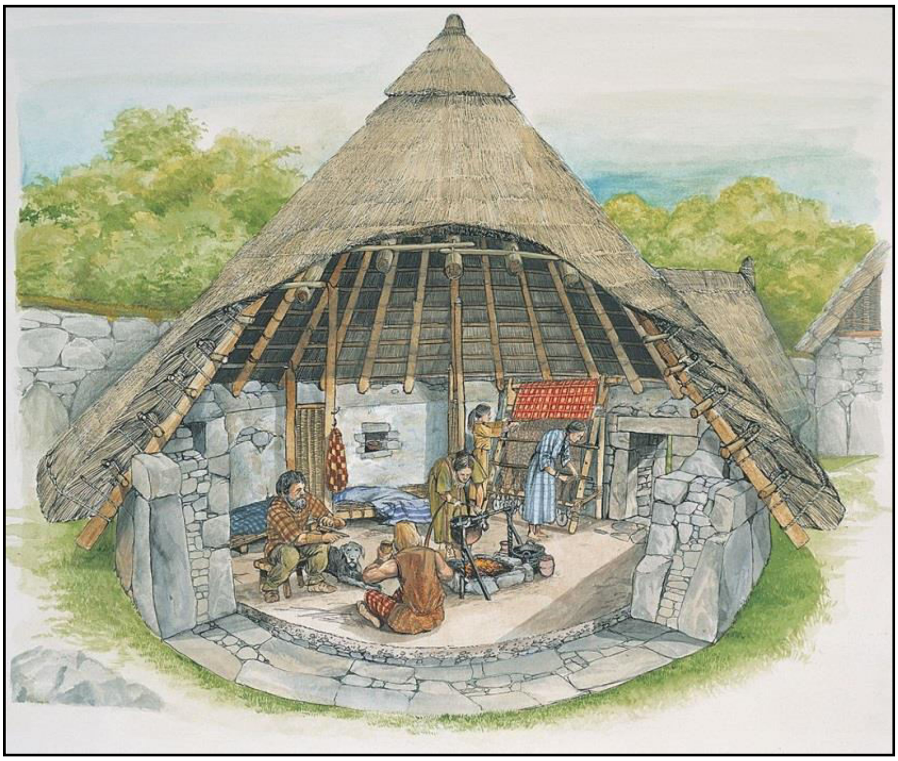


Figure1. Artist's impression of Iron Age roundhouse showing a well-built double faced wall, thatched roof and central hearth, typical of architecture at this time (Steele, 2013).

Further occupational evidence remains across the landscape, byres areas were used to hold animals separately, although 'byre-houses' were found to accommodate both humans and animals in a single enclosure. Industrial-based roundhouses were built to contain craftwork and metal work processes with both kilns and smelting furnaces discovered in excavations (Bradley, 1991; Pearson, 1999; Giles, 2007).The abundance of loose rock scattered across the landscape encouraged the formation of clearance cairns created to make space for agricultural fields. Lazy bed cultivation is still present today and is often found close to roundhouse structures. Ritual is thought to have played an important part in Iron Age culture with burial cairns, symbolic stones and treasured items found within settlement communities. A number of early studies (Wait, 1985; Boast and Evans, 1986; Hingley, 1991; Parker Pearson and Richards, 1994) regarded the orientation and space use division of roundhouses, suggesting life may have been structured by ritual and worship of the sun. Over a period of 10 years cumulative research formed the cosmological model (shown in figure 2), as a way of representing life the ritualistic culture that could have been undertaken by roundhouse dwellers (Haselgrove and Pearson, 2007).

Armit (2006) believes Iron Age communities were entwined in strict social and religious beliefs. The cosmological model (Figure 2) suggests the orientation of the circle was sun-based and could have represented birth to death. Living and sleeping, food preparation and storage or ritual areas were thought to have been organised in sunwise structure (Fitzpatrick *et al*., 1994; Parker Pearson *et al*., 1994). To reinforce this argument, artefact evidence in substantial roundhouses was significantly favoured to the right hand side and included pottery, ash, bone and burnt flint. This theory has, however, faced criticisms (Haselgrove and Pope *et al*., 2007) as the fragmentary nature of archaeological evidence means that it cannot accurately be concluded that ritual and beliefs controlled daily life. Evidence from literature suggests that a lot of information is known about roundhouse construction and function, but less is known about society and community structure that could answer the more difficult questions (Ralston and Edwards, 2003; Harding, 2004).

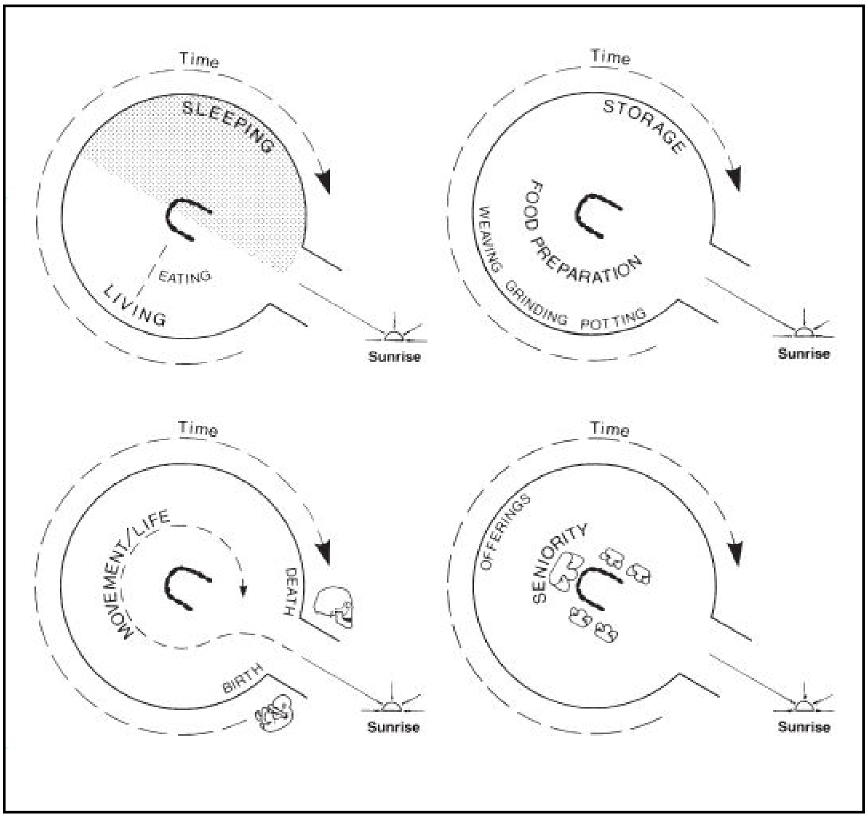


Figure 2. Suggestions as to the function and space use of British Iron Age roundhouses, with Interpretations of the sunwise movement, house layout, a metaphor of the human life cycle and the organisation of ritual and seniority around the hearth (Fitzpatrick 1994, Haselgrove & Pope 2007).

Organisation of areas

The organisational areas of a roundhouse are thought to have been separated depending on its use. Occupied houses may have included a sleeping area, workshop, animal enclosure and food preparation areas, with a hearth based in the centre. It is thought that timber partitions often divided private areas, while the central floor remained open for communal purposes (Armit, 2006). It can be hard to interpret floor space use as daily activities and floor cleaning alters the deposition of materials. Site also commonly experience post occupational influences which can alter the chemical balance of the soil (Armit, 2009). It is often difficult to determine daily activities and functional areas within a floor space even with material evidence available as its presence may be the result of later activity. Well defined floors have been examined at Cnip in Lewis clearly showing the construction, development and final abandonment in the structure and soil phases (Armit and Ralston, 2003; Armit and Ceron-Cerrasco, 2006)

Excavations of roundhouses

There is no published literature of roundhouse excavations in the area of Wester Ross that can be matched against the study site. The siting and recording of roundhouses has been limited to Ordnance Survey, enthusiasts, Forestry Commission and archaeologists. This means many more sites are yet to be identified or surveyed, with the prospect of site excavations even more limited.

A newly discovered roundhouse found in Brodick, Arran, was partly excavated in 2005 due to site preparation of a leisure development. It was well preserved and held particular interest because of its substantial fifteen meter internal diameter (similar to study site) and complex souterrain. Artefacts included two coal rings and a spiral bronze ring, highlighting its use in manufacturing and local craftsmanship, which is suggested to represent a high status settlement in the area (Mudie, 2005).

An excavation at Culduthel Mains Farm on the southern outskirts of Inverness revealed a large Iron Age settlement consisting of seventeen roundhouses, with the largest and most elaborate measuring twenty meters in external diameter (Murray, 2006). Five of the roundhouses contained iron-smelting furnaces identifying the structures as craft-orientated industrial areas. Across the site over 171 iron artefacts were recovered along with wood, decorative objects and leather remains.

A large eighteen and a half meter Late Bronze Age and Early Iron Age roundhouse was discovered in Bancroft, Buckinghamshire by Williams and Zeepvat (1994). It hosted three post-rings and a drainage gully with artefact recovery such as ceramics and pig bones. Webley (2007) compared large roundhouses in Southern England with wheelhouses in Scotland, as artefacts are often found on the right hand side of the floor, relative to activity areas, whilst the left hand side is associated with sleeping and composes of fewer finds. However, artefact placement has not followed this pattern universally across Britain and does not seem to follow a trend from earlier Bronze Age Settlements (Dawson, 2006). Webley (2007) addresses substantial roundhouse structures excavated at Longbridge (Chadwick Hawkes, *unpublished*), Houghton Down (Cunliffe and Poole, 2000) and Dunston Park (Fitzpatrick *et al*., 1995)that were all significant structures (11m-18m) noted to detail artefact concentrations on the left hand side.

Project aims and objectives

This study aims to demonstrate the effectiveness of using multi-element analysis as a tool to identify functional areas within a roundhouse, in order to determine past human activity. This study has two main objectives.

- Analyse soil chemistry to determine past human activity.
- Review and evaluate ICP-AES analysis as a tool to aid the interpretation and prospection of data in an archaeological context.

Methods

Location of study

The study site is a Late Bronze Age/ Early Iron Age roundhouse located in Gairloch, Wester Ross, Ordnance Survey grid reference NN 80599 77130

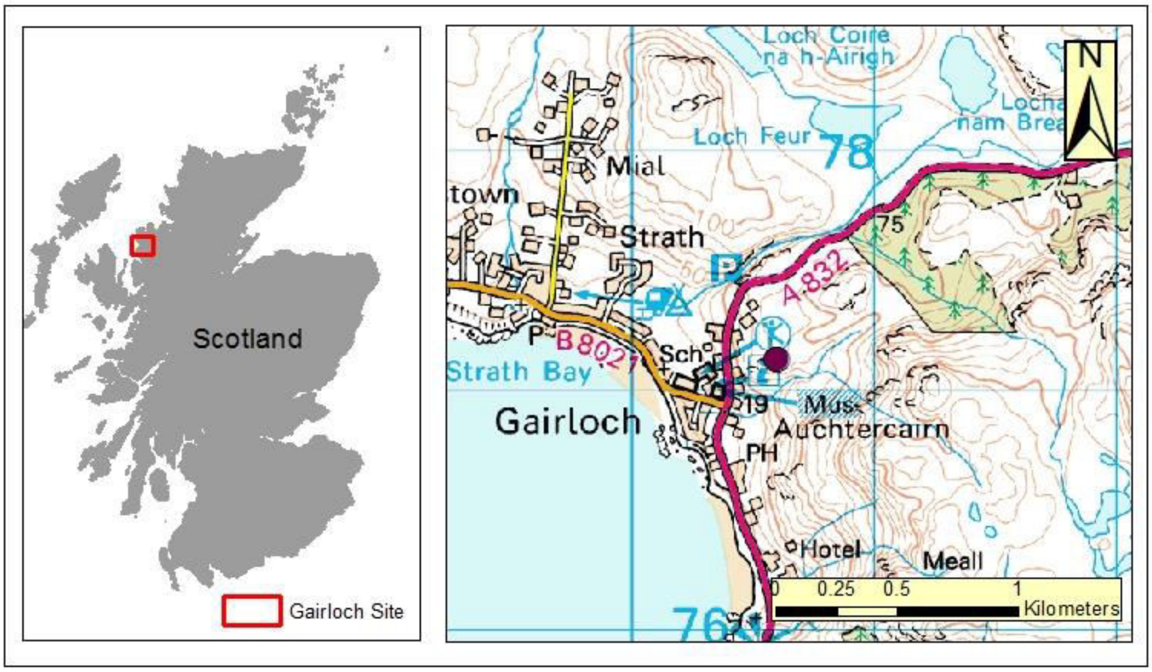


Figure3. Auchtercairn roundhouse located by purple circle (map courtesy of EDINA,2013)

Regional setting

The region of Wester Ross is scattered with the remains of built structures such as roundhouses, brochs and duns. An initial walk over survey considered 'simple' roundhouses in Achiltibue, Strathain and Lochbroom to review the similarities and differences occurring at each site across the landscape. It was noted each site had varying characteristics of size, location and structure, suggesting that roundhouses may not have been solely used for occupation.

Table 2. Characterisation of round structures examined during walk over study.

Location of roundhouse	Construction	Terrain	Entrance Facing	Diameter (M)	Landscape	Present Vegetation	Features
Auchtercairn	Stone build	Flat slope	S/E	17	500m from sea Loch	Heather and bracken	Reddened Soil. Three defined soil layers
Strathain	Stone build	steep hillside	S/E	8	Inland	Grazing	Build on platform. Black floor deposit
Rhue, lochbroom	Stone build	hillside	S/E	10	50m from sea loch	Heather	Possible hearth. Collapsed wall
Achnahaird	Stone build	hillside	N/A	8	5m from seashore	Bracken	Sand Dune lazy bed remains - post glacial soil
Loch Raa	Stone build	hillside	S/E	10	6m from loch	Bracken	Drainage ditch. 3Hearths. Cooking trough

History of Auchtercairn land use

The land above Auchtercairn holds significant evidence of past occupation of varying time periods in the last 3000 years. The settlement as a whole consists of at least 10 roundhouses - varying in size from 6-20 meters in diameter. It comprises an impressive 19th century fank, field and wall systems, evidence of agricultural rig and furrow and old transport roads (See Appendix 1). Today, a major woodland scheme has planted over 2 million native trees on the area in and around this site. Such a diverse, well preserved location has drawn the interest of archaeologists who hope to better understand past human activities in the area.

Study site

The study site is an abandoned Bronze Age or Iron Age roundhouse situated on the south-west slope of Torrna h-Ulaidhe and positioned above the village of Gairloch (OS reference, NN 80599 77130). The roundhouse itself spans 17 meters in diameter with an inside diameter of 13 meters, and is positioned across an area of naturally flattened topography. Evidence of later occupation remains within the north-east quadrant of the circle and was likely to have been a shieling. A similar shaped structure is also located out with the circle to the south-east. This roundhouse holds particular interest due to its large size in relation to structures of the same period that are more commonly smaller built at around 7-10 meters in diameter.

Geology and site environment

The Lewisian Complex form is the underlying metamorphic rock in Wester Ross with meta-basalt of the Loch Maree group (Amphibolite schist) found within the Auchtercairn site. Torridonian sandstone was later deposited over 1200-900 million years ago though this can only be seen as erratic boulders due to glacial action 30,000 – 15,000 years ago. The Wester Ross Re-advancement (WRR) interrupted the retreat of the marginal ice sheets by reforming during an interim period of climate cooling, leaving behind fragmented moraine that defines the limits of the ice sheet movement (Ballantyne and Stone, 2012). After the ice sheets retreated, the surface deposits were removed revealing bedrock, while coastal zone uplift created raised beaches that produced fertile land. An unpublished study by Welti (2011) revealed roundhouse locations are often related to glacial moraine deposit areas, which would have supported crop cultivation and provided a source of building materials.

Field work

The roundhouse was marked out in a grid like system with seven lines positioned in an east-west direction and one positioned north-south. The single north-south line was placed off centre to ensure excavation work on the central test pit was not disturbed. An initial site survey took place to review the magnetism of the soil through a magnetic susceptibility meter, and a hand held GPS was used to locate the exact roundhouse position as it is not marked on an Ordnance Survey map. Auger samples were taken from the top soil to a depth of 0-20cm at one meter intervals along the central lines, thereafter at 2m intervals on the remaining 6 lines. Where large rocks were present the soil sample was taken as close to the area as possible or not taken at all. At the entrance to the roundhouse 10 augers samples were taken and marked on the plain table sheet. Protective gloves were used while removing soil from the ground into sealable bags in order to reduce contamination. Test pits 1 meter x 1 meter were dug to allow soil profile analysis at each level down to the occupation layer or natural ground layer, both in the centre of the roundhouse and positioned 5 meters out with the structure. Up to 5 samples were taken around the central test pit and one sample from each soil layer. A soil trench was also dug across the exterior wall to characterise its construction.

Laboratory work

Soil samples collected from the study site were weighed then air-dried in a greenhouse for 5 days. The samples were re-weighed to calculate the soil moisture content, then disaggregated by a mortar and pestle and individually passed through a 2mm aperture stainless steel sieve to remove stones and larger organic matter. From the prepared samples 16 were selected at random to test the magnetism of the soil using an MS2 Bartington magnetic susceptibility meter, recording the high and low frequency magnetism. To determine soil pH, 20 samples were selected at random and tested in 1 part soil to 5 parts water. Nitric acid (5ml) and 0.25g of soil were digested in a CEM Mars microwave for 1 hour then filtered through Whatman No2 filter paper. Deionised water was added to take the filtrate to 100ml. A Perkin Elmer 3300RL ICP-AES analysed the diluted samples for 24 elements in each prepared solution. Following analysis, all glassware was washed in the dishwasher and rinsed with distilled water. Altogether 107 soil samples were collected and analysed in this project.

In a spread sheet format the soil chemical element values were collated to work out the mean, standard deviation and the limit of detection values. The limit of detection value then represented the background element concentration of the soil, with any tested chemical element values falling below this being discarded.

Data analysis using Geographic Information System (GIS)

The roundhouse site was located on Google images using an OS grid reference then three icon markers were positioned on the image to identify known locations on the map, such as buildings or field boundaries. Using remote sensing software ENVI 4.8 the image was geo-corrected along with the OS map icons in order to accurately locate the roundhouse. This information was imported into ArcMAP10 (details shown in appendix 3). The Google image of the roundhouse was blocky due to the images pixilation and could therefore not be annotated further. A detailed plan of the roundhouse was scanned, geo-corrected and imported into ArcMap10 in order to mark the exact location the soil samples were removed from. The chemical element results from the ICP-AES analysis were attached to the attribute table in ArcMap and more specifically to the associated map sample points. A digital representation of each chemical element across the roundhouse was created.

Statistical analysis

Using Minitab statistical software a Multivariate Factor Analysis test was used to evaluate the outcome of 24 chemical elements. It is designed to transform the original variables into new uncorrelated variables, and displays the variable in a linear format. Factor analysis is a data reduction technique that explains observed variances in the data.

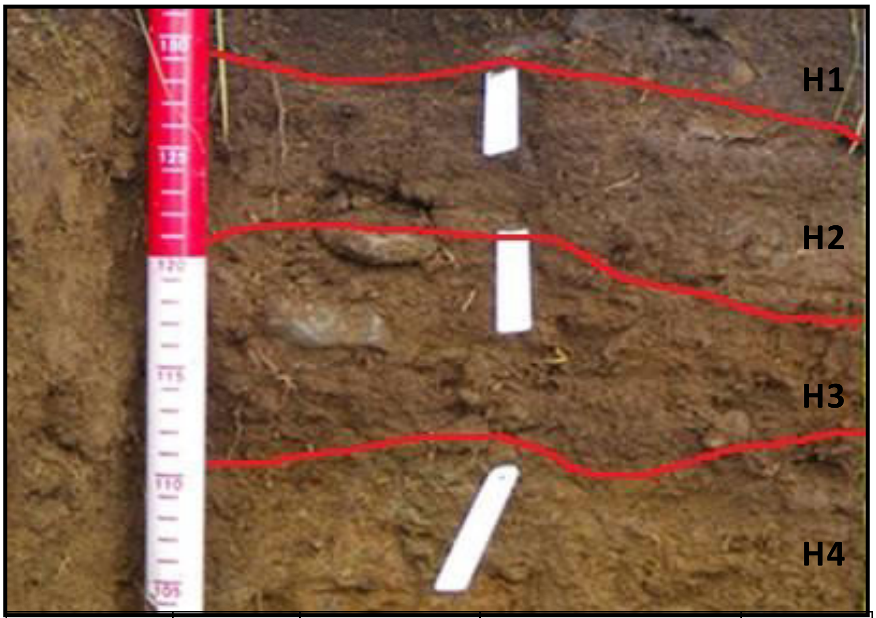
Results

Soil test pits were used as an aid to evaluate the soil profile and its changes over time. They were dug through the anthropogenic based layers down to the 'natural' layer that represents the underlying geology. The aim of this explorative work was to discover buried structures and artefacts, and to better understand the original undisturbed soil processes.

Figure 4. Showing off-site soil pit with horizons marked in white tabs. Associated vegetation cover of heather and rough grass.

Figure 5. Showing roundhouse central pit with stone slabs and evidence of oxidised soil. Surrounded by grass vegetation.

The above figures 4 and 5are annotated photographic representations of the soil profile taken from two 1 meter x1meter test pits on site. Figure 4 is the off-site soil test pit dug 5 meters away from the perimeter of the roundhouse in order to evaluate soil formation through time. The horizons have been marked out by white tabs and show soil formation down to the underlying base level. Similarly, figure 5 represents the on-site central test pit and its associated layers. The photograph is positioned to consider the stone floor and reddened soil. The large stone in the middle of the pit is thought to account for the later built shieling structure.



Horizon	Munsell Colour	Colour	Feature	Stone Size
H1	7.5YR	Brown/ Yellow	Organic matter and roots	limited
H2	7.5YR	Darker Brown	mineral flecks	Small
H3	7.5YR	Loamy Sand	Reddish tinge	Medium
H4	7.5YR	Yellow/Olive	Mottling	Large

Figure 6.Showing off-site test pit and soil layer markers with surrounding heather and grass vegetation. Pit dug down to natural floor layer. Attached is a table with additional information regarding the soil profile.

The soil horizons of the off-site test pit are annotated on figure 6 to highlight the changing soil characteristics over time. H1 is the youngest layer showing the decomposition of organic matter and the presence of vegetation roots. H2 presents a dark soil that is peat forming and contains mineral deposits within the soil. H3 details a lighter brown soil with a red hint to it. The fourth horizon H4 represents the oldest layer with a yellow/olive tinge and mottling soil and the presence of larger unsorted rocks.

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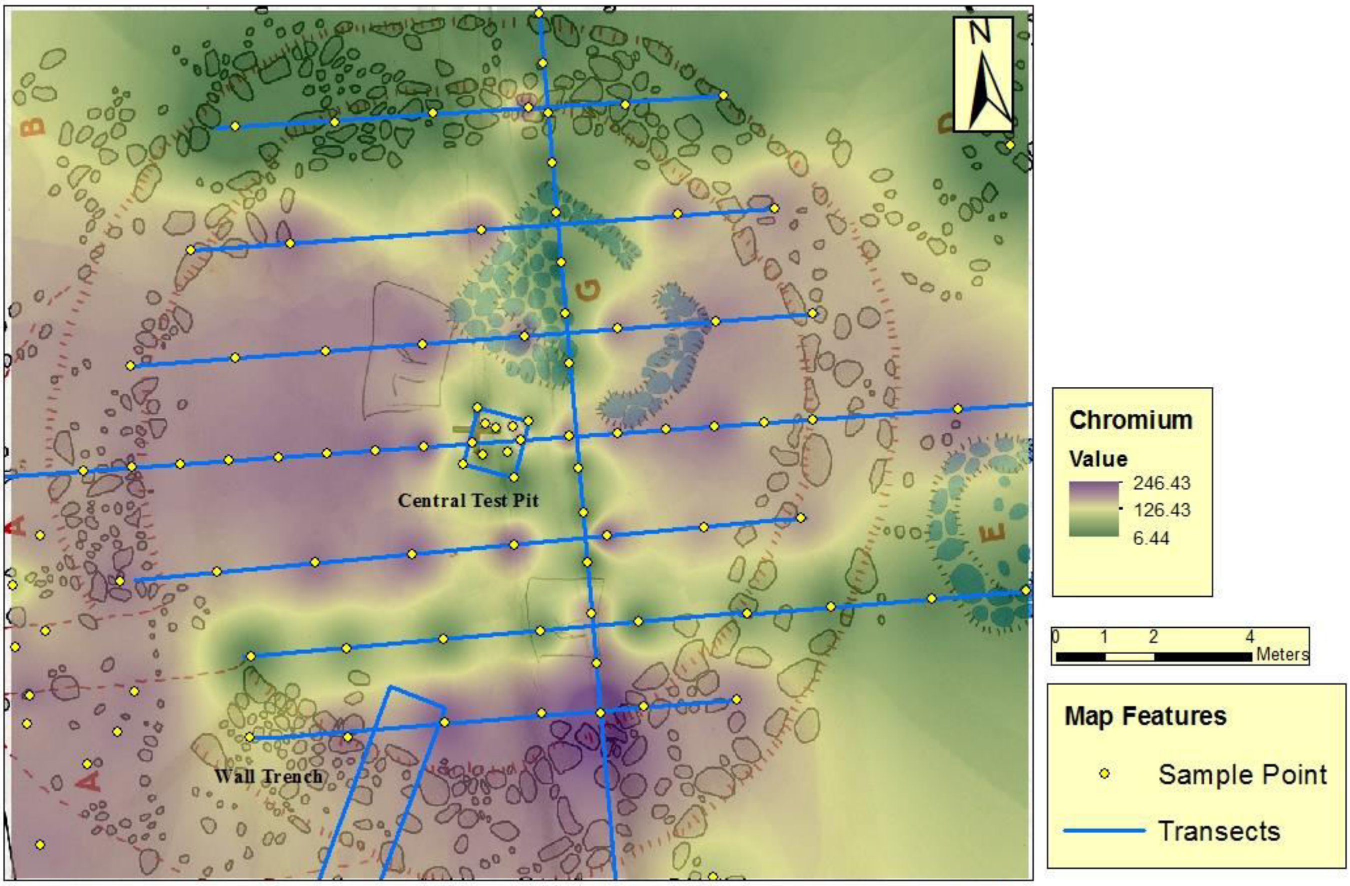
Horizon	Munsell Colour	Soil	Feature	Stone Size
H1	7.5YR	Dark Brown	Roots, bracken matt	Total 20%
H2	7.5YR	Black and loamy	Related to North Shieling	Slab paving
H3	7.5YR	Orange/ Brown	Heat affected stone, ash soil	Large slabs
H4	7.5YR	Compacted Orange clay	Local soil	Medium

Figure 7. Soil profile of the central test pit indicating four horizons down to the natural layer, with an attached table detailing characteristic features of the soil profile.

The central test pit shown in figure 7 shows horizons marked out by a white tab and annotated to distinguish each layer. The youngest layer represents H1 showing a dark brown root and organic matter layer. H2 is a loamy soil and was associated with large flat slabs that could be related to the shieling structure remains still present in the roundhouse. In H3 the soil is an orange and brown colour which could represent the oxidisation of iron minerals, possibly the result of intense heating. The final layer H4 indicates the local soil in compacted clay, similar to that of the off-site floor layer. The results from both soil test pits can be compared against each other to indicate layers influenced by anthropogenic activity and this will be discussed in the following section.

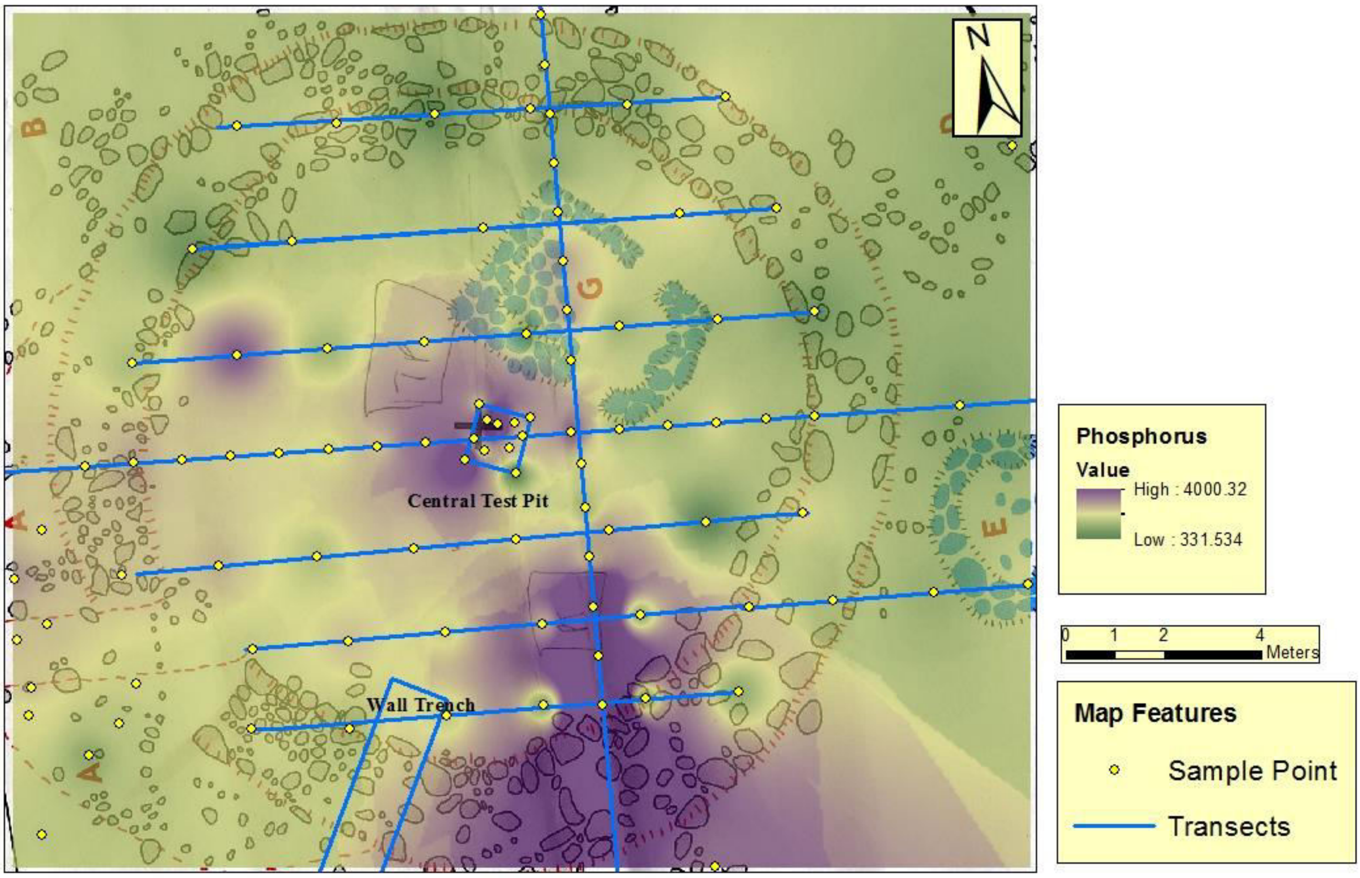
ICP-AES concentration maps

The results from ICP-AES analysis were input into ArcMAP in order to illustrate chemical element concentration variations across the roundhouse floor space. A plan of the roundhouse shape and stone position formed the base layer of the maps. The sample points represent the location of removed soil and all associated data with annotations of the central test pit, wall trench and line transects included. Of the 12 elevated elements 6 are represented in the results and include chromium, phosphorous, aluminium, sodium, copper and boron. Maps 1-6 show a select variety of results that represent the whole range of element concentration results as a clustering of results was found. The elevated concentrations shown on each map are above background levels and vary between elements. Groupings of phosphorus, magnesium, iron and manganese identified highly elevated concentrations in the south-east section within the structure, whereas chromium, aluminium, boron, sodium and copper are distributed in a random pattern throughout the structure. The trends vary in each map and show elevated concentrations. However, they are not significant enough to be able to denote accurate comments on their occurrence and anthropogenic associations.



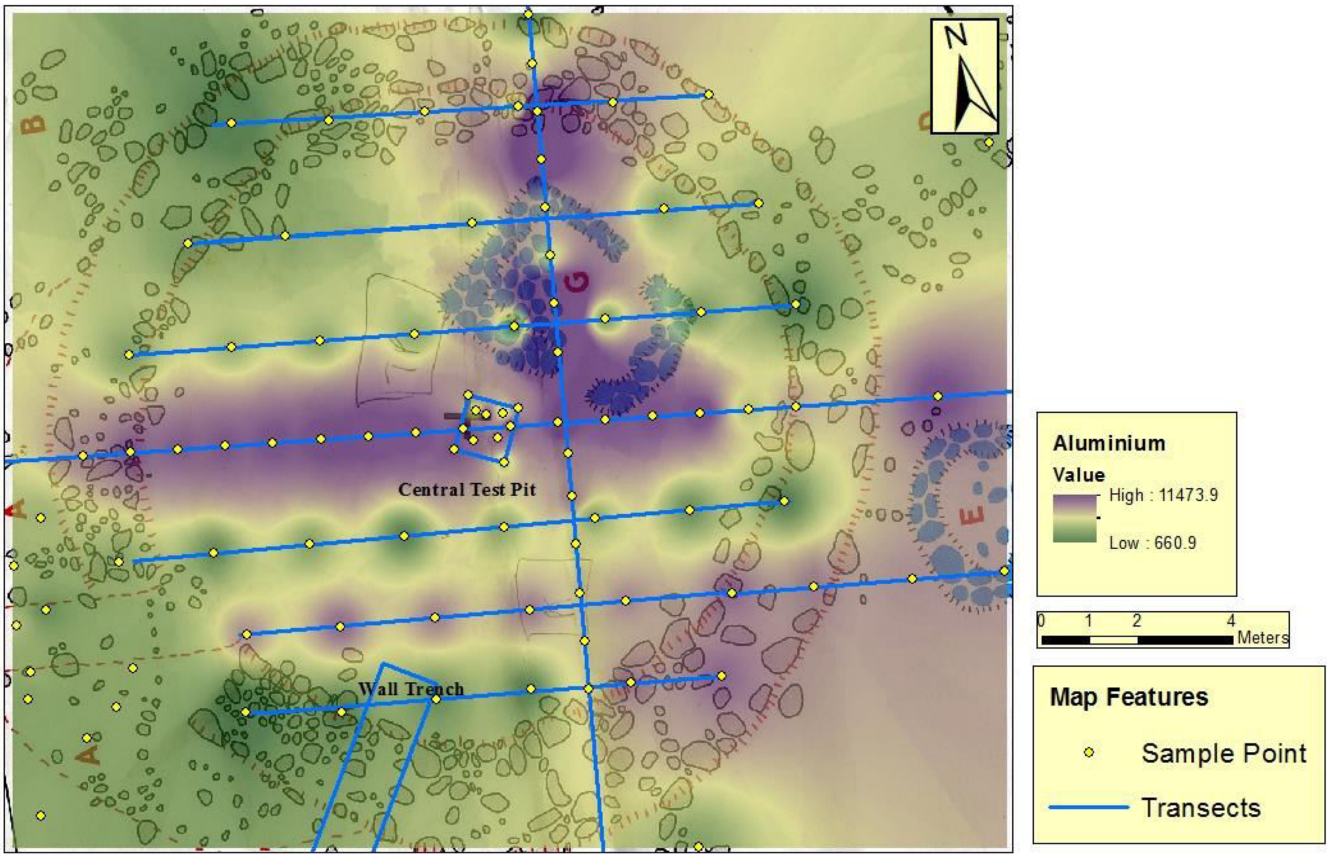
Map1. Detailing the concentration of Chromium (Cr) across the roundhouse structure on a colour ramp of purple (high) to green (low). Soil sample location is shown by yellow point

Chromium (Cr) distribution is concentrated around the entrance points and easterly wall, with the highest value of 246ppm located at the inner wall on the south side of the roundhouse. Low concentrations are found in the centre and northern wall. Although not shown on the map, boron (B) concentrations followed a similar distribution pattern across the site. Overall Cr distribution is quite random across the site as three lines present significantly low values.



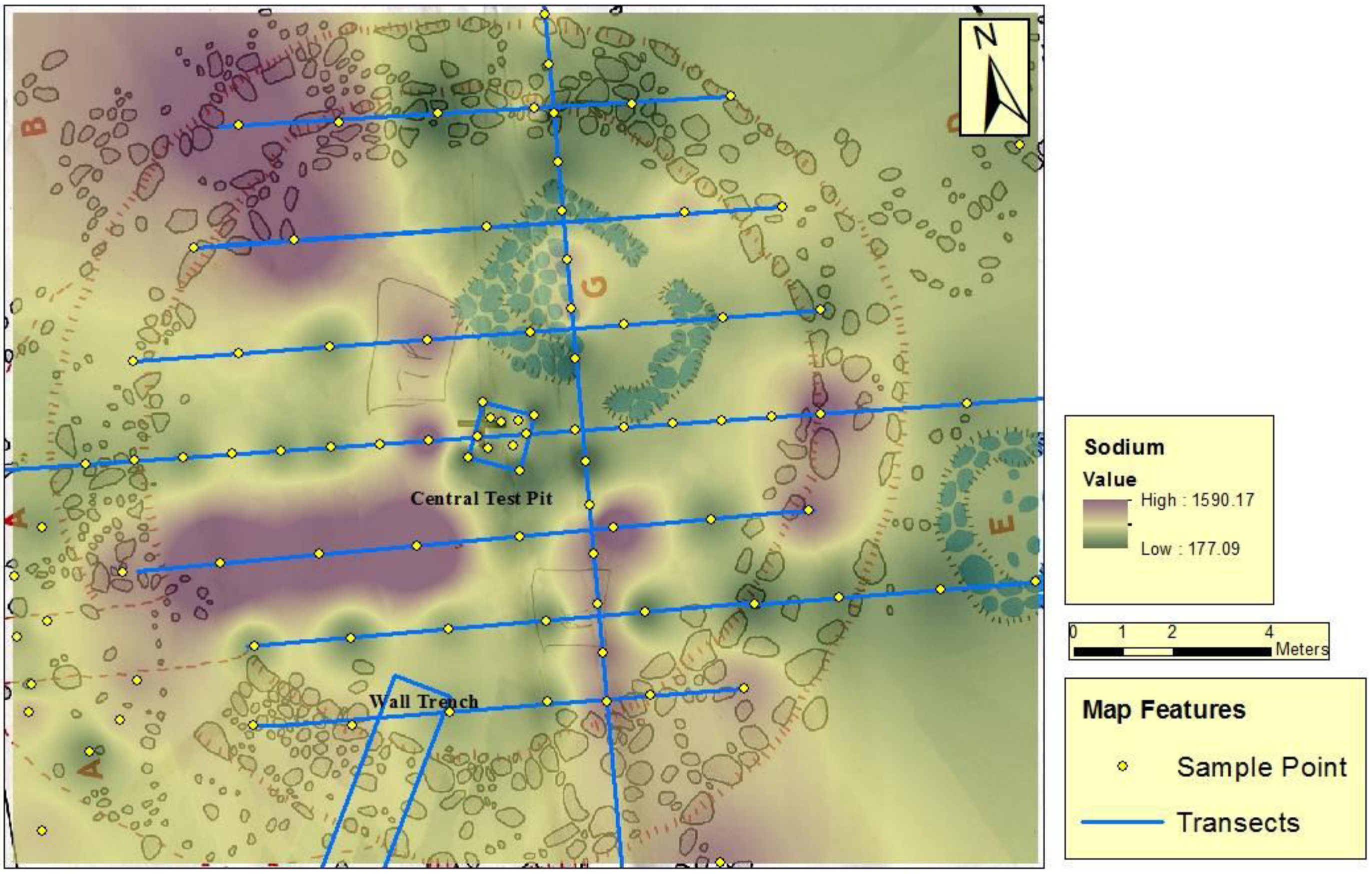
Map2. Detailing the concentration of Phosphorus (P) across the roundhouse structure on a colour ramp of purple (high) to green (low). Soil sample location is shown by yellow point

Phosphorous (P) concentrations are highly concentrated in the south side of the roundhouse with the highest value of 4000ppm recorded, with a second enhancement area sited alongside the central test pit. The chemical element concentration in this section was also true of magnesium (Mg), manganese (Mn) and Iron (Fe) although not shown in the results section. Remaining site concentrations represented in yellow and green show low levels of enhanced P in the majority of areas across the site. This concentration pattern is unusual and could be the result of a number of factors, but overall these results do not significantly define anthropogenic activity on site. The chemical element concentration in this section was also true of magnesium, manganese and iron although not shown in the results section.



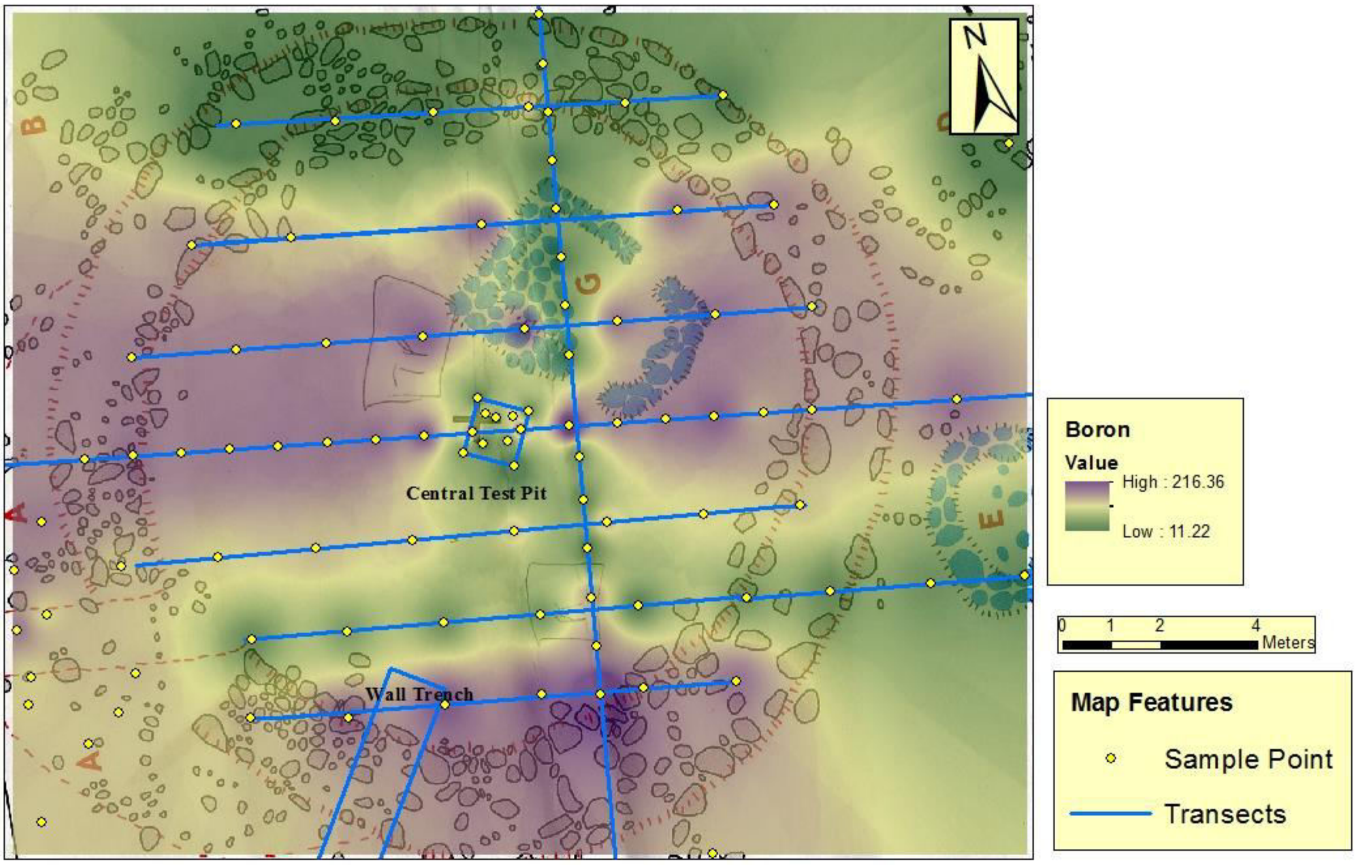
Map3. Detailing the concentration of Aluminium (Al) across the roundhouse structure on a colour ramp of purple (high) to green (low). Soil sample location is shown by yellow point

Aluminium enhancement (Al) across map3 is found to be high on the central transect line at 11473ppm with the lowest on site reaching 660ppm. The enhanced concentrations occur in a very linear pattern and do not appear naturally spread across the site, which may be due to a number of factors, which will be discussed in a later section. Enhancement of Al occurs off-site in the south-east corner of the roundhouse at the shieling building, whereas samples from the entrance points (south-west section) and transect points inside the structure show considerably lower values.



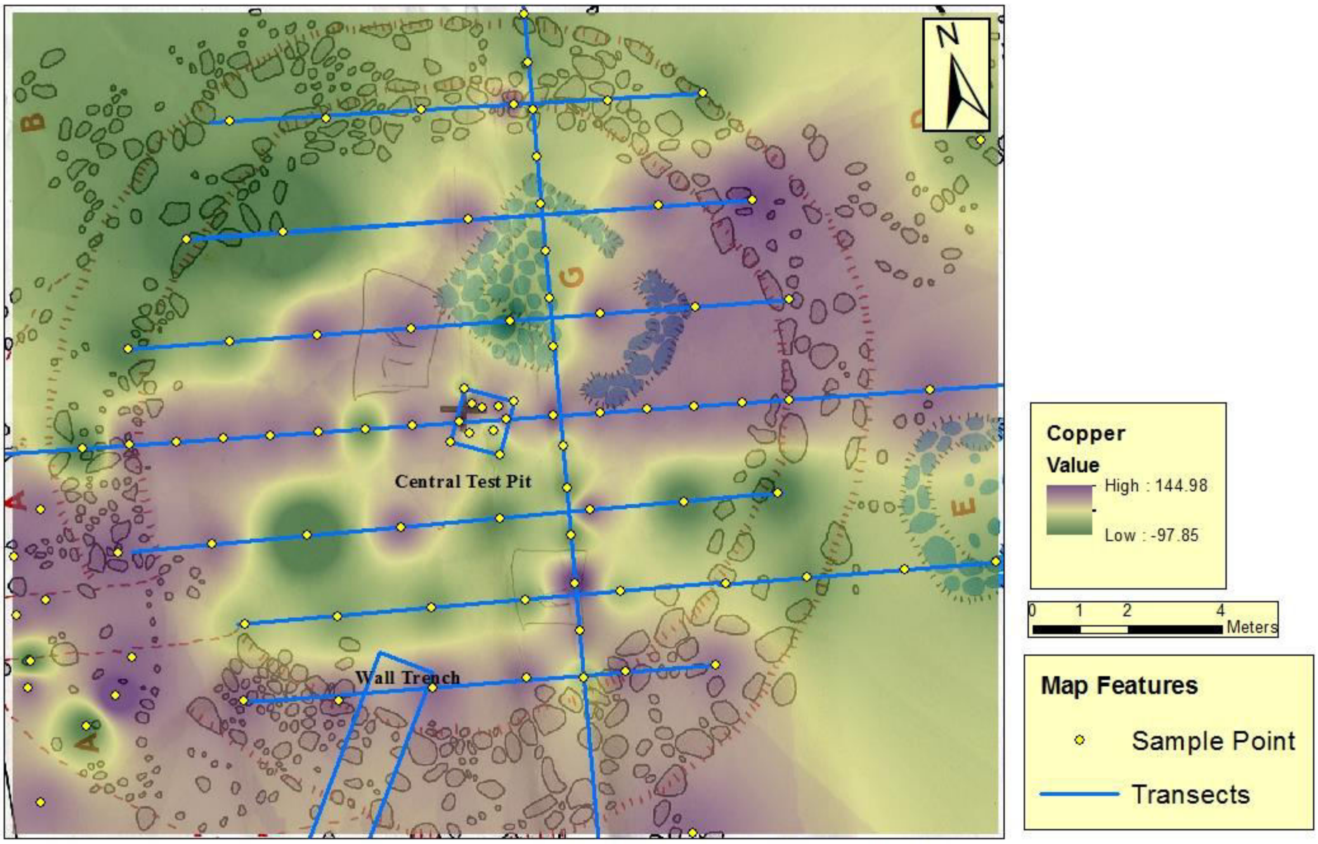
Map4. Detailing the concentration of Sodium (Na) across the roundhouse structure on a colour ramp of purple (high) to green (low). Soil sample location is shown by yellow point

The sodium (Na) concentrations shown in map4 vary across the site with high value enhancement up to 1590ppm shown in purple. Low concentrations at 177ppm are found around the central test pit and to the north. This pattern of enhancement is not evenly spread across the site. Sodium concentrations are present across the majority of the site, with high concentrations occurring at 17 sample points in total.



Map5. Detailing the concentration of Boron (B) across the roundhouse structure on a colour ramp of purple (high) to green (low). Soil sample location is shown by yellow point

Map 5 shows the concentration of boron (B) throughout the roundhouse with a high value of 216ppm and a low value of 11ppm. High value concentrations of boron have separated into three distinct sections across the site. Low concentrations are present in the most northerly transect, as well as on the north to south transect. No significant levels of elevated boron are found around the central test pit area.



Map6. Detailing the concentration of Copper (Cu) across the roundhouse structure on a colour ramp of purple (high) to green (low). Soil sample location is shown by yellow point

Copper (Cu) enhancement shown on map6 is identified around the entrance point and southern wall close to the excavated trench, with high concentrations across the central transect line and north-east quadrant of the roundhouse. The areas represented in green fall under detection limits with the lowest at -97ppm. The concentration trends are significantly spread over a large area of the internal structure, but large areas still represent undetectable concentrations.

pH and magnetic susceptibility

The pH results of twenty random soil samples shown in table 3 indicated a mean value of 3.84 with the lowest value at 3.6 and the highest value at 4.6. There is not a significant variation in soil pH across the site and remains strongly acidic throughout. However, the highest value was taken from the central pit, an area likely to have been influenced by anthropogenic activity.

Table 3. Result of pH measurements

pH Measurements	
Sample Line	**pH**
8	3.87
5	4.10
1	3.9
7	3.6
4	4.1
7	3.75
5	4.13
6	4.06
2	4.17
6	4.27
8	4.08
10	3.78
10	3.82
4	3.77
1	3.85
3	3.77
5	3.86
8	3.83
5	4.5
Pit	4.6
Average	**3.84**

The laboratory tests of magnetic susceptibility (Table 4) were taken from 16 random soil samples from the test site and indicate a low range frequency of 1.3-4.08 and a high frequency 9.04 - 12.04. On-site test results are not included in the test results as they varied significantly across the site without showing any patterns or trends.

Table 4. Summary of magnetic susceptibility measurements.

Magnetic Susceptibility Reading				
Random sample	**Pot Weight (g)**	**Soil Weight (g)**	**Low Frequency**	**High Frequency**
1	3.34	10.1	2.93	10.87
2	3.67	9.87	2.2	10.16
3	4.01	10.03	1.84	9.88
4	4.2	10.01	2.28	10.24
5	2.76	10.03	3.76	11.58
6	2.92	10.2	2.4	10.43
7	2.72	10.2	2.58	12.04
8	2.86	7.82	2.35	10.3
9	2.22	10.2	4.08	11.96
10	2.72	10.05	2.75	12.14
11	2.72	9.19	1.39	9.04
12	2.68	2.68	1.66	9.67
13	2.73	10.31	3.36	11.12
14	2.72	10.12	1.57	9.56
15	2.72	10.2	1.89	9.81
16	2.37	10.1	1.99	9.84

Statistical analysis using multivariate factor analysis

Multivariate Factor Analysis was selected to analyse the complete set of element data to identify underlying correlations of varying degrees. Each of these factors is expressed in a linear combination of observed variables and is represented in a graphical format. Factor analysis takes large data sets which are difficult interpret and identify underling relationships that occur. It then presents them as a number of features, without losing important information. Table 3 and table 4 determine the results from Minitab analysis showing the variables of 12 chemical elements and their connection relationship. Nickel (Ni) was removed from the analysis as its activity within the soil was not well represented by Geographic Information System (GIS) maps as most of the samples were below detection levels.

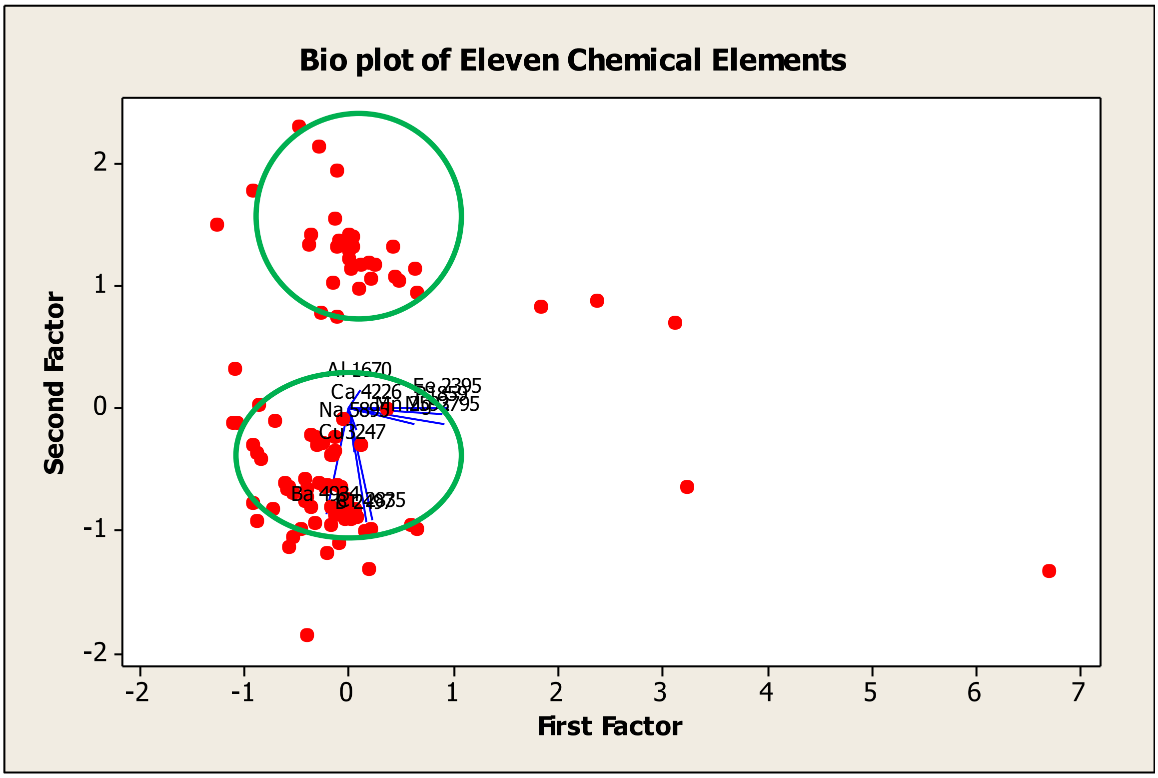


Figure 8. Sample results of Factor Analysis showing the distribution of two variables across the graph. Two clear sample point clusters as represented in green circle with three outliers occurring between factors 3-7. The blue linear lines represent each chemical element sampled.

The biplot result of multivariate factor analysis shows the data sample points in red and the stretched element in blue. Two clear clusters have formed, one in the upper section 0-1 and the other around (0 to -1) in the lower section. These two clusters represent a divide in the data set and have appeared to show a marked difference. The elements are stretched in two main directions, to the right are Fe, Mg, Mn, Al, P and Cr, and downwards are Ba, B and Cr. The remaining elements Cu, Na and Ca are shorter in length and closer to the centre.

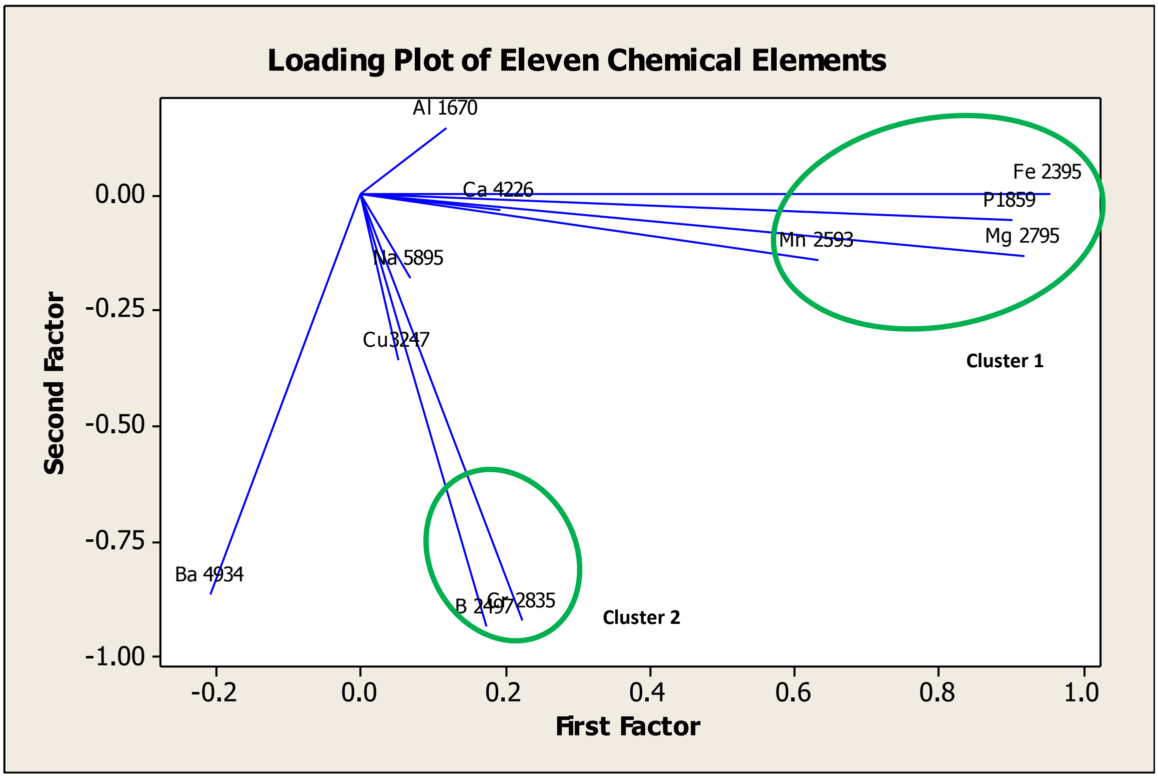


Figure 9. Loading plot result of Factor Analysis showing detailed representation of individual element directions. Two clear clustering groups occur (represented by green circle) with the remaining smaller lines less stretched.

The results of the loading plot offer a clear representation of each element stretched across the graph. Two clear clustering groups have formed with Fe, P, Mg and Mn moving to the right of the graph, whereas, B, Cr and Ba are moving downwards with Cu and Na in a shorter stretch. The Plot suggests that some form of relationship exists in the right hand cluster.

Discussion

The results demonstrate that multi-element analysis has detected element enhancement across the site that may be the result of anthropogenic activity. Of the 24 elements analysed, 12 produced concentrations detectable above the background levels, and included Ag, Bi, Cd, Co, In, K, Li, Pb, Sr, Ni and Zn. However, no clear elemental patterns or trends become apparent that could accurately determine site activity. Interpretation of chemical element enhancement requires careful analysis to ensure viable conclusions can be drawn, as chemical input and the natural geochemistry of the soil must both be considered as well as, an understanding of how metals become bound to various horizons in the soil. Anthropogenic element evidence cannot be ruled out, but the effect of soil processes, vegetation changes and geological variation through time will alter present chemical characterisation.

Soil properties

The soil pH ranges from 3.7 to 4.1 with a mean value of 3.85, represented in table 3. The strong acid soil and vegetation (predominantly heather and bracken) occurs uniformly across the site with no significant trends emerging, other than a slight rise in pH around the central test pit area. The low pH values are typical of peat and gley forming soils found in Wester Ross –as a result of the persistent cold and wet climate. The results of soil moisture loss shows across the range a reduction is water content between 16% to 66% with an average sample loss of 36%.This is a small volume considering peaty soils have the ability to hold considerable quantities of water and may be indicative an dry period experienced in the region prior to sampling.

During the walkover study, on-site magnetic susceptibility readings were taken to assess soil magnetism across the site. This technique offers a non- destructive technique for rapid measurements of soils, in a simple manner. The readings varied significantly from random point to point and changed when placed on top of underlying rocks. The results in table 4 show no significant magnetic variation between the random sample points tested in the laboratory. It might have been expected that the central hearth areas would have shown higher values due to material deposition over time. Magnetic variation in a study by Peter *et al*. (2000) noted enhanced areas around the hearth and middens, giving indications of anthropogenic activity. At this site however, the influence of varied geology skews the values of enhanced soil magnetism resulting in inconclusive results.

Excavation work on the off-site test pit (Figure 6) reveals the natural development of soil over time and can be used as a control against the on-site test pit. This method allows for inter comparison between the two pits and may reveal anthropogenic activity or artefact finds. The on-site central test pit (Figure 7) shows four soil horizons moving from dark brown organic layer in the upper profile, down to a lighter brown, then an olive sand colour of the natural bedrock. Throughout the soil profile flecks of charcoal were located in horizon 2, although, these may post date the roundhouse and relate to the more recently built shieling structure. Archaeological excavations of roundhouses have uncovered occupation layers that define the residence time and subsequent abandonment of structures (Church, 2002; Armit and Ralston, 2003; Armit, 2006; Jones *et al*., 2010). However, no occupational layer or artefact evidence was recovered from this site. Red oxidised iron rich soil and stones (shown in figure7) were found in horizon 3 possibly representative of intense heating of the soil from the above shieling layer but may have also occurred over time, similar to that found by Longworth *et al.* (1987).

Bracken (*Pteridium aquilinum)* is an aggressive growing fern that disrupts archaeological soils. It effectively tolerates acid conditions, grows rapidly and produces strong rhizomes in the soil. Not only does it conceal archaeological remains above ground, it does considerably more damage underground (Scottish Natural Heritage, 2011). They can displace finds and destroy the stratigraphy, as the soil layers cannot be read. Further disruption occurs when plants are uplifted from a site, as this also disrupts layering patterns. The Auchtercairn roundhouse is situated in an upland acidic environment prone to bracken growth. The vegetation patterns on the site may well have altered the stratal layers of the soil at the Auchtercairn roundhouse however, in depth plant analysis was not a substantial contribution to the overall study. As this site was previously covered in bracken and heather it prior to the roundhouse discovery, disturbance of the soil during vegetation removal may be a contributing factor to soil stratal mixing.

Soil chemistry characteristics

Total soil elements concentrations include ions bound in crystal structures of primary minerals; while secondary minerals are absorbed on the surface include clays, oxides and carbonates. Others are bound in a solid organic matter, free ions and soluble and inorganic complexes in the solution (Alloway, 2013). These forms include the 'available' elements although they only represent a fraction of the element form and in this study the total element concentrations were analysed. If anthropogenic activity is not altering the soil composition at this site then it likely two fundamental soil processes are at work: soil leaching and element redistribution or comparatively, the retention elements that remain in the soil. Positive charged free hydrogen ions bind with negative charged exchange sites on organic matter and clay particles, displacing such ions as Mg, Al and Ni. Leaching occurs moving the displaced elements down through the soil profile resulting in the reduced availability of nutrient content to vegetation. The fundamental principle of how vegetation alters the chemical composition and mineral dissolution has been yet to clarified, as little is known about the effects on soil change and chemical weathering through time (MacCarthey). Residual matter present of soils is built up of organic matter and geology, formed with underlying weathered bedrock such as gneiss and quartz.

Phosphorous distribution and interpretation

Phosphorous (P) has played a large role in detecting human activities on ancient settlements for close to a century. The concentration of P represented in map 2 shows three sample points in the south-east quadrant which have high values up to4000 ppm, with a second cluster of enhancement around the central hearth area. The trends remain difficult to interpret, as samples immediately out-with the high values dramatically drop, which is unlikely to be exclusively the result of natural or anthropogenic processes. Phosphorus in itself is never found as a free element naturally occurring in the soil, apart from orthophosphate ions which represent 0.1% of the total soil solution. Cultural inputs of P are relatively stable in the soil at scales of hundreds of year, but apparently less so at tens of thousands of years (Holliday *et al*., 2010). The element itself comes in three phases, organic P, inorganic phosphate or total P which can be analysed individual or altogether as they may hold different forms of information. The elevated levels could have originated from bone matter, food inputs, organic animal matter or through the underlying natural geology and soil processes, although it is unusual to find such high concentrations in the one location coupled with an immediate drop across the remainder of the site. Similarly, magnesium (Mg), manganese (Mn), Iron (Fe) concentration are elevated at the same location, the results may be showing the effect of ion exchange and redistribution throughout the soil. Alternatively phosphorous is highly responsive in the environment and reacts with oxygen to form phosphates, as they are now negatively charged they bind strongly with clays and Fe oxides, reducing the tendency to be leached, thus detectable in through soil analysis.

Acid soils are greatly affected by water through precipitation, overland and underground flow, which will aid the leaching and weathering processes in the soil (Kumar *et al*., 2012). It can be suggested that an accumulation on P has occurred on this site. However its presence is not evenly distributed, a possible artefact of anthropogenic activity could also be representative of many other factors. On the other hand, Multi-element analysis by Wells *et al*. (2000) showed calcareous soils retain phosphates for a very long time, which is significantly different to the interactions found in peat acid based soils.

Aluminium distribution and interpretation

Aluminium (Al) concentrations have been regarded as a proxy for natural chemical element levels within the soil due the conservative nature of lithogenic elements that bind to clay minerals (Oonk *et al*., 2009). It becomes mobilised under acid conditions and is considered phytotoxic at pH <4.5, which will have an effect on vegetation growth (Jones and Kochian, 1996). The results from map 3 indicates aluminium (Al) concentrations are high across the central transect line and around the shieling structure, with a notable rise off-site to the north to east. If these results represent the natural soil element accumulation then a more widespread occurrence would be expected, as total available aluminium concentrations in clay soils would be significant. However, distribution appears to be linear and could represent sampling or analytical error. Soil samples taken across the site varied in volume and organic matter content due to the presence of underlying rocks. This may have affected the element accumulation and leaching of soils over time. In the laboratory the analysis took place in two stages, resulting in ICP-AES element detection parameters fluctuating slightly between analysis, and as the accumulation concentrations are so small it is enough to show distribution variations. In the literature Al does not appear to contribute to anthropogenic activity and enhancement. Middelton (2004) found Al, Mg, Fe and Mn enhancement may be better explained through geochemical process.

Sodium distribution and interpretation

Sodium (Na), although not associated as an anthropogenic indicator in soils, it is a standard element for determining sea water influence in precipitation and is considered a significant contributor to the base cation content of soils (Whipkey *et al*., 2000). As the roundhouse is located on the slopes above a sea loch and coastal environment deposition of salt could occur. Result on map 4 shows the distribution of Na across the site, no significant patterns have emerged with enhancement seemingly random. As the prevailing wind direction is from the south-west, accumulation across the site would be expected to be evenly distributed with higher values around the wall structure. Overall sodium concentrations do not reveal any notable patterns or trends that can be accurately define any activity whether anthropogenic or naturally occurring.

Chromium, Copper and Boron distribution and interpretation

Boron is a naturally occurring metal in the soil and is adsorbed by plants in small quantities; high levels can results in toxicity which does not promote vegetation growth. Map 5 represents its distribution across the site with the highest value reaching 216 ppm and three areas of elevated concentrations. Similarly, chromium shown in map 1 follows a similar distributional pattern with three clear divisions based around the entrance, eastern wall and southern wall. Altogether in the site three transect lines do not show any enhancement, especially around the central pit area. This trend is very uniform and is unlikely to be the result of natural element distribution in the soil. By comparing both boron and chromium results the trends suggest sample or analytical error as both distributions are similar. The central east-west line shows no enhancement at all, even though it runs directly through the centre of the house, it would be more rational had some enhancement been detected.

Copper (Cu) is a common metal found naturally throughout the environment in rock or minerals and is transported in wind-blown particulate, decaying vegetation, sea spray and forest fires (Flemming and Trevors, 1989). Once in the soil it binds to organic matter and minerals, and can stay bound in the soil for a long time (Niragu, 1979). The results of Cu in the distribution again show a similar spread throughout the site as B and Cr. As there is a small variation between the concentration values the distribution output may be highlighting the purple coloured points as significantly higher when actually there may not be a variation and could be the result of ICP-AES analysis. The statistical test for multivariate factor analysis in figure 10 shows two clear clusters of data which on further analysis represent a division between the two sample sets tested through ICP-AES, which has therefore altered the element concentration values within each test set. Figure 9 shows the elements directionally stretched across the graph with two clustered arrangements. Cluster 1 shows the pull of Mg, Fe, P and Mn which is representative of the data as accumulation of these elements follow similar on site patterns. Cluster 2 pulls the elements B, Cr, Cu and Na altogether in a downwards direction which, again follows the elemental patterning across the site which are shown on the maps throughout the results section.

ICP-AES advantages and limitations

The soil samples removed from the roundhouse underwent analysis through ICP-AES, a technique which uses the intensity of light emitted at a particular wavelength to determine the concentration of a chemical element in a sample. The light emitted is related to the de-excitation of the electrons in atoms of the element (Malainey, 2011). A number of advantages are offered by ICP-AES method including rapid sample testing and cost-effective process. It has the ability to detect trace element limits to parts per million more than previous techniques such as AAS (Atomic Absorption Spectroscopy) and test kits in a field laboratory (Terry *et al*., 2000). The instrument is superior in analysing trace elements of archaeological soils, in comparison with methods- based approaches.

In archaeological soils the properties of many single elements become ambiguous for the purpose of defining a function or activity, as they remain vague and cannot accurately define a single process without empirical evidence (Middleton, 2004). Multi-element analysis along with selective extraction techniques would provide a greater insight into site function and the organisation of space than traditional excavation or single element analysis alone. It is a minimally invasive technique that requires very small samples in order to detect trace elements.

A notable trend found in archaeological ICP-AES literature is that studies took place at locations where a previously known context regarding function and spatial organisation occurred, allowing for comparative chemical analysis to confirm associated enhancement. Entwistle *et al*.(1998) studies floor plans of a small farming community on Skye, Wilson *et al*.(2005) conducted studies on 18th century farmsteads, while Middleton (2004) led studies of houses occupied between in the mid-18th and 19th century. The roundhouse in this study is estimated to be around 2000 years old and notably older than the study sites aforementioned. The substantial age difference between sites is likely to have a marked effect on the retention of anthropogenic signatures, as geochemical processes, atmospheric deposition and subsequent land use are all contributing factors to altering soils.

The procedure of element extraction differs between studies as some use weak or strong acid digestion techniques. This is an important decision as digestion ultimately makes available the elements for detection (Middleton, 2004). Further study is needed to determine the most effective technique to use for archaeological sites. As previously discusses ICP-AES in this study, determines the total concentration of an element such as P, when part of the element may hold more historic information.

Site characterisation and function

The accumulation of information from this study allows some assumptions to be made on determining the function of this Bronze Age or Iron Age roundhouse. As there is no previous data or records known to exist for this site, all information is based on evidence gathering and an accumulation of information. The discovery of a central hearth is the only proof of anthropogenic activity as the ICP-AES analysis proved insufficient at identifying associated anthropogenic element signatures and no artefacts were found. Similarly, no occupational evidence was recovered from the central and off-site test pits. This may be the result of natural soil mixing processes or roundhouse occupation on site may have been short-lived. A well-maintained floor would have encountered regular sweeping and reduced the ability of elements to accumulate or build-up over time (Armit, 2006). Comparatively, occupation layers have been revealed at a number of sites in Wester Ross by Welti (2011). This is backed up by the element analysis results as no emergent patterns highlight domestic or industrial use.

The most striking feature of the roundhouse is its size (17meter diameter), as simple structures are often built considerably smaller. As the element results are vague and cannot determine site function, observations can be made on site function due to its architecture and location. The entrance to the roundhouse is uncharacteristically large and could relate to the impressive vista across undulating land and sea loch. The prevailing winds in the area drive in a south-westerly direction which would not be the optimal position due to exposure, and could therefore lead toward a ritual or community structure based around the movement of the sun. Amateur archaeologists have suggested that during winter solstice the sun is positioned directly in line with the roundhouse entrance (Wildgoose and Welti, 2012).

Ritual in the Iron Age is thought to have played an important role (Haselgrove and Pope, 2007) and may reflect the direction and size of the structure. The presence of a central hearth is indicative of site activity, however elemental analysis does not provide any enhancement in this area or evidence of domestic activities throughout the site and so ritual patterns may be considered. The settlement as a whole is unenclosed, implying there could have been a community based structure (if roundhouses all date to same period). Therefore, the large roundhouse was used as communal area and not as a fully occupied house. The ICP-AES results relate to this suggestion in some way as no anthropogenic occupation layer was present as a result of long term occupation and may only have been used on specific occasions .

Webley (2007) suggests that large roundhouses in England were built in a select time period, resulting in the small numbers of similarly constructed houses, later abandoned in favour of new designs. However, it is possible to compare structures found in Southern England to those in Northern Scotland? Similarly knowledge on community structure throughout Iron Age is known to a lesser extent. Auchtercairn appears to have been an unenclosed settlement which could indicate an open community or an association of authority within the site.

There are a number of potential points of weakness associated with this study. The sampling strategy could be improved by taking more samples out-with the structure to be used as a comparison between element concentrations found inside the roundhouse soils. Multi-element analysis is accepted in the academic literature as a beneficial addition to archaeology, although concerns regarding the depth from which samples are collected, method of analysis undertaken, and the interpretation of results are still present (Entwistle *et al*., 2007.)Depositional and soil formation is likely to have occurred over the last 2000 years which may have hidden the chemical signature. The effects of vegetation on the soil may also have been a contributing factor to soil stratal characteristics.

Conclusion

ICP-AES multi- element analysis techniques makes for a powerful tool in aiding the understanding of functional areas space organisation at archaeological sites. This technique expands the repertoire available to archaeologists in studying important sites, with the provision of quantitative data that was once unobtainable. Results obtained from this project have remained inconclusive as element enhancement across this site was not significant enough as to distinguish accurately soil origins from, anthropogenic, natural or analytical means.

A shortage of site records or information undoubtedly presents major challenges to answering unknown questions about the prehistoric past. However, the accumulation of explorative and analytical data from the Auchterchairn roundhouse allows for suggestions to be made in regards to its possible function. The central test pit soil accumulation did not substantially differ from the off-site control pit, and no evidence of an occupational layer existed, which could be related to the sites later activity, soil mixing, a very short occupation period or regular clearing and sweeping of the floor. Soil sample analysis shows significant enhancement of P, Mg, Mn and Fe concentrations were elevated across the site but significantly in the south-east corner, with B, Ca, Cu and Na following a wider distributional pattern across the site, which is likely related to the natural geochemistry of the soil. Overall site function suggestions at present, relate to a community based structure that was possibly used for ritual or gatherings. This is because of the uncharacteristically wide entrance, unique structure size, site location with magnificent views and lack of significant occupation layers in the soil. No artefacts were recovered from the test to support or disprove this theory, but further site excavation work may reveal more. Other than the large size of the roundhouse, no similarities between previously excavated roundhouses have been revealed.

The mystery behind the function of this roundhouse may be unveiled in the future through more extensive excavation work. Further work is indeed necessary to identify the chemical characteristics of Iron Age roundhouses, especially through the use of multi-element analysis, as no known (published) studies have been conducted. Data collected from a range of comparable sites can then be modelled to assess the similarities and differences between sites, and may lead to better prediction rates that determine site function.

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Appendix 1

The figures below show the settlement of Auchterncairn and associated roundhouses with a layout plan of the roundhouse study site. Areial photograph of Auchtercairn settlement showing roundhouse sites in yellow, farming wall systems in orange and old rig and furrow in a sand colour. The annotations indicate a site that has been highly active through time and only recently has farming declined to allow for tree growth and development.

Figure 1. Areial photograph of Gairloch roundhouse and surrounding settlement (Sourced from Welti, 2011 *unpublished)*

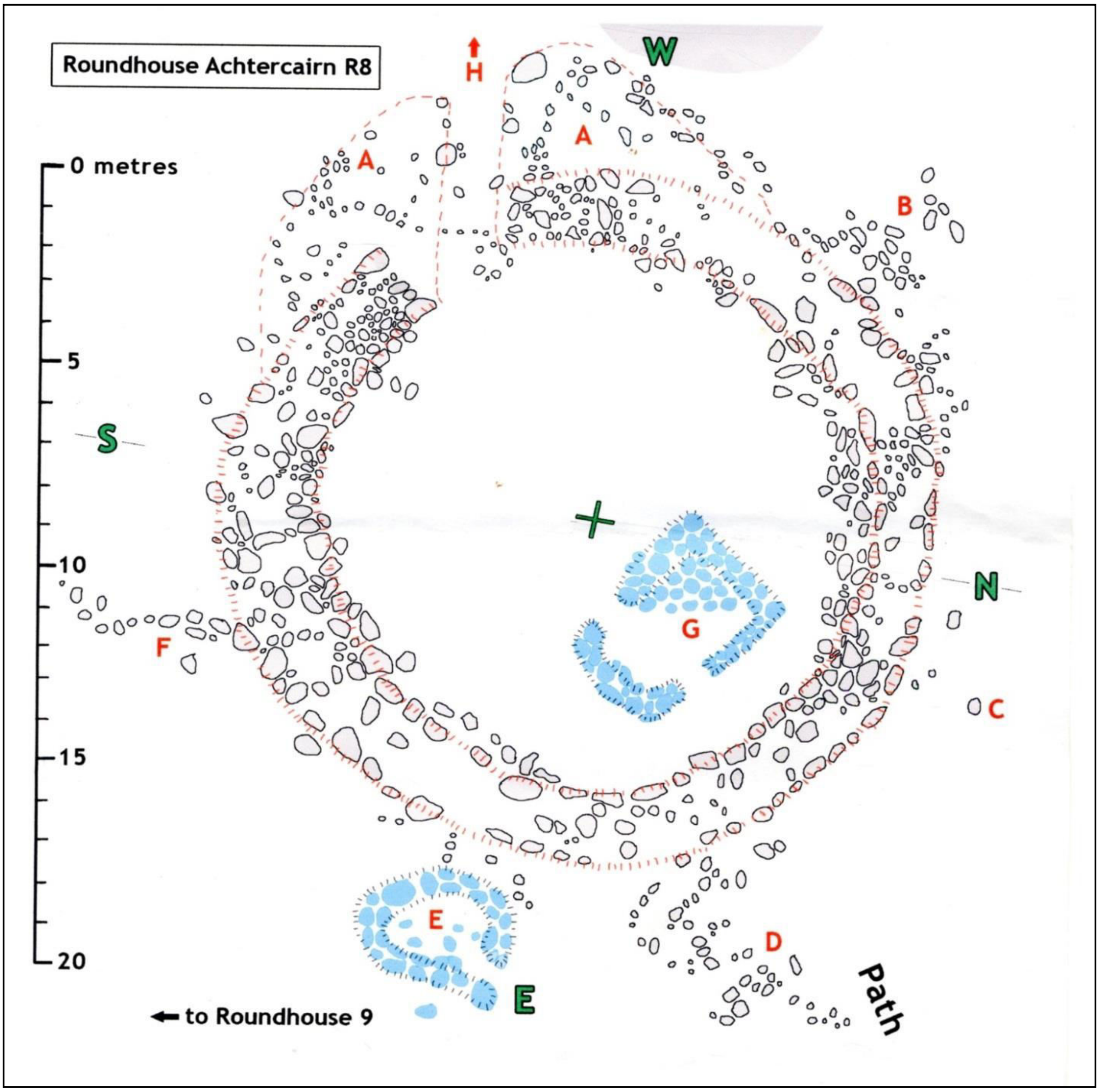

Figure 2. Roundhouse structure and directional position, with two additional structures highlighted in blue.

Appendix 2

Table 1. Raw data containing chemical element concentrations that were above background detection limits in parts per million (ppm).

Al 1670	B 2497	Ba 4934	Ca 4226	Cr 2835	Cu3247	Fe 2395	Mg 2795	Mn 2593	Na 5895	Ni 2216	P1859
3513.2	216.88	47.52	1822	247.08	29.28	108280	10424	5724	789.6	29.36	4016
3654.4	132.36	132.36	1653.2	152.16	85.44	66760	7680	2558.8	789.2	20.68	2413.6
3774	122.36	44.6	1698	135.68	135.68	60240	7708	5404	760	20.68	2754.8
3287.6	49.52	20.36	1365.6	53.04	6.68	28576	2832.8	1368.8	789.6	8.08	975.6
11708	53.92	32.64	2006	57.6	9.88	26952	3360	1442.4	387.44	10.84	907.6
10420	51.6	18.96	1084.8	54	34.72	25852	3204	1292.4	325.52	8.88	810.4
11496	58.92	26.08	1448.4	61.08	23.44	34096	3718.4	2515.6	668	9.6	1063.2
3167.2	46	31.52	1631.2	45.76	25.96	26048	2846.92	923.6	657.6	6.84	1052
3916.8	62.72	12.32	1086.4	66.92	38	35124	3276.8	650.4	465.2	8.44	867.2
6852	42.64	179.2	1160.8	43.76	26.6	20688	2401.2	455.6	298.2	6.12	638.8
9228	56.2	29.092	861.6	57.36	14.36	30660	2559.2	684.8	234.12	7.6	581.6
3472.4	48.4	7.72	1498	42.28	3.6	26284	2234.8	409.6	401.2	6.12	720.4
1554	11.2	8.72	1203.2	8.76	8	29124	854	32.88	599.6	1.92	783.6
3565.2	43.52	13.44	1808.8	27.56	4.04	23360	2788.4	642.4	485.2	7.48	884.4
4280	56	13	1245.2	55.48	35.32	31076	2756.4	608.4	313.08	66	643.6
2428	112.24	102.28	900.4	150.64	97.76	26700	2216	995.6	661.2	62.52	879.6
3740	40.32	145.6	1034.8	38.52	28.24	21444	1867.6	978.4	220.44	5.04	483.2
2222.4	25.2	11.6	1990	20.76	5.56	30660	1788.8	141.36	830	2.96	876
1046.4	11.24	14.76	2039.2	6.4	8.44	26284	1616.8	98.12	1085.6	1.72	781.6
4488	50.48	12.92	567.6	53.32	23.2	28080	2380.8	1754.8	361.96	67.6	938.8
4552	50.64	15	560.4	53	46.96	28320	3010.4	1262	173.16	10.56	1119.2
2861.6	17.12	36.48	537.6	18.24	6.72	8552	1431.2	363.92	176.56	3.2	318.68
4612	55.48	11.84	718	56.68	4.72	30448	2527.2	952	530.4	7.2	751.2
4724	63.52	15	842.4	63	38.36	35176	2374.8	600.4	199.2	7.2	872.8
4392	50.08	18.64	1516	45.44	13.84	26376	2689.6	1282.8	435.2	7.12	852
4468	56.6	8.8	778.8	51.28	36.68	30112	2024.4	912	320.64	5.48	673.2
4672	54.24	14.72	1044.4	55.44	5.64	30096	2232.4	971.2	363.24	5.96	768.8

5080	62.28	19.04	887.6	70.72	44.68	34528	3318.8	2380.4	277.52	6.16	949.6
4580	42.76	11.32	701.6	46.2	28.2	23276	2270.8	1752	284.8	6.8	668.4
4824	59.04	28.76	1674.8	56.48	7.92	30672	3444.4	2260.8	351.44	8.04	1056.8
4652	58.04	10.96	1177.6	56.36	6.6	30912	3128.4	1476.4	441.2	7.8	855.2
5076	64.76	14.4	853.2	68.28	7.8	35356	3351.6	1168	351.68	9.08	972.8
4420	53.12	18.2	1366.8	46.28	27.44	28036	2757.6	1127.6	426	6.48	822.8
5652	65.12	45.92	1218	87.08	76.04	36044	6000	1210.4	235.8	15.64	2043.6
5568	67.6	73.52	1890.4	71.96	78.16	32968	8304	2173.6	335.92	58.52	2854.4
5052	39.2	29.96	1151.2	43.12	33.96	21540	2261.2	903.2	332.44	7.8	837.2
5148	52.56	22.84	1070	55.28	16.76	28280	2836.4	1975.2	503.2	77.6	988
5728	147.36	100.28	1190	150.12	99.44	26300	2904.4	612.4	398.44	-64.04	580.8
4060	130.48	105	1568.4	125.12	98	16600	1995.2	336.4	924.4	-67.6	744.8
3069.2	122.04	101.68	1554.4	118.8	95.84	13660	1582.4	91.72	584	-66.8	762.4
5944	157.44	102.52	1280.4	156.12	97.8	31864	3139.6	1282.8	528.8	-6	874
5680	146.32	102.12	1030.4	146.72	97.32	26416	2968.4	936.8	467.2	-66.2	710.4
5528	138.8	101.36	922.4	141.76	96.88	23000	2186	641.6	468.4	-69.08	721.2
6424	188.96	183.88	1806	146	111.52	20476	3062.4	691.6	486	-53.84	1267.2
5952	146.96	104.52	975.6	152.56	102.08	26316	3435.6	1684.4	437.6	-64.12	844.4
5964	139	114.8	1489.6	147.76	118.56	22236	4416	1862.8	838.4	-61.04	1091.2
6108	163.28	107.52	1366.4	167.16	100.96	34716	4324	1614.8	1018.4	-62.36	1284
6052	151.64	98.76	970.4	159.76	-5.96	29192	3633.6	1544.8	544.8	-60.92	982
5844	145.16	98.36	970.4	150.16	98.16	25952	3122	1610	398.08	-64.88	862.8
5764	146.68	96.28	967.6	152.64	97.88	27076	2974	784	405.2	-67.48	913.6
5544	144.48	106.4	1214.8	147.28	95.84	25348	2965.2	1327.6	568.4	-64.72	944.8
5436	141.04	115.96	1557.2	141.48	98.56	23412	3123.2	2301.2	402.8	-66.64	962.4
5448	148.24	102.04	1768	145.56	99.24	27064	3150	874.4	470	-54.52	1051.6
4600	133.6	105.92	1244	130.92	-21.8	19716	2000	666.8	437.6	-65.12	937.2
5160	146.44	146.44	1026.8	145.28	95.24	26136	2403.2	1002.4	725.6	-64.12	654.8
4752	138	99.8	1194	136.72	94.04	21736	2207.2	772.8	599.6	-67.44	648
1517.6	158.76	101.92	1018.8	162.2	98	30840	3156.4	1356.8	398.36	-64.08	646
1695.2	162.48	98.36	1035.6	167.56	103.72	34208	3880	1215.6	444.8	-61.8	818
1580.8	147.32	96.8	980.8	144.88	96	24952	2600	885.6	623.6	-65.36	780
656	116.56	105.24	1612.4	111.84	98.08	8768	1320.8	128.88	578.8	-69.4	873.2
1281.2	127.6	98.44	1025.2	123.64	92.88	15460	1463.2	287.12	385.4	-68.4	528
2072.4	148	102.6	1111.6	144.92	98.12	24628	2580	2580	452.4	-65.76	710.4

2231.2	142.32	113.08	1007.2	142.08	103.12	22996	2356	1316	484.4	-64.28	713.6
2164.8	150.4	97.44	1243.6	146.76	-17.6	25172	2466	704.4	467.6	-70.04	654
2429.2	156.36	105.24	1254.4	155.8	99.12	28320	3006.8	1812	804.4	-64.32	959.2
2398.4	142.36	109.28	832	145.12	103.96	22388	2180.4	2101.2	407.6	-65.12	707.2
2610	140.24	123.16	1340.4	140.32	6.84	20628	2346.8	4628	600.8	-64.52	1370.4
2150.8	140.84	97.72	1076	138.8	-22.84	21556	2216	1200.4	562	-66.28	757.6
2693.2	137.6	120.72	1384.8	138.24	116.48	20004	2214.8	853.6	559.2	-64.04	759.2
2403.6	144.44	104.44	1442.8	141.24	99.16	23400	2750.4	945.2	633.2	-65.16	898.4
2683.2	151.92	99.56	794	147.76	97.36	26672	2259.6	709.2	410	-64.84	779.6
2102.8	131.72	101.52	1109.2	128.84	-29.2	17308	1506.4	54.52	655.6	-68.52	508.8
2642	143.28	109.12	1404	136.44	98.8	22120	3056.4	1783.6	416.4	-65.2	944.4
2610	141.8	115.56	1795.6	97.92	106.56	21772	3300.8	1892.8	498	-67.32	1115.6
2758.8	143.16	106.92	1508	139	100.52	21652	2990.4	1942	473.6	-65.08	978
1447.2	110.52	99.32	1576	132.36	-25.32	19376	2712.8	539.2	817.2	-52.64	894
1769.6	106.8	100.28	918.8	131.72	-26.84	16916	1514.4	592	367.88	-65.4	421.2
2363.6	114.72	106.48	1224	162.6	102.24	30664	3189.6	1346.4	1171.6	-58.04	1065.6
2424	112.64	107.32	1523.2	158.16	-9.04	28240	3426	2132.4	412.4	-82.8	930.8
1291.6	113.96	102.88	1156.8	159.24	103.04	27448	3426	1070	1590.8	-59.08	969.6
2294	115.04	109.24	1860.8	153.04	-98	28628	3420.8	439.2	1080	-71.04	772
1762	107.04	114.08	1662	131.6	96	18364	1734	400	1486.8	-77.72	1004
2510.4	24.08	15.4	1542	21	17.44	13032	1504.4	124.36	422.8	3.2	614
2406	111.08	105.4	1169.2	140.6	104.76	22148	2331.2	2010.4	536.8	-66.92	1172
2495.2	107.4	119.2	1007.6	141.24	111.12	19024	3758.8	2295.2	606.8	-60.68	1010
1724.4	106.16	104.8	1263.2	126.96	100.76	17400	1663.6	1139.2	576.8	-64.84	975.6
2460.8	107.2	107.2	1665.2	151.84	-16.76	28276	3386.8	1603.6	504	-64.8	963.6
2169.2	110.2	146.4	1993.6	138.52	100.36	20304	2842	1022	650	-67.32	874.4
2362.8	115.24	101.88	1352.8	147.08	103.4	25552	2953.6	1061.2	693.6	-73.92	849.6
2297.6	112.68	105.28	1638.8	146.04	145.2	24880	3056.8	649.6	626.4	-67.72	783.6
2189.2	112.48	105.44	1355.2	141.68	-23.44	23924	2367.6	339.56	376.44	-72.6	634
2297.6	112.68	100.32	1638.8	146.04	94.52	24880	2984.8	649.6	626.4	-61.8	783.6
2348	111.76	102.56	975.6	148.08	105	24832	2398	2258.4	752.4	-62.76	954.8
2267.6	116.36	112.8	2231.2	99.08	99.08	31152	3712.4	549.6	779.6	-69.68	1268.8

Table 2. Data from each soil sample showing the moisture loss content from the to dry weigh

	Wet Weight (g)	Dry Weight (g)	Mass Moisture Loss (g)	Total Moisture loss (%)
NS 420	**118.87**	**90.4**	**28.47**	**24**
NS520	**108.96**	**82.21**	**26.75**	**25**
NS620	**159.86**	**115.31**	**44.55**	**28**
NS720	**93.61**	**78.92**	**14.69**	**16**
NS1020	**93.51**	**64.21**	**29.3**	**31**
NS1120	**159.51**	**106.55**	**52.96**	**33**
NS1220	**109.79**	**69.7**	**40.09**	**37**
NS1320	**56.21**	**31.61**	**24.6**	**44**
NS1420	**142.57**	**83.5**	**59.07**	**41**
NS1520	**166.12**	**127.07**	**39.05**	**24**
NS1620	**150.24**	**85.13**	**65.11**	**43**
NS1720	**40.3**	**22.14**	**18.16**	**45**
NS1820	**78.49**	**33.69**	**44.8**	**57**
8L0	**55.93**	**32.65**	**23.28**	**42**
8L2	**79.59**	**47.76**	**31.83**	**40**
8L4	**45.03**	**19.87**	**25.16**	**56**
8L6	**68.34**	**45.06**	**23.28**	**34**
8L8	**61.88**	**25.04**	**36.84**	**60**
8L10	**20.02**	**8.44**	**11.58**	**58**
CTX1	**29.57**	**13.52**	**16.05**	**54**
CTX2	**29.68**	**15.09**	**14.59**	**49**
CTX3	**31.33**	**8.16**	**23.17**	**74**
NS820	**132.04**	**79.07**	**52.97**	**40**
NS920	**97.89**	**66.52**	**31.37**	**32**
5L0	**78.53**	**52.81**	**25.72**	**33**
5L2	**93.78**	**68.97**	**24.81**	**26**
5L4	**85.57**	**57.13**	**28.44**	**33**
5L6	**149.34**	**116.53**	**32.81**	**22**
5L8	**87.49**	**56.26**	**31.23**	**36**
5L10	**83.51**	**63.14**	**20.37**	**24**
5L12	**59.93**	**38.49**	**21.44**	**36**
5L14	**50.49**	**22.33**	**28.16**	**56**
5L16	**72.95**	**32.79**	**40.16**	**55**
CTX4	**119.76**	**89.43**	**30.33**	**25**
CORE	**89.67**	**43.21**	**46.46**	**52**
CP1	**108.41**	**78.95**	**29.46**	**27**
CP2	**112.36**	**73.63**	**38.73**	**34**
EW2	**221.84**	**179.21**	**42.63**	**19**
EW5	**29.81**	**17.04**	**12.77**	**43**
EW6	**65.69**	**52.19**	**13.5**	**21**
EW7	**166.72**	**115.63**	**51.09**	**31**
EW8	**147.7**	**110.07**	**37.63**	**25**
EW9	**149.72**	**119.71**	**30.01**	**20**
EW10	**116.03**	**79**	**17.7**	**32**

EW12	**76.81**	**33.55**	**43.26**	**56**
EW13	**120.53**	**77.18**	**43.35**	**36**
EW14	**130.13**	**95.35**	**34.78**	**27**
EW15	**242.25**	**164.48**	**77.77**	**32**
EW16	**184.76**	**150.67**	**34.09**	**18**
EW17	**83.33**	**37.04**	**46.29**	**56**
EW18	**22.08**	**13.86**	**35.92**	**37**
EW19	**76.83**	**48.82**	**28.01**	**36**
EW20	**113.26**	**82.72**	**30.54**	**27**
7L0	**77.06**	**40.27**	**36.79**	**48**
7L2	**86.07**	**61.95**	**24.12**	**28**
7L4	**82.22**	**49.12**	**33.1**	**40**
7L6	**99.51**	**70.59**	**28.92**	**29**
7L8	**57.1**	**25.37**	**31.73**	**56**
7L10	**20.93**	**16.39**	**4.54**	**22**
4L0	**73.95**	**52.12**	**21.83**	**30**
4L2	**123.79**	**83.21**	**40.58**	**33**
4L4	**151.51**	**97.28**	**54.23**	**36**
4L6	**52.39**	**32.13**	**20.26**	**39**
4L8	**43.85**	**24.16**	**19.69**	**45**
4L10	**94.76**	**56.76**	**38**	**40**
4L12	**63.75**	**38.06**	**25.69**	**40**
4L14	**78.54**	**42.11**	**36.43**	**46**
6L0	**77.43**	**65.24**	**12.19**	**16**
6L2	**62.55**	**28.99**	**33.56**	**54**
6L6	**84.26**	**45.15**	**39.11**	**46**
6L12	**105.1**	**84.37**	**20.73**	**20**
E1	**62.69**	**51.48**	**11.21**	**18**
E2	**50.19**	**33.51**	**16.68**	**33**
E3	**32.49**	**20.29**	**12.2**	**38**
3L0	**67.19**	**22.89**	**44.3**	**66**
3L2	**145.96**	**93.13**	**52.83**	**36**
3L4	**153.71**	**100.11**	**53.6**	**35**
3L6	**131.96**	**66.44**	**65.52**	**50**
3L8	**216.29**	**175.72**	**40.57**	**19**
6L10	**42.41**	**12.63**	**29.78**	**70**
3L12	**62.96**	**22.1**	**40.86**	**65**
Outside	**87.14**	**71.02**	**16.12**	**18**
CP4	**127.89**	**113.87**	**14.02**	**11**
CP3	**126.18**	**90.48**	**35.7**	**28**
E4	**31.16**	**22.4**	**8.76**	**28**
E5	**61.53**	**45.98**	**15.55**	**25**
E6	**20.76**	**10.9**	**9.86**	**47**
E7	**82.09**	**63.85**	**18.24**	**22**
E8	**81.08**	**51.46**	**29.62**	**37**
E9	**119.46**	**84.76**	**34.7**	**29**
E10	**66.66**	**44.09**	**22.57**	**34**
3L14	**112.01**	**92.74**	**19.27**	**17**

Appendix 3

The pictures below are screen shots taken to show the process involved in producing the GIS maps. The Google image was geo-corrected along with Ordnance survey maps, then imported into ArcMap software.

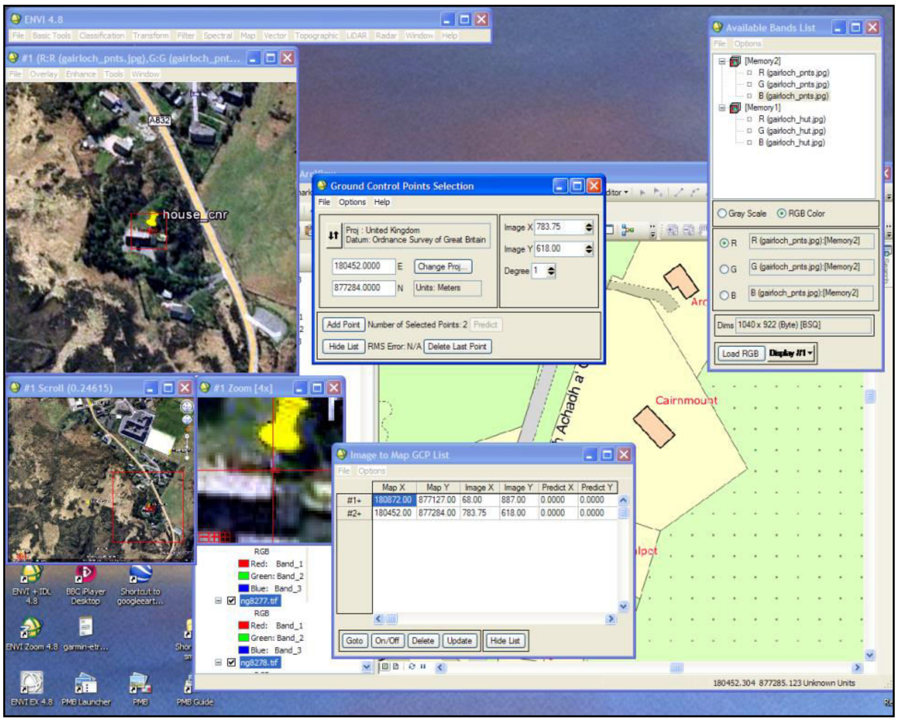

Figure 3.1 Yellow icon placed on known points around Auchtercairn in order to geo-correct rounhouse position.

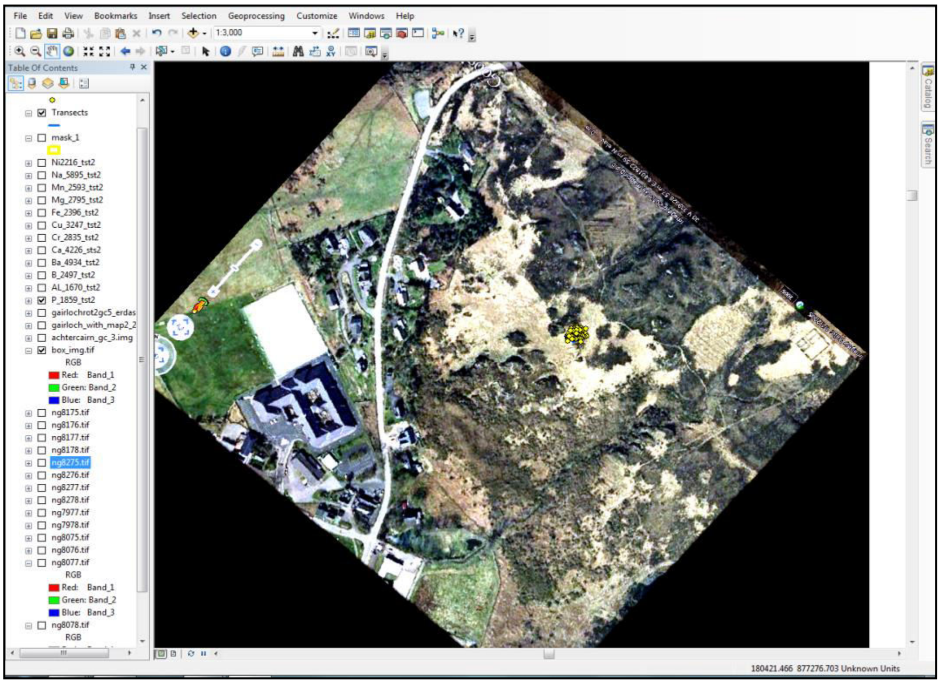

Figure 3.2 showing Google Earth image of roundhouse location, with

sample points shown by small yellow circles.

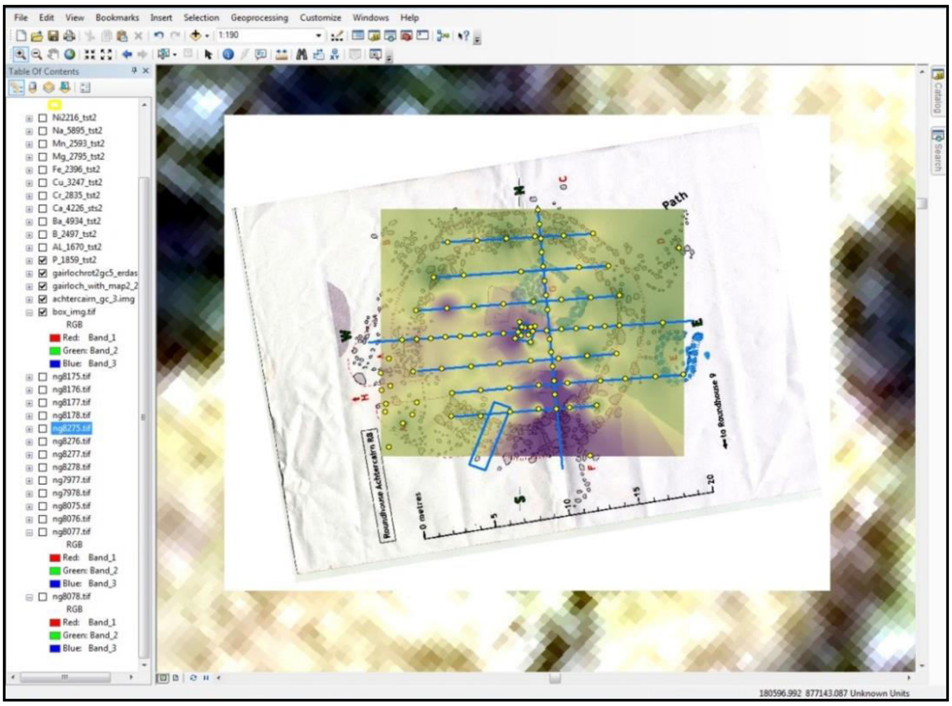

Figure 3.3 Roundhouse location geo-corrected with Google Earth, Ordnance Survey, Structual plan and soil sample points.

Time sheet

Please complete the time sheet each time you carry out some work on your Honours project. This includes all lab and field work, preparation of materials and equipment, travelling to and from field sites and all data analysis. It does not include background reading or writing the dissertation. For each session give the date, start and end time plus a description of the work. Each time you complete a line please add the duration to your running total so you can keep a track of the time you have invested on your practical work.

Date	Start Time	End Time	Total	Running Total Hours	Description
1st June	12	4	4	4	Organising field work trip
Travel Both ways	9	5	8	12	Travel
10th June	10	12	2	14	Meeting and equipment collection
14th-16h June	9	5	8	22	Travel to Ullapool and walk over study of roundhouses.
17th-18th June	9	5	8	30	Gairloch- Field sample collection
19th June	9	11	2	32	Field sampling
22nd June	11	4	5	37	Sample preparation
23th June	10	4	6	43	Sample preparation – drying out
28thJune	10	4	6	49	Sample preparation – Sieve/label
29thJune	10	4	6	55	Sample preparation – Sieve/label
1st July	10	4	6	62	Sample preparation – Sieve/label
3rd July	12	3	3	65	Sample prep – second set dry out.
9th July	11	2	2	67	Soil pH and Mag sus testing
27th July	2	3	1	68	Equipment Training

30th July	9	5	8	76	Sample analysis
31th July	9	5	8	84	Sample analysis
1st Aug	9	5	8	93	Sample analysis
12th Aug	7	5	10	103	Glasgow Library
26th Sept	10	12	2	105	ICP- AES
27th Sept	12	4	4	109	Data interpretation
1st Nov	9	5	8	117	Data input
2nd Nov	9	5	8	125	Data input
9th Jan	9	5	8	133	GIS
12thJan	9	5	8	141	GIS
13th Jan	9	5	8	149	GIS
15th Feb	9	5	8	157	GIS
22nd Feb	9	5	8	165	GIS
1stMarch	9	5	8	173	Data Analysis
3rd March	9	5	8	181	Data Analysis
4th March	9	5	8	189	Data Analysis
9th March	10	5	7	196	Statistics
10th March	12	7	7	203	Statistics
11Match	12	8	8	211	Scatterplot and statistics
12 March	9	5	8	219	Resource room
18th Feb	7	4	8	227	Glasgow Uni library
19th Feb	9	4	7	239	Mitchell Library Glasgow
20th Feb	8	6	10	249	Edinburgh Uni library
Meetings	9	12	3	252	Meetings with Clare altogether
Total	**252**				