APPENDIX 2

SEDIMENTARY ANALYSIS OF SOIL SAMPLES

by

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Introduction

A series of routine soil tests and detailed mineral magnetic analysis were carried out for 20 sub-samples taken from the bulk samples removed during excavation. This report presents the results and discusses the implications for site formation processes and the preservation and taphonomy of ecofacts and artefacts, with particular reference to plant macrofossils.

Research basis

The samples were processed for doctoral research conducted by Mike Church to present a regional synthesis on the prehistoric use of plants in Lewis. This research is based on plant macrofossil assemblages recovered from over ten sites excavated by the University of Edinburgh, as part of the wider Calanais Archaeological Research Project (CARP). A number of recurrent research questions were formulated for the sedimentary analysis from each of these sites including;

1) Can basic sedimentary analysis help interpret differential preservation of ecofact and artefact types between sites?

2) Can basic sedimentary analysis give insights into generic site formation processes?

3) Can detailed mineral magnetic analysis of ash components on the site a) allow taphonomic models for carbonised plant macrofossils to be proposed and b) source the fuel types burnt in the hearths?

Methods

On-site sampling

A sub-sample of approximately 0.25 litres was removed from the bulk samples prior to wet-sieving. Hence, the sampling strategy reflects that of the bulk samples taken on site from 1985 and 1987. These were taken when the excavator deemed a context to be worthy of sampling, a strategy known as 'judgement sampling' (Jones 1991). 'Judgement sampling' does not statistically represent the sampled population (i.e. the archaeological contexts across the site) so the results presented in this report will be biased in the favour of stratigraphically important and perceived 'rich' contexts. However the 20 samples processed can present a general picture of preservation systems and site formation processes across the site, with more detailed information regarding the single contexts sampled.

Laboratory methodology

Each sub-sample was subjected to the following analyses; basic soil description (texture and colour), moisture and organic content, pH and mineral magnetic analysis. The methods employed for each test are described below.

1) Basic soil description

The basic physical characteristics of the 'wet' soil were described through texture and colour. The texture was estimated following Hodgson (1976) whilst the colour was estimated using Munsell colour charts (1992).

2) Moisture and organic content (following Hodgson 1976)

Approximately 20g. of 'wet' soil was dried at 40°C for 24 hours before being dry sieved through a 2mm. gauge to remove stones and larger particles. The sieved material was then placed in a weighed crucible and placed in an oven at 100°C for five minutes to drive off any latent moisture within the soil. The crucible and soil were then weighed before being placed in a furnace for four hours at a temperature of 550°C, to incinerate the organic component. The crucible and material were then weighed and the percentage organic content (by weight) calculated.

3) pH (following Hodgson 1976)

The pH of the soil was measured using a Pye Unicam PW 9410 digital pH meter, calibrated to 7 and 4 pH buffer solutions. Approximately 20g. of 'wet' soil was added to 50ml. of distilled water. The solution was left for 20 minutes and periodically stirred. Then the probe of the meter was immersed in the solution for two minutes and a reading taken. Only one reading was taken from each sample owing to time constraints.

4) Magnetic susceptibility

The samples were dried at 40°C and dry sieved through a 2mm. gauge to remove stones and larger particles. Volumetric (κ) high and low frequency magnetic susceptibilities were measured with a Bartington MS2 meter and MS2 laboratory coil. Mass specific magnetic susceptibility (χlf) and percentage frequency dependent ($\kappa fd\%$) were then calculated following Dearing (1994).

Results and discussion

Tables 2 and 3 present the basic results from the sedimentary analysis. Some of the samples were labelled with both sample and context whereas others were simply labelled with a context. The results will be first analysed in terms of ecofact and artefact preservation, then generic site formation processes will be addressed before the detailed mineral magnetic analysis presented.

Site preservation systems

When analysing artefacts and ecofacts within a site assemblage, consideration must be given to the overall preservation environment of the site. Material such as pottery, stone, glass and carbonised plant macrofossils survive in the most hostile soil conditions but other material types, such as bone, require specific conditions for their preservation. Table 3 outlines the soil pH for all the sub-samples, with values ranging from 4.02 to 5.45 and a mean of 4.68. This acidic soil environment means very few fragments of uncarbonised bone and shell survived on the site, with only very resistant elements, such as teeth, occasionally surviving. The moisture and organic contents varied from very low values for the clay samples (such as S.87/3) to relatively high values for the more organic samples such as S.87/4. Within three of these more organic samples (S.87/4, S.87/6 and C.161) flecks of uncarbonised wood were recovered from the wet-sieving. This demonstrates that the soil conditions in certain contexts on the site were just on the threshold for uncarbonised plant macrofossil preservation as evidenced by the waterlogged levels at Dun Bharabhat and Loch na Beirgh (Church, 1996). However, the condition of the material from the land-based site at Dun Bharabhat was so poor that no identifications of the plants could be made.

Site formation processes

The samples cover a range of contexts that can be separated into groups of like formation, dependent on their context type and sample composition.

1) Destruction level

Only two bulk samples were taken from the secondary occupation destruction level; a sample of burnt plant material with no sediment component (C.169; see Appendix 3 for composition) and a sample of inorganic clay (C.137). Presumably the clay was either stored within the structural entity that was destroyed during the conflagration or was part of the structural entity itself. The magnetic susceptibility for the clay (χlf = 0.42) is higher than the low levels usually associated with natural clay from Lewis. This magnetic enhancement supports the conflagration interpretation, as sediments exposed to heat gain some enhancement (Peters *et al.*, in prep.)

2) Gallery fills

Two bulk samples (C.161, C.164) were taken from Gallery 4, associated with the secondary occupation. The low magnetic susceptibility values point to little domestic ash input into the sediments. Again C.164 probably represents collected natural clay, without the magnetic enhancement of the conflagration. The low magnetic susceptibility, pH and relatively high organic content of C.161 may point to predominantly natural infilling of the gallery for this sediment.

3) Construction material

Three samples were taken from structural elements of the secondary occupation of the site. Two samples (S.87/9 and S.87/3) comprised natural clay used for hearth foundation and wall bonding respectively. Both had limited magnetic enhancement similar to the clay within the destruction layer. Again this enhancement presumably stems from exposure to heat, the hearth foundation from *in situ* burning and the wall bonding perhaps from the conflagration. The third sample comes from the wall core of a secondary structure external to the main site. This material had the texture and colour of domestic ash, consistent with the very high magnetic susceptibility of the sample. Domestic ash and other domestic refuse are a common wall fill material from prehistoric structures through to post-Medieval blackhouses in the Western Isles. This mixture of material allows the wall core to maintain its moisture content and structure, an important consideration for drystone wall material (Jim Crawford, pers. comm.)

4) Hearth material

Four samples were taken from ashy material within and spilling from the central hearth, associated with the secondary occupation. All the samples consisted of ash, with high magnetic susceptibility, and presumably resulted from the final *in situ* burning within the hearth.

Three of the samples were subjected to more detailed mineral magnetic analysis, to source the fuel types used (*infra*).

5) Occupation

These occupation deposits consisted of interleaving lenses of material accumulated during occupation of the complex Atlantic roundhouse (CAR). Three samples were taken from the primary or pre-CAR occupation and seven samples were taken from the main CAR occupation. The samples displayed a wide variety in composition, even within the same context e.g. C.158. This reflects the variability in the sediments that would be deposited from activity within the structure. Therefore, there are samples relating to 1) the spread of ashy material from the central hearth (e.g. C.176 with higher values of magnetic susceptibility) 2) from the deposition of more organic material, as flooring for example (e.g. S.87/4 with high organic content and low magnetic susceptibility) and 3) occasional patches of natural clay (e.g. C.158a).

Taphonomic models for carbonised plant macrofossils

From the site stratigraphy and sedimentary analysis it is possible to propose two general taphonomic models for the preservation and subsequent dispersal of carbonised plant macrofossils across the site. The first involves the *in situ* burning represented by the destruction deposits and the hearth material. The second involves the subsequent removal and dispersal of the plant remains from the central hearth into the surrounding occupation deposits (cf. Peters *et al.*, 2000). This can take the form of deliberate cleaning of the hearth by the occupants or gradual incorporation of small amounts of ashy material into the surrounding floor levels over time.

Fuel sourcing

It is important to source the fuel types used on Atlantic Scottish sites for two reasons. Firstly, fuel was an important resource to be procured and managed as there was very little tree cover by the Iron Age in the Western Isles (Birks, 1994; Gilbertson *et al.*, 1996; Lomax and Edwards, this volume). Also, research has shown that different fuel types produce varying numbers and proportions of plant parts and species (McLaughlin, 1980; Dickson, 1998; Church *et al.*, in prep b). Therefore, in order to disentangle the fuel-derived plant macrofossils from those relating to use of plants by humans, it is necessary to apply a technique that can identify the dominant fuel source and then eliminate the corresponding macrofossils from further analysis.

Two techniques have been developed using laboratory-based mineral magnetic measurements for assessing fuel types from ash residues (Peters *et al.*, in prep.). The first technique is based on room temperature magnetic measurements; a discriminant analysis biplot has been produced from measurements of susceptibilities (initial and frequency dependent), anhysteretic remanent magnetisation and isothermal remanent magnetisations (cf. Thompson and Oldfield, 1986). The biplot shows the clear discrimination of wood and well-humified peat fuel types, with some overlap between fibrous-upper peat and peat turf. The second technique involves monitoring the variation of susceptibility as it is heated from room temperature up to 700°C and cooled back to room temperature. Fibrous-upper peat and peat turf show a characteristic single drop in susceptibility with heating at 600°C, whereas well-humified peat and wood display one, sometimes two, drops in susceptibility with heating at 330°C and/or 550°C.

The two techniques have been applied to four samples from Dun Bharabhat (see Figures 51 and 52). Samples with a high ash content were selected. These are from Contexts 131, 165, 210 (secondary occupation hearth material) and 176 (ash spread in main CAR occupation layers). The discriminant analysis biplot suggests that the ash spread, C176, is a mixture of well-humified peat and fibrous-upper peat/peat turf. The drop in susceptibility at approaching 600°C suggests that for the small sub-sample used in the high temperature measurements, fibrous-upper peat/peat turf is dominant. In comparison to C176, the high temperature susceptibility curves for the other three samples display drops in susceptibility at significantly lower temperatures, suggesting well-humified peat/wood. The positioning of these three samples on the discriminant analysis biplot is interesting. They show a similar trend to the well-humified peat ash, but are plotting further to the right than the experimental data. Comparison to ash deposits from the Cnip wheelhouse complex and Beirgh, both on the Bhaltos Peninsula (Church *et al.*, in

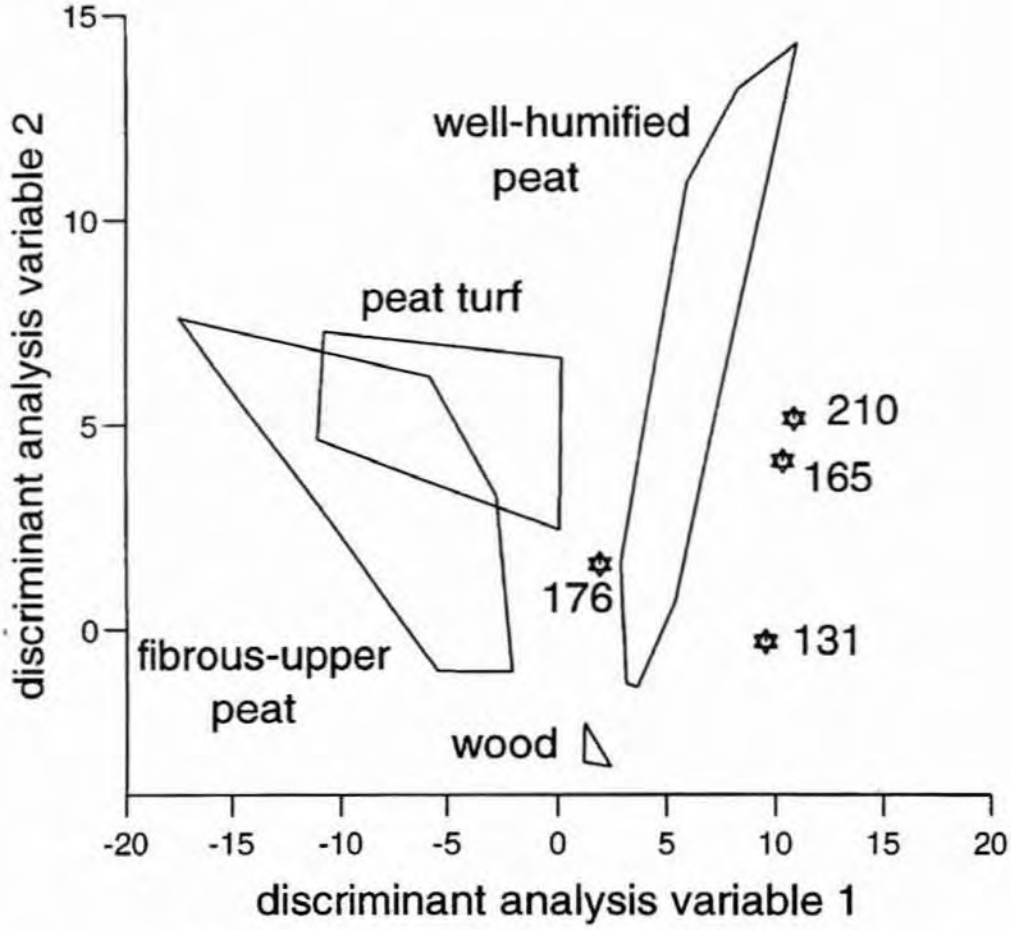

Figure 51: Discriminant analysis of four peat samples

prep.a), suggests that we are observing a very localised use of fuel sources.

Therefore, from the small number of samples analysed, well-humified peat seems to be the dominant fuel source with peaty turf also burnt. Peaty turf could be obtained from very close to the site, judging by the widespread heathland component in the pollen diagram (Lomax and Edwards, this volume). Well-humified peat is usually found in large quantities within the widespread blanket bog of the interior of Lewis. The nearest area to the Bhaltos peninsula would have been the adjacent Uig Peninsula, with its more rolling topography, encouraging the widespread formation of blanket bog. The recurrent pattern of the well-humified samples on the biplot across the three sites also implies that the sites procured and managed the peat banks from potentially the same place. This suggests an element of co-operation between the sites in terms of resource procurement, perhaps involving communal effort in the peat gathering. It also points to a long-term stability in the division and tenure of the peatlands, as occupation of the three sites spans over half a millennium.

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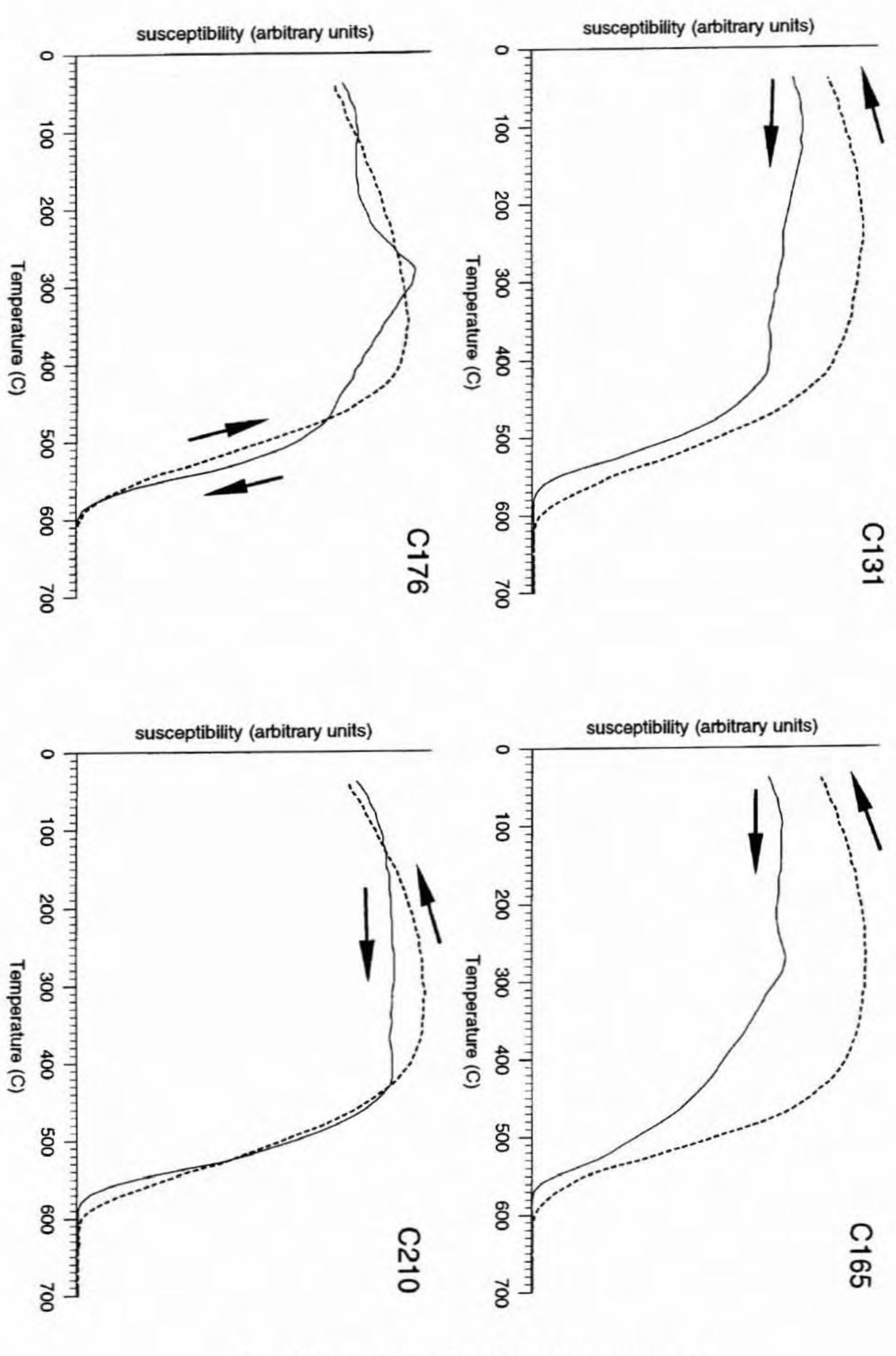

Figure 52: Susceptibility variation of four peat samples

Sample	Context	Generic context	Phase	Texture	Colour	Munsell
N/A	163	Occupation	Main CAR occupation	sandy silt	pale yellow	2.5Y 7/4
87/4	177	Occupation	Main CAR occupation	sandy silt	brown	7.5YR 4/2
87/8A	177	Occupation	Main CAR occupation	sandy silt	brown	10YR 4/3
87/8B	177	Occupation	Main CAR occupation	sandy silt	brown	10YR 4/3
N/A	206	Occupation	Main CAR occupation	clayey silt	black	2.5Y 2.5/1
87/6	176a	Occupation	Main CAR occupation	sandy silt	reddish grey	5YR 5/2
87/7	176b	Occupation	Main CAR occupation	sandy silt	reddish yellow	5 YR 6/8
N/A	158a	Occupation	Primary or pre CAR occupation	silty clay	light grey	2.5Y 7/2
N/A	158a	Occupation	Primary or pre CAR occupation	silt	very dark brown	2.5Y 2/7
Pit	158	Pit fill	Primary or pre CAR occupation	sandy silt	very dark grey	10YR 3/1
N/A	161	Gallery fill	Secondary occupation	sandy silt	very dark brown	2.5Y 2/7
N/A	164	Gallery fill	Secondary occupation	silty clay	dark greyish brown	2.5Y 4/2
87/9	204	Hearth foundation	Secondary occupation	clay	light grey	2.5Y 7/2
N/A	165	Hearth material	Secondary occupation	silty clay	very dark grey	5YR 3/1
N/A	203	Hearth material	Secondary occupation	silty clay	yellowish brown	10YR 5/6
87/13	210	Hearth material	Secondary occupation	sandy silt	dark yellowish brown	10YR 3/4
N/A	131a	Hearth material	Secondary occupation	clayey silt	brown	10YR 5/3
87/3	183	Wall clay bonding	Secondary occupation	clay	very pale brown	10YR 8/2
N/A	14	Wall fill	Secondary occupation	sandy silt	yellowish brown	10YR 5/8
N/A	137	Destruction layer	Secondary occupation destruction	clay	light grey	2.5Y 7/3

Table 2: Sub-sample description

Sample	Context	Moisture content (%)	Organic content (%)	pH	Magnetic susceptibility (High frequency) *	Magnetic susceptibility (Low frequency) *	χlf ~	κfd% ~
N/A	163	4.10	7.79	4.95	17	17.5	0.21	2.86
87/4	177	42.42	37.18	4.36	2.5	3	0.08	16.67
87/8A	177	17.59	20.28	4.49	47.5	51	1.26	6.86
87/8B	177	25.05	21.49	4.73	56	58	1.05	3.45
N/A	206	57.68	22.86	4.02	5	5	0.12	0.00
87/6	176a	29.11	30.48	4.61	248	266	5.26	6.77
87/7	176b	2.26	5.85	4.76	546	586	7.97	6.83
N/A	158a	28.95	2.18	4.58	3	3	0.03	0.00
N/A	158a	27.29	21.23	4.59	7.5	8	0.13	6.25
Pit	158	3.80	10.82	4.87	45	48	0.80	6.25
N/A	161	55.69	37.76	4.36	4.5	5	0.11	10.00
N/A	164	14.28	3.50	4.82	5	5	0.05	0.00
87/9	204	11.91	1.68	5.45	38	41	0.42	7.32
N/A	165	42.85	7.12	4.97	887	956	20.69	7.22
N/A	203	15.19	2.18	5.11	363	391	4.71	7.16
87/13	210	31.85	20.81	4.3	1525	1624	35.15	6.10
N/A	131a	33.45	11.76	4.6	858	924	15.17	7.14
87/3	183	1.12	1.86	4.73	30	31	0.30	3.23
N/A	14	9.43	21.73	4.47	1561	1601	18.86	2.50
N/A	137	2.00	3.39	4.74	38	39	0.42	2.56

Table 3: Sub-sample routine soil test results

* *Volumetric S.I. Units*

~ $10^{-6}m^3/kg$