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The soil micromorphology, phosphate and magnetic susceptibility from White Horse Stone, Aylesford, Kent (WHS98)

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1 SUMMARY

A total of 29 thin sections and 41 bulk samples were analysed in order to investigate the 'soils' of four major periods: the late Glacial, the early Neolithic structure 4806 posthole and gully fills, later prehistoric palaeosols and some early-middle Iron Age feature fills – the study of the last being greatly aided by experiments at Butser Ancient Farm.

A study of the late Glacial environment (Profiles F and G and Profile Ib) demonstrated that although cool climate conditions produced mass-movement deposits in the White Horse Stone valley, low-level biological activity that was probably seasonal, continued. The 'Allerød soil' is not *in situ* and occurs as reworked 'humic' soil clasts deposited during the Younger Dryas, 'soil' layers sometimes being separated by a whitish soliflual sediments(s). A very similar sequence was studied at Ventnor on the Isle of Wight. Mature rendzina soil formation on *stable* valley sides is inferred for the Allerød, when the presence of humans cannot be ruled out.

Investigations of the early Neolithic structure 4806 that included 27 bulk analyses, determined that its likely use was 'domestic' throughout, with fills seemingly reflecting inputs from beaten floor soils that were characterised by the trampling of combustion zones containing burned soil and charcoal. Most phosphate enrichment seems to have come from the inclusion of fine bone, at least in places. There was no evidence of *in situ* animal stabling, although there is the possibility that the highest phosphate measurements could relate to a fill of burned stabling waste (see early-middle Iron Age below) *or* burned bone. No definitely contemporary hearth was located, and the strongest magnetic susceptibility enhancement (indicative of burning) was in fact found in a fill outside the structure.

The period before the Iron Age when the valley soils may have been eroded down to the late Glacial deposits cannot be identified from the soil study. Moreover, a late prehistoric subsoil fill at the Pilgrim's Way site (Profile Ia) , and turf found in feature fills at the early-middle Iron Age settlement indicate that mature rendzinas (stable slope conditions) had been re-established by this time. Early-middle Iron Age mixed farming – crop processing, animal stabling, domestic occupation and hearth(s) affected by possible near-industrial temperatures – was recorded. The highest measurements of phosphate at White Horse Stone resulted from the burning of byre waste (i.e. the seasonally (?) -formed phosphate-encrusted stable floor), the rest of the dung presumably having been employed as manure. Down-slope a later prehistoric colluvial ploughsoil formed, with arable agriculture seemingly supported by low intensity manuring of materials similar to that produced by the early-middle Iron Age settlement. High-energy, water-saturated gravel-rich fans

and colluvium, likely implying rill and gully erosion of the chalk substrate, buried this colluvial ploughsoil – a phenomenon presently found across the chalk of southern England. The report is supported by 10 tables and 16 figures.

2 INTRODUCTION

The multi-period site of White Horse Stone, Kent was visited and sampled on the 18th of September 1998 by Dr. Macphail, Dr. Martin Bates (University of Wales, Lampeter) and Elizabeth Stafford (Oxford Archaeology) collected additional samples.

Four 'soils' of archaeological importance occur at White Horse Stone and Pilgrim's, namely:

1. An Allerød palaeosol and associated Pleistocene sediments,
2. An early Neolithic structure soil (posthole and bedding gully fills), and late Neolithic posthole fill,
3. Later prehistoric palaeosols
4. Iron Age occupation soils (posthole and pit fills).

The Neolithic posthole fills were assessed in August 2000 (Macphail and Crowther, 2000).

A number of research questions were identified prior to this study (Rail Link Engineering, 2003), and these are addressed in the Discussion. White Horse Stone was studied in relation to other local and analogue sites. These include well-dated soil/sediment and faunal (e.g. mollusc) sequences from the Channel Tunnel site of Holywell Combe, Folkestone and Watcombe Bottom, Ventnor, Isle of Wight (Kemp *et al*., 1994; Preece, 1992; Preece and Bridgland, 1998; Preece *et al*., 1995), models of Neolithic land use supported by soil studies (Macphail and Linderholm, 2004); later prehistoric colluvium from southern England (Allen, 1992, 1994, 2000); and both experimental and analogue data from 'Iron Age' settlements (Macphail, 2000; Macphail *et al*., 2004).

3 SAMPLES AND METHODS

Both undisturbed Kubiena box and 150-460 mm long monoliths were taken and/or received from Oxford Archaeology. These were examined, and in some cases sub-sampled for bulk samples, before being cut up for thin section preparation (Goldberg and Macphail, 2003).

Six profiles of the late Glacial and later prehistoric palaeosol from White Horse Stone (Profiles A, B, G and F) and Pilgrim's Way (Profiles Ia and Ib, samples 92 and 98) were analysed using 20 thin sections and 7 bulk samples. The Neolithic postholes/gully fills were analysed by 4 thin sections and 27 bulk samples; and the Iron Age settlement by 5 thin sections and 7 bulk samples, respectively (Table 1). A total of 29 thin sections and 41 bulk samples were thus analysed. (Hayden 2006, Figs. 5 and 7, Stafford 2006 Figs 1-7).

Table 1: List of bulk samples

Fieldwork event	**Feature/ sequence**	**Sample**	**Context**	**Description**
ARC PIL98	Profile Ia	92a*	857	IA ploughsoil
		92b*	923a	Base of hollow fill(s): 36-41 cm
		92c*	923b	Base of hollow fill(s): 41-44+ cm
ARC PIL98	Profile Ib	98a*	857	IA ploughsoil
		98b*	960	Periglacial
		98c*	961	Periglacial
		98d*	920	Periglacial
ARC WHS98	4164	142*		IA pit
		143a*		IA pit
ARC WHS98	4350	143b*	4351	IA posthole
ARC WHS98	2214	144a*		IA pit
	2214	144b*		IA pit
	2214	145*		IA pit
ARC WHS98	4831	529a*		Hearth fill, late Neolithic
ARC WHS98	4887	473a*	4887	Posthole, early Neolithic structure 4806
	4835	625a*	4835	Posthole, early Neolithic structure 4806
	5117	367	5118	Posthole, early Neolithic structure 4806
	5115	368	5116	Posthole, early Neolithic structure 4806
	4848	372	4849	Posthole, early Neolithic structure 4806
	4855	373	4856	Posthole, early Neolithic structure 4806
	4815	376	4816	Posthole, early Neolithic structure 4806
	4857	380	4858	Posthole, early Neolithic structure 4806
	4822	400	4823	Posthole, early Neolithic structure 4806
	5003	408	5004	Posthole, early Neolithic structure 4806
	5113	414	5114	Posthole, early Neolithic structure 4806
	4905?	423	4906	Posthole, early Neolithic structure 4806
	5019	519	5021	Posthole, early Neolithic structure 4806
	5205	535	5206	Posthole, early Neolithic structure 4806
	4809	545	5146	Posthole, early Neolithic structure 4806
	4811	548	5133	Posthole, early Neolithic structure 4806
	5028	583	5030	Posthole, early Neolithic structure 4806
	5268	640	5269	Posthole, early Neolithic structure 4806
	5291	693	5292	Posthole, early Neolithic structure 4806
	e 5294	694	5295	Posthole, early Neolithic structure 4806
	5327	741	5328	Posthole, early Neolithic structure 4806
	5369	781	5370	Posthole, early Neolithic structure 4806
	5156	618*		Bedding gully, early Neolithic structure 4806
	5156	429		Bedding gully, early Neolithic structure 4806
	5156	444		Bedding gully, early Neolithic structure 4806
	5156	609		Bedding gully, early Neolithic structure 4806
	5156	610		Bedding gully, early Neolithic structure 4806

* Samples taken to complement thin section analysis

3.1 Soil micromorphology

Samples were impregnated with a crystic resin mixture, cured and cut up to fit a 75x50 mm format (see Figs 3-4), and sent to Quality Thin Sections, Arizona University where they were manufactured into thin sections (Murphy, 1986). Thin sections were analysed under plane polarised light (PPL), crossed polarised light (XPL) and oblique incident light (OIL), and using fluorescence microscopy (blue light – BL), at magnifications ranging from x1 to x200. XPL is useful for distinguishing non-calcareous soils from calcareous ones (which have high interference colours under XPL); OIL helps identify charcoal and burned/rubefied material; while BL picks out such autofluorescent inclusions as 'apatite'-rich bone and other calcium phosphate enriched materials, such as stabling waste. Thin sections were described according to standard authorities and reference studies on soil micromorphology applied to soils, sediments and archaeology; and counts made (see Appendix 1, Tables 2-3) (Bullock et al., 1985; Courty et al., 1989; Goldberg et al., In preparation; Macphail and Cruise, 2001; Murphy, 1986; Reineck and Singh, 1986; Stoops, 2003). The site was also studied in the light of works on Quaternary geology and Holocene valley sedimentation (Bell, 1983; Bell and Boardman, 1992; Catt, 1986; Catt and Bronger, 1998; Catt, 1990; Mücher, 1974; Van Vliet, 1998).

3.2 Chemistry and magnetic properties

Analysis focused on soil magnetic susceptibility and phosphate, both of which are routinely determined in archaeological site investigation.

3.2.1 Phosphates

Phosphates are present in all organic material (plant tissue, excreta, bone, etc.). As they are released by organic decomposition processes, they tend to form insoluble compounds and thus become 'fixed' within the mineral fraction of soils and sediments. Many forms of human activity lead to phosphate enrichment and, under favourable conditions, this may remain detectable for 10^2-10^3 years (see reviews by Bethel and Máté, 1989; Crowther, 1997; Heron, 2001). In order to establish the form of the phosphates present, **phosphate-P_i** (total inorganic phosphate) and **phosphate-P_o** (total organic phosphate) were determined separately. These were summed to give total phosphate (phosphate-P), and the ratios **phosphate-P_i:P** and **phosphate-P_o:P** (expressed as percentages) were calculated. Analysis was undertaken on the fine earth fraction (i.e. <2 mm) of the bulk samples. Phosphate-P_i and phosphate-P_o were determined using a two-stage adaptation of the procedure developed by Dick and Tabatabai (1977) in which the phosphate concentration of a sample is measured first without oxidation of organic matter, using

HCl as the extractant (P_i); and then on the residue following alkaline oxidation with NaOBr (P_o).

3.2.2 Organic matter

In addition, determinations were made of LOI (loss-on-ignition), which is used here to provide an approximate measure of organic matter. Analysis was undertaken on the fine earth fraction (i.e. <2 mm) of the bulk samples. LOI was determined by ignition at 375°C for 16 hrs (Ball, 1964) – previous experimental studies have shown that there is no significant breakdown of carbonate at this temperature

3.2.3 Magnetic properties

χ (low frequency mass-specific magnetic susceptibility) in soils and sediments largely reflects the presence of magnetic forms of iron oxide (e.g. maghaemite) – this being dependent upon the occurrence of iron and of alternating reduction-oxidation conditions that favour the formation of magnetic minerals. Enhancement is particularly associated with burning, but is also caused by microbial activity in topsoils (see reviews by Clark, 1990; Scollar *et al.*, 1990). χ_{max} is a measure of maximum potential magnetic susceptibility, determined by subjecting a sample to optimum conditions for susceptibility enhancement in the laboratory. In general it will tend to reflect the overall iron concentration of a sample. χ_{conv} (fractional conversion), which is expressed as a percentage, is a measure of the extent to which the potential susceptibility has been achieved in the original sample, viz: $(\chi/\chi_{max}) \times 100.0$ (Tite, 1972; Scollar *et al.*, 1990). In many respects this is a better indicator of magnetic susceptibility enhancement than raw χ data*,* particularly in cases where soils or sediments have widely differing χ_{max} values (Crowther and Barker, 1995; Crowther, 2003).

Analysis was undertaken on the fine earth fraction (i.e. <2 mm) of the bulk samples. A Bartington MS1 meter was used for magnetic susceptibility measurements. χ_{max} was achieved by heating samples at 650°C in reducing, followed by oxidising conditions. The method used broadly follows that of Tite and Mullins (1971), except that household flour was mixed with the soils and lids placed on the crucibles to create the reducing environment (after Graham and Scollar, 1976; Crowther and Barker, 1995).

3.2.4 Correlation

Pearson product-moment correlation coefficients (*r*) have been used to examine relationships between the various properties analysed for the 24 samples of posthole fills from the early Neolithic structure. Log_{10} transformations were applied to data sets with a skewness of ≥1.00

in order to increase parametricity. Statistical significance was assessed at $p \leq 0.05$ (i.e. 95% confidence level).

4 RESULTS

4.1 Soil micromorphology

Microstratigraphic analysis on the 29 thin sections identified and described 36 different layers/contexts. During the descriptive process void space was estimated for each layer and a maximum of 20 characteristics, pedofeatures and inclusions were counted (Appendix1, Tables 2 and 3). Counts were made, for example, of flint gravel, chalk gravel, 'generic' biogenic calcite, earthworm granules, slug plates, and calcite root pseudomorphs (Becze-Deák *et al.*, 1997; Canti, 1998), charcoal, possible flint flake, pottery, bone, coprolite, often articulated phytoliths, burned soil, anthropogenic soil (e.g. enriched in fine charcoal and phytoliths and probable dung) and phosphate stained material (as inferred from autofluorescent characteristics)(Courty *et al.*, 1994; Goldberg et al., in preparation). These findings, which contributed to the identification of soil microfabric types (SMTs) and microfacies types (MFTs) (Courty, 2001), were also complemented by bulk analyses, to produce 'facies types' (Barham, 1995). Seven MFTs (A-G) and 13 sub-types were differentiated on the basis of their sediments/parent material, pedological activity and anthropogenic character, namely:

- *MFTs A, B* and *D1-2*: lateglacial soils and sediments (Figs 3, 5-8),
- *MFT F1-3*: Neolithic anthropogenic influenced soil feature fills (Figs 9-10),
- *MFTs E* and *C*: later prehistoric palaeosols variously influenced by anthropogenic activity (Figs 11-12), and
- *MFT G1-4*: Iron Age anthropogenic feature fills (Figs 13-16).

4.2 Chemistry

The analytical results for the samples analysed are presented in Tables 4-6 (Appendix 1); summary data for the principal context types in Tables 7-8 (Appendix 1); and Pearson correlation coefficients for the relationships between LOI, magnetic susceptibility and phosphate in the posthole fills from the early Neolithic structure in Table 9 (Appendix 1). The results for the samples that complement the thin section analysis are also presented in Table 3 (Appendix 1). Overall, the samples are predominantly minerogenic, with only two having ≥5.00% LOI (maximum, 9.02% in sample 143a from IA pit 4164) and the majority having <3.00% LOI. Thus, contexts that may initially have contained quite organic-rich materials (e.g. the Iron Age pits) would appear to have lost much of their organic matter through post-deposition decomposition processes, and this is reflected in the generally high proportion of inorganic phosphate present in the samples – the phosphate-P_i:P ratio being mostly ≥60.0%.

Both magnetic susceptibility and phosphate-P, which are key anthropogenic indicators, display very wide variability – χ: range, 6.5-202 x 10^{-8} SI; χ_{conv}: 2.22-52.6% and phosphate-P: 0.474-49.7 mg/g. The maxima recorded for χ_{conv} and phosphate-P are both exceptionally high values.

Overall, the χ_{max} values are quite low (mostly <400 x 10^{-8} SI), which presumably reflects the presence of relatively low concentrations of Fe. There is, however, considerable variability in the χ_{max} values (range, 85.4-927 x 10^{-8} SI) and, while χ is more strongly correlated with χ_{conv} than χ_{max}, there is quite a wide scatter in the regression plot of χ against χ_{conv} (Fig. 1). In these circumstances, χ_{conv} provides the most reliable measure of susceptibility enhancement.

4.2.1 Profile Ib (ARC PIL98) periglacial deposits

The periglacial deposits (samples 98b-d) are characterized by having very low LOI values (range, 1.46-2.29%) and showing no signs of magnetic susceptibility enhancement (χ_{conv}: 2.22-3.75%) or phosphate enrichment (phosphate-P: 0.512-0.631 mg/g). As would be anticipated, the values of each of these properties increase up through the section, but even the top sample (98b) shows no clear evidence of modification as a result of human activity. Nevertheless, the 'Allerød' soil (98b – context 960), located above the Younger Dryas solifluction deposits, displays peaks in LOI, P and χ_{conv}.

4.2.2 Profile Ia (ARC PIL98) soils in base of subsoil hollow (923)

The two samples analysed both have a relatively high LOI, which increases up the section from 4.05% (sample 923b) to 5.61% (sample 923a). These results support the interpretation of these as being from a buried rendzina topsoil. The χ_{conv} (7.26 and 6.53%, respectively) and phosphate-P (1.31 and 1.71 mg/g) values are much higher than recorded in the periglacial deposits. While the phosphate-P figures are quite low for a rendzina topsoil (cf. 1.89-2.41 mg/g recorded in modern rendzina at Overton Down – Crowther, 1996), the χ_{conv} values are relatively high (cf. 1.62-3.27% at Overton Down – Crowther, 2003), and may possibly provide some evidence burning.

4.2.3 Profiles Ia and Ib (ARC PIL98) Iron Age ploughsoil (857)

The two samples (92a and 98a) analysed are very similar in terms of LOI (4.69 and 3.95%, respectively), χ_{conv} (5.85 and 5.63%) and phosphate-P (1.75 and 1.16 mg/g) to the older topsoils in the subsoil hollow, and may possibly provide some evidence of burning.

4.2.4 Posthole fills of early Neolithic structure 4806 (ARC WHS98)

In total, the fills of 22 postholes from the early Neolithic structure were analysed, including two (sample 473a from posthole 4887 and sample 625a from posthole 4835) which were also investigated in thin section. Overall, the fills have a low LOI, with only one (sample 473a, 4.09%) having a value ≥3.00% (Appendix 1, Table 5). Although only two of the χ values exceed 40.0 x 10^{-8} SI (maximum, 99.8 x 10^{-8} SI, sample 473a), six of the samples have χ_{conv} values of ≥20.0% and there is quite marked variability in magnetic susceptibility enhancement (χ_{conv}, range 4.02-35.4%). There are highly significant positive correlations between LOI and both χ and χ_{conv} (Appendix 1, Table 6). These could reflect variations in the amounts of more humic topsoil (which has a higher χ as a result of natural soil fermentation processes) and/or charcoal (directly associated with burning) between the different fills. With the notable exception of sample 423 (from posthole 4905), which has a very high phosphate-P concentration of 5.54 mg/g and might therefore include some bone, the fills display consistently low phosphate-P concentrations, mostly <0.750 mg/g (maximum, 0.937 mg/g in sample 437a). On the basis of these data it seems reasonable to assume that values <0.750 mg/g represent background concentrations, and that values in the 0.750-0.999 mg/g range may possibly reflect a limited degree of enhancement. The absence of a significant correlation between phosphate-P and LOI is not unexpected, given the very low LOI of the fills (reflecting active organic decomposition over several millennia). Overall, there would seem to be more evidence of magnetic susceptibility enhancement than phosphate enrichment in these pit fills, and the lack of correlation between magnetic susceptibility and phosphate-P could possibly be attributable to phosphate-P concentrations of 0.750-0.999 mg/g being within the range of natural background variation.

The spatial distribution of magnetic susceptibility enhancement (χ_{conv}) and phosphate-P in the various posthole fills is presented in Fig. 2. In terms of magnetic susceptibility enhancement, no clear pattern is evident within the structure, with the higher values being quite widely distributed. In fact, by far the highest χ_{conv} value (35.4%) was recorded in posthole 5291, which is located outside the main structure. The phosphate-P data, in contrast, show a grouping of three postholes with possible enhancement (i.e. ≥0.750 mg/g), including the one exceptionally high value (5.54 mg/g in posthole 4905?), in the southeastern half of the structure. This could possibly indicate stabling of animals in this part of the building, though caution must clearly be exercised in interpreting such a limited data set.

4.2.5 Bedding gully fills of early Neolithic structure (ARC WHS98)

In total, five samples of bedding gully fills were investigated, including four from feature 5155. The samples have a very low LOI (maximum, 2.88%). There is therefore no evidence of a build-up of organic material within the gullies, as might be anticipated if the features had been regularly waterlogged. All five samples appear to show signs of magnetic susceptibility enhancement, especially samples 618 and 444 which have χ_{conv} values of just over 20.0%.

The phosphate-P concentrations (maximum, 0.710 mg/g) provide no evidence of phosphate enrichment. Unfortunately, all five samples analysed are from gullies at the northwestern end of the structure (Fig. 2).

4.2.6 Late Neolithic hearth fills 4831/5202 (ARC WHS98)

The fill (sample 529a) from this posthole has a relatively high LOI (4.28%) and shows extremely strong evidence of magnetic susceptibility enhancement (χ_{conv}, 29.2%) and clear signs of phosphate enrichment (phosphate-P, 4.34 mg/g).

4.2.7 Iron Age posthole fills (ARC WHS98)

The posthole fill (sample 143b) shows extremely strong signs of magnetic susceptibility enhancement (χ_{conv}, 39.5) indicative of burning, and clear signs of phosphate enrichment (phosphate-P, 3.05 mg/g).

4.2.8 Iron Age pit fills (ARC WHS98)

Of the four pit fills sampled, samples 142, 144a, 144b and 145 show extremely strong evidence of magnetic susceptibility enhancement (χ_{conv}, range 27.2-52.6%) and clear signs of phosphate enrichment (phosphate-P, 3.92-49.7 mg/g). The phosphate-P concentrations are much higher than those recorded in any other samples (Appendix 1, Table 4). The exceptionally high phosphate-P concentration in sample 144a strongly suggests the presence of bone or other form of concentrated apatite, as might be associated with midden-type material. Sample 144b has a notably low LOI (1.64%), which could be a consequence of burning.

The remaining sample (143a), which was seen to be black coloured (7.5YR2/0) in the field, is distinguished by having a much higher LOI (9.02%), and showing less evidence of magnetic susceptibility enhancement (χ_{conv}, 15.7%) and, particularly, phosphate enrichment (phosphate-P, 2.13 mg/g). Compared with the other pit fills, this sample also contains a higher proportion of organic phosphate. The higher organic matter content could reflect the organic-rich character of the original fill (perhaps less affected by burning than the other pit fills) and/or inhibited decomposition of organic matter.

5 DISCUSSION

5.1 The Pleistocene

5.1.1 The Pleistocene palaeosol and periglacial deposits (MFT A, B and D1-2)

The late Glacial soils and sediments were studied from three profiles, G and F (ARC WHS98) and profile Ib (ARC PIL98), where 3 bulk samples were also investigated (Table 1). Investigations focused on the periglacial deposits (4934 and 4936; 920, 960 and 961, respectively) bracketing the late Glacial palaeosol (4935; within 960, respectively)(Figs 3-8). Soil micromorphology employed the following general micromorphological characteristics to differentiate broadly 'temperate' from 'cool-climate' features:

- 'Temperate' – burrowing by mesofauna, excrements of mesofauna, crumb to fine blocky structures, rooting (channels and associated calcite root pseudomorphs), biological homogenisation, earthworm granules and slug plates (Babel, 1975; Bal, 1982; Canti, 1998; Preece *et al*., 1995).
- 'Cool-climate' – massive structure, calcitic cementation (fine calcitic soil infills from soil inwash), secondary calcium carbonate and void hypocoatings, chalk gravel, fine micritic 'chalky' sediments containing chalk gravel, closed vughs and associated intercalations and void infills; and pans of micritic chalky sediment (Becze-Deák *et al*., 1997; Fedoroff *et al*., 1990; Fedoroff and Goldberg, 1982; Kemp, 1986; Preece *et al*., 1995).

Apart from rounded soil clasts ('Allerød soil'), no other features found in cold climate soils, such as link cappings, embedded grains, fissuring and platy structure from ice, etc., were noted (Romans and Robertson, 1974; Van Vliet, 1998; Van Vliet-Lanöe, 1985). As found in earlier Pleistocene sites in southern England (e.g. Anglian Period? terrestrial units at Boxgrove, West Sussex); cool-climate phenomena of mass-movement and soliflual deposition can be periodically interspersed with interstadials characterised by human occupation and biological activity – e.g. by plants and such mesofauna as earthworms (Macphail, 1999; Roberts and Parfitt, 1999, Figs. 83l-83n). The MFTs at White Horse Stone also show such a mixture of features.

The lowermost 'Older Dryas' deposit: MFT A described from 4936 (Profiles F and G; samples 301, 300b) and 920, 960 and 961 (Profile Ib; sample 98) is a very poorly humic (rare to occasional organic matter; very low LOI – 1.46-1.71%) cloudy grey micritic and silt-rich (loessic?) fine sediment that contains common angular to sub-rounded chalk gravel, and rare non-calcareous loessic soil fragments. (Catt and Staines (1998, 73), identified the presence of late Devensian loess at Holywell Coombe.) At White Horse Stone, this poorly sorted solifluction/soliflual valley bottom 'diamict', which is of likely both down-valley (axial) and valley-side origin, was thoroughly biologically worked (rooted, burrowed with mesofaunal excrements)(Fig 5). This is also reflected in the small difference between the chemistry of contexts 961, 920, and 960. Soil micromorphological features of pedogenesis in deposits of the same age were also found at Ventnor (Preece *et al*., 1995). At White Horse Stone ensuing and continuing solifluction/soliflual sedimentation led to 'soil' burial and partial infilling of voids with fine chalky sediment; the pseudomorphic replacement of roots by micritic calcite; and formation of pseudo-calcitic void hypocoatings and void hypocoatings – again as found at

Ventnor. Trace amounts (<1%) of fine charcoal are present. The same MFT A (periglacial soil/sediment) is also present above the 'palaeosol' (see below) in contexts 4934 and 960.

The 'Allerod' soil deposit: MFTs B, D1 and D2 are characteristic of the late Glacial palaeosol (4935 at White Horse Stone and within 960 at the Pilgrim's Way site). No *in situ* humic soils are present. In fact, MFT D2 is a calcareous, gravel-rich soil/sediment ('diamict') that is similar to MFT A, but is composed of humic silty and fine loamy soil fragments (see below), which was partially biologically worked after emplacement (Fig 7). Overall, it contains more organic matter (occasional to many organic matter), and more charcoal (rare to occasional) compared to MFT A, which accounts for the darker colours in the field (2.29% LOI; 3.75%χ_{conv}). Even so, these measurements are only half what was recorded for the *in situ* early-middle Iron Age rendzina soil in the subsoil hollow at the Pilgrim's Way site (see below). Charcoal up to 2mm in size, a single fragment of amorphous organic matter (animal dropping?), and a fine sand-size bone fragment are recorded.

Soil formation can be defined as immature (calcaric lithosol, or grey rendzina or parendzina (Avery, 1990), although the soil fragments are derived from earlier-formed more mature and humic rendzinas. The nearest modern equivalent is the Wantage soil series, a loamy grey rendzina with an extremely calcareous silty clay loam subsoil on chalk, which is often found associated with; a) other grey rendzinas (Gore and Upton series within the Wantage association), and b) deeper non-calcareous profiles in valley deposits (e.g. Panholes and Coombe series), as in the Andover 1 soil association 'mapped' at White Horse Stone (Jarvis *et al*., 1983). On the steeper valley slopes at Holywell Coombe, rendzinas and stagnogleyic rendzinas were identified at this generally much more moist site (especially in the valley bottom), where drift geology is underlain by Gault Clay (Preece and Bridgland, 1998).

It can be noted that earthworm granules are rare to absent generally (see MFT B) in these periglacial soils and deposits, inferring probable low numbers of these fauna in these 'soils'. Very few earthworms were found in the porous chalk bank at Overton Down (Bell *et al*., 1996), and no earthworm granules at all were recorded in the lateglacial (Upper Palaeolithic/Windermere [Allerød] Interstadial palaeosol (calcaric lithosol) at King Arthur's Cave; (Macphail et al., 1999). Probably, in the last case, this was because of xeric conditions. This situation in the valley at White Horse Stone is therefore quite different compared to other examples of lateglacial palaeosols where the palaeosol is marked by strikingly increased numbers of earthworm granules (Kemp *et al*., 1994; Preece *et al*., 1995).

It seems likely that at White Horse Stone more mature rendzina soils were present elsewhere on the valley sides and in Profile 1b sample 98b, at Pilgrims Way, the palaeosol is best represented by an inwash of rendzina soil fragments (MFT B), which is humic like the soil clasts in MFT D2, but is characterised by whole and fragmented earthworm granules (maximum 0.5 mm), slug plates, chalk gravel, humus-stained land snail shell, fine charcoal and a natural flint flake (3 mm)(Fig 6). This inwash deposit is 30 mm thick and is associated with coarse silt infills (elutriated fill/wash of quartz and biogenic calcite grains?), very abundant intercalations, void infills and the later formation of secondary micrite. This is therefore evidence of 'Allerød' humic rendzinas (cf. Icknield soil series; (Jarvis et al., 1984), being present *locally*, as found at Ventnor, Isle of Wight and Holywell Coombe (Kemp *et al*., 1994; Preece and Bridgland, 1998; Preece *et al*., 1995). At other sites in Kent where Kerney *et al* (1980) studied the molluscan sequences, the soils are described as chalky colluvia, where mass-movement has produced a 'soil' composed of coalesced eroded soil fragments, for example as at Halling and Holborough (Macphail and Scaife, 1987, fig.2.4). The Ventnor palaeosol is similarly described as "transported, accretionary and welded", and not truly an *in situ* soil (Kemp *et al*., 1994)(Preece *et al*., 1995).

At White Horse Stone Profiles F and G sampled a narrow pale calcareous stringer that runs across the sloping valley floor (Figs 3 and 8). Unlike at Holywell Coombe (Preece, 1992; Preece and Bridgland, 1998) this is not tufa. (Holywell Coombe is a much 'wetter' site because of the underlying Gault Clay.) Instead, it is a very poorly-humic fine calcareous sediment containing few to frequent chalk gravels, forming closed vughs and a 1 mm thick pan-like feature at its base (MFT D1). Essentially, it is the soliflual deposit of a chalk mud subsoil. As at Ventnor, the 'Allerød' soil is divided by such deposits.

There are therefore two main questions to address. Firstly, if Allerød humic rendzinas formed on the valley sides and slopes, where is the *in situ* valley floor Allerød soil? If the valley floor Allerød soil is missing, are the late Glacial palaeosols recognised at White Horse Stone, simply an expression of renewed cool climate (Younger Dryas) erosional activity and seasonal biological working. The faunas and radiocarbon dating of the 'palaeosol' could thus be considered – in the strict sense – in part relict (Appendix 1, Table 10). The 'Allerod' soil can be considered, as at Ventnor, to be "part of a vertical sequence representing a single complex soil with transported, accretionary and welded components" (Preece *et al*., 1995). But where is the evidence of an undisturbed *in situ* 'Allerød' soil at White Horse Stone? The micromorphology can be utilised to argue equally for: i) a possible single stable period of 'Allerod' soil formation (now unrecorded); and, ii) its total erosion from the valley floor during the ensuing Younger Dryas when by mass-movement it was transported into its present position as totally *reworked* 'Allerød' soil – typical frost-worked soil clasts (Appendix 1, Table 10; Figs 6-8).

At Holywell Coombe an *in situ*, but truncated, stagnogleyic argillic brown earth was identified on the lower valley sides, and this has caused difficulties in reconciling such a mature soil type to such a short-lived (600 years?) pedogenic episode as the Allerød, with for example 5 times the present-day rate of decalcification required (Catt and Staines, 1998).

These authors also recognised that such mature soils have not been found elsewhere in Europe, as this present study has found. A review of the photomicrographs (Plates 3A-C) may suggest the possibility that textural pedofeatures induced by ('cold climate') mass-movement and structural collapse may have been mistaken for textural features formed by relatively long-term clay 'illuviation' in argillic soils *sensu stricto* (Table 1)(Duchaufour, 1982; Fedoroff *et al*., 1990; Fedoroff and Goldberg, 1982).

Secondly, is there any evidence of human activity? Trace amounts of charcoal in the soliflucted deposits could suggest very low inputs of burned organic material that is either relict of natural fires or from the dispersed presence of humans – as found across Europe (Van Vliet-Lanoë et al., 1992). In the Allerød soils, which were transported into in the valley, concentrations of charcoal are higher. This may imply the possible presence of human groups. At Gough's Cave, where Upper Palaeolithic activity left masses of bones, including those of humans, sediments against the cave wall included no traces of human activity, although Allerød biological working and renewed Younger Dryas sedimentation were recorded (Macphail and Goldberg, 2003; Stringer, 2000).

5.2 The Neolithic

5.2.1 The early Neolithic structure 4806

Three thin section samples were studied, two from postholes (M473 and M625) and one from a gully fill (M618). These three samples and 24 others from the structure were also investigated through bulk analyses. Reynolds (1979, 1994) has shown from the construction (in 1975) and dismantlement (in 1990) of the Pimperne House at Butser Ancient Farm that posthole fills can form during the early period of use of a structure because of rapid rotting away of the wood, even whilst the structure is still stable. As the Old Demonstration Area of Butser was located on Lower Chalk colluvial rendzinas, the same conditions of 'post preservation' are assumed for the early Neolithic structure at White Horse Stone. The posthole fills may then relate to the early period of use of this structure. Many workers, especially in the field of macrofossils, believe that posthole fills reflect very localised floor soil deposits and their inclusions. Thus 'zoning' of structures into various activity areas was suggested – e.g. tripartite divisions were identified in Scandinavia (Engelmark, 1992; Engelmark and Viklund, 1986; Viklund, 1998; Viklund *et al*., 1998). Following on from this, it has also been demonstrated that the soil micromorphology, chemistry and magnetic properties of floor deposits reflect use of space in structures, and this has been corroborated by palynology (Courty *et al*., 1994; Crowther, 1996; Macphail *et al*., submitted 2003; Macphail *et al*., 2004).

Soil micromorphology and chemistry of posthole and gully fills (samples 473, 618 and 625):

At White Horse Stone there is consensus between the interpretations of the soil micromorphology and bulk data (Appendix 1, Table 3).

Posthole fill 4887 (sample 473) comprises material from a presumed early Neolithic humic rendzina/brown rendzina soil, which contains very high amounts of fine charcoal, a flint flake, pot and two very fine bone fragments (Figs 9-10). This evidence, combined with a relatively high LOI, strong signs of burning (χ_{conv}, 24.2%), and possible indication of phosphate enrichment, suggest an infill of a beaten-soil floor formed by the trampling of scattered combustion zone debris. Thus, this posthole fill would indicate the location of a trampled humic and fine charcoal-rich domestic (?) occupation surface in the northern end of the structure.

Posthole fill 4835 (sample 625) again shows strong signs of burning (χ_{conv}, 19.8%), and possible indication of phosphate enrichment, with a similar microscopic content of flint flake and bone fragments, but with fewer charcoal fragments compared to 4887. This infers a fill of similar domestic beaten-floor origin in the middle of the house towards the western gully, but perhaps one less strongly developed compared to 4887.

Gully fill 5155/5156 (sample 618) shows strong signs of burning (χ_{conv}, 22.1%), but no evidence of phosphate enrichment, with the 'taphonomic' possibility of the original gully being affected by chalky soil inwash, and later receiving a biologically-mixed infill of charcoal-rich trampled soil – possibly from the same source as infilled local posthole 4886 (fill 4887). As a consequence, the overall anthropogenic signal is a little lower than at fills 4835 and 4887. This may reflect its location by a putative wall (i.e. being less intensively 'used'), which mirrors what was found at the Pimperne (1975-1990) and Longbridge Deverel Cowdown (since 1994) Round House reconstructions at Butser Ancient Farm (Macphail *et al.*, 2004).

Soil micromorphology, chemistry and chemical pattern of posthole fills:

Overall, the soil micromorphology and bulk analyses indicate a not unexpected high input of local rendzina topsoil into the postholes and gullies, although concentrations of organic matter have become markedly reduced through time (Crowther *et al.*, 1996). The use of the structure appears to be dominantly domestic – with high magnetic susceptibility values being widely distributed, fine charcoal being ubiquitous and enhanced values of phosphate-P being likely associated with bone fragments. Such a pattern would indicate the formation of a beaten floor, which has spread combustion zone ('hearth') debris throughout the structure, along with microscopic anthropogenic inclusions of pot and worked flint. No hearth area, as such, was found through this 'survey' (cf. magnetic susceptibility maps at Brean Down (Allen, 1990);

Pimperne House, Butser, (Allen and Reynolds unpublished?)), with the highest χ_{conv} (35.4%) being found outside the house (posthole 5291). The highest and an exceptionally high phosphate-P measurement of 5.54 mg/g is located in the south-eastern half of the structure (4005). The possibility of concentrated burned? ($\chi_{conv,}$ 21.6%) animal waste could be considered here, with burning also being reflected in the low LOI and very high P_i:P (89.5%). These data are very similar to those from some Iron Age pit fills (especially sample M 144) that contain probable burned dung, as identified in thin section. Unfortunately, it is impossible to interpret posthole fill 4905 more fully without soil micromorphology, but it can be suggested that if animal waste is present, it is in a burned form and is unlikely to represent the *in situ* stabling of animals in this part of the structure – such unburned stabling waste has a different chemistry, marked by high LOI and a very low magnetic susceptibility (Macphail *et al.*, Submitted 2003; Macphail *et al.*, 2004). Finally, it can be noted that the burning of animal dung was a specific management practice during the Neolithic and has been widely reported – Mediterranean (Boschian and Montagnari-Kokelji, 2000; Macphail *et al.*, 1997), Hungary (Crowther, Macphail in Whittle, in preparation) and Orkney (Simpson, 1998). Such conjectures for White Horse Stone should be treated with great caution, however, as no micromorphological evidence of burned dung was found, and a fill containing burned bone could give an equally high phosphate measurement.

5.2.2 The late Neolithic structure

Soil micromorphology and chemistry of hearth fill 529:

This feature was investigated through a single combined thin section and bulk analysis. It can be summarised as a biologically-worked fill with a marked anthropogenic signature – fine charcoal-rich with burned bone, of likely domestic occupation/combustion zone /trampled floor origin. This anthropogenic signature is reinforced by a marked phosphate-P concentration (4.34 mg/g) and high χ_{conv} value (29.2%), although χ_{conv} is similar to that of all of the Neolithic fills. Thus, overall these findings suggest domestic occupation, and as found here and from the finds recovery from the late Neolithic pits (see section), this occupation was apparently intense.

5.3 Later prehistory/early-middle Iron Age

At White Horse Stone the palaeosol was investigated through 8 thin sections, and at Pilgrim's Way by 4 thin sections and 4 bulk analyses.

5.3.1 Profile Ia subsoil hollow

At Pilgrim's Way the subsoil hollow appears to contain a buried humic rendzina topsoil that is totally biologically worked and contains few chalk clasts compared to the overlying palaeosols. The soils at Pilgrim's Way are essentially more clay-rich brown rendzinas (cf.

Andover series) compared to the grey and/or humic rendzinas (cf. Upton and/or Icknield series, respectively) at White Horse Stone generally (Jarvis *et al*., 1984). From both experimental (Overton Down) and analogue studies it can be considered as a relatively mature 'topsoil' that was once decalcified (Carter, 1990; Crowther et al., 1996; Macphail et al., 2001). If it has been decalcified, then fossil molluscs may not have survived. Large amounts of fine charcoal, traces of very fine bone, and possible magnetic susceptibility evidence of burning, all indicate a moderately strong anthropogenic signal. On the other hand, the soil micromorphology of the hollow (i.e. its totally biologically worked character) is in contrast to the ploughsoil character of the overlying early-middle Iron Age palaeosol (see below). Thus, the subsoil hollow was not simply infilled with a later prehistoric ploughsoil colluvium, as for example described for an upper subsoil hollow fill on chalk at Balksbury Camp (Allen, 1995; Macphail, 1995); and as found higher up in the Pilgrim's Way sequence. Whatever its date, the fill reflects a possibly lengthy period of stability after a moderately strong anthropogenic impact.

5.3.2 Profile Ia and Ib later prehistoric/early-middle Iron Age palaeosol

There is a coincidence of bulk data evidence (χ_{conv}) of 'burned soils' being present and evidence in the palaeosol (857) of fragments of burned soil and occasional to many fine charcoal. The presence of other anthropogenic materials including pottery, burned daub, bone and likely cereal phytoliths may indicate manuring (see Fig 11), the relatively low phosphate-P concentration (maximum, 1.75 mg/g) suggests that this was of low intensity. These inclusions occur in a microfacies type (MFT C) that is characterised both by indications of high levels of biological activity, such as excrements of soil fauna, earthworm granules and slug plates, and by textural pedofeatures (intercalations and void coatings and infills) that have sometimes been part-worked by burrowing fauna. This indicates co-eval biological topsoil activity and physical soil disturbance. These microfeatures and the geoarchaeology of the site as whole (see below) suggest that the later prehistoric palaeosol is a ploughsoil colluvium (Allen, 1988; Allen, 1992; Farres *et al*., 1992; Kwaad and Mücher, 1979; Macphail, 1992). Results from studies of experimental colluvial rendzina ploughsoils at Butser Ancient Farm and late prehistoric colluvial deposits on the chalk (e.g. Strawberry Hill) also support this suggestion (Allen, 1994; Gebhardt, 1990; Gebhardt, 1995). The presence of anthropogenic inclusions further indicates various levels of manuring (Macphail, 1998; Macphail *et al*., 1990; Simpson, 1997). Some chalky void coatings also indicate inwash from overlying and ensuing colluviation (see Fig 12).

5.3.3 Profiles A and B later prehistoric/early-middle Iron Age palaeosol

The palaeosol at White Horse Stone (4144) shows exactly the same kinds of microfeatures and microscopic inclusions that are indicative of a manured ploughsoil colluvium (e.g., including possible burned dung and weathered hammerscale?), in all three profiles studied (Fig 11). Manuring would be necessary to produce good yields on colluvial rendzinas because phosphate is often poorly available and organic matter is rapidly oxidised in arable soils (Duchaufour, 1982, pp 216-217; Voroney *et al*., 1981). It is quite clear also that the early-middle Iron Age settlement (see below) could supply 'manure' of the types found in the palaeosol. Additionally, it is possible that the anthropogenically-enriched soils of the settlement could supply soil of the kind found in the palaeosol, if eroded.

As stated above, the palaeosol shows evidence of plough mixing and structural disturbance, alongside biological working, as found in all types of arable soils (Courty *et al*., 1989; Jongerius, 1970; Jongerius and Jager, 1964; Mücher *et al*., 1990; Pape, 1970), and as noted experimentally at Butser (Goldberg *et al*., in preparation; Reynolds, 1981). Once ploughing has occurred, biological activity will work the soil, and this will happen rapidly – as monitored at Butser after the 'abandonment' of the arable fields in 1989-1990. At White Horse Stone and Pilgrim's Way there is biological microfabric evidence of slightly-, moderately- and strongly-worked ploughsoil. There are also layers, e.g. contexts 4151 and 4160, which appear to be chalk gravel fans/chalk slurry-like colluvial deposits, which are more sedimentary in character than pedological (Fig 12). These can be very compact, with 25% voids compared to 65% voids in the biologically-worked palaeosol (e.g. M115, Profile B). Chalky intercalations, void infills forming closed vughs and pan-like formations are present. Continued sedimentation (Farres *et al*., 1992) has also meant that the environment is highly calcitic and plant roots are pseudomorphically replaced with calcite crystals (as in the Pleistocene soil-sediments), and soil can become 'cemented' through secondary micritic impregnations and pseudomycelia (e.g., M298a, Profile F; Becze-Deák *et al*., 1997). Extant root channels can then be part infilled by chalky inwash during ensuing colluvial episodes. These all demonstrate the episodic instability of the later prehistoric ploughed rendzinas, with not only losses of topsoils, but probably accelerated rill and gully erosion leading to deeper erosion and the formation of chalk gravel-rich colluvia in the White Horse Stone valley (Allen, 1992; Boardman, 1992).

5.3.4 The Iron Age settlement – posthole and pit fills

The fills of four pits and a posthole were investigated employing 5 thin section and 6 bulk samples. The posthole fill (4351, sample 143b), or probably more accurately termed post-pipe fill (Reynolds, 1994), shows a two-fold history of infilling. Firstly, there is a primary fill of very strongly to strongly burned material, which is characterised by the presence of a vesicular slag-like siliceous substance (including part-melted quartz) and various plant and dung-tempered daub (Fig 4). The soil is often rubefied by burning, and some chalk fragments and organic material (articulated long phytoliths) are partially phosphate-stained, and show

BL (blue light) autofluorescence. The latter effect has been noticed in the floors of stables through the draining away of animal waste (Heathcote, 2002; Macphail and Cruise, 2001; Macphail *et al*., 2004). These findings are consistent with an extremely high χ_{conv} value (52.6%) possibly indicating an 'industrial' hearth, with temperatures possibly of >800ºC (Courty et al., 1989); and measured phosphate enrichment (see below for further discussion of the latter).

The later fill, that was burrowed-in at a later stage in the structure's history – probably by a small mammal (13 mm wide burrow; Fig 4) – is more likely to have originated from a domestic beaten(?) floor, as for example found at Iron Age Maiden Castle and at Butser (Macphail, 1991; Macphail and Cruise, 2001).

Samples 142 (150-230 mm) and 143a (270-350 mm) come from layers in pit 4164. The lower fill is composed of a turf and chalk gravel 'dump'. The turf was very biologically active and highly humic, with amorphous organic matter staining of likely dung input origin contributing to the noticeably high LOI (9.02%) and relatively high proportion of organic phosphate (P_o:P, 38.1%) compared to the other Iron Age fills that also show signs of burning, i.e. phosphate mineralisation (range P_o:P, 4.0-15.9%). The soil also contains high amounts of fine charcoal, a scatter of very fine likely coprolitic (stained) bone, and two possible small fragments of human coprolites (Figs 15 and 16), that all contribute to the modest phosphate-P concentration of 2.13 mg/g. It is therefore clear that this 'natural' turf is very local to the settlement and was influenced by livestock (as well as by middening and animal scavenging) – a finding mirroring turf studies of the early-middle Iron Age site of Folly Lane, St. Albans (Macphail *et al*., 1998; Wiltshire, 1999).

The upper fill (142) also contains similar turf, but this has been burned and rubefied, and occurs alongside the burned waste from cereal processing that is composed of micritic (Poaceae) ash (1-2µm compared to wood ash – 15-20µm; (Courty *et al*., 1989; Wattez and Courty, 1987) and long articulated phytoliths (see 145 below). Again, this burned debris is consistent with the very high χ_{conv} (40.2%). Burned subsoil clay of likely Quaternary origin is also present.

Pit 2214 sampled by thin section 144 was layered, and bulk analysis was carried out on the middle (144a) and lower (144b) layers – the upper layer being the same as the lowermost. These deposits are somewhat enigmatic, and interpretation is not helped by the burrowing and rooting of the uppermost and lowermost layers. The middle layer is much more dense and little worked. The layers represented by 144b are a fine to coarse granular deposit of micritic (grassy?) ash aggregates and rubefied chalky subsoil, with only rare quartz silt present. Amongst these are biogenic calcite from earthworm granules, slug plates and root pseudomorphs, with the last of these often being fragmented. In addition, there are fine charcoal fragments and inclusions of long articulated phytoliths embedded within a yellow

(PPL) and highly autofluorescent (BL) cement (see Figs 13 and 14). The middle layer (144a) is formed by a dense mass of ash, with extremely abundant articulated phytoliths, many of which still occur within this yellow and highly autofluorescent cement. Examples of embedded phytoliths up to 3-4 mm long occur. Again, only rare grains of silt-size quartz are present. Both layer types show that they are highly burned (χ_{conv} = 27.2-37.2%) and phosphate-rich – producing the highest amounts of phosphate-P recorded at White Horse Stone, with the mixed burned soil, ash and phytolith layer measured at 9.97 mg/g, and the middle dense phytolith ash layer containing 49.7 mg/g. Fortunately, the experimental material from the Moel-y-Gar stable floor (1977-1990), Butser Ancient Farm, which was studied through soil micromorphology, microprobe, XRD, phosphate, magnetic susceptibility, macrofossils and palynology (Macphail and Cruise, 2001; Macphail *et al*., 2004; Macphail and Goldberg, 1995), provides some clues to the origins of the 144 material. Further, material of the same kind of origin has been similarly investigated in detail from the early medieval settlement at London Guildhall (Macphail *et al*., submitted 2003). The pit fill of 144 can thus be best interpreted as burned waste from a stable(s). Dung in stables is removed to manure arable fields, but the basal layers of the dung accumulation which have become trampled and phosphate soaked during the over-wintering stabling period are difficult to remove (Bakels, Bottema and Reynolds, 1992, pers. comm.) and may have been less frequently carried to the fields. This floor deposit – a phosphate 'cemented' crust of compacted phytolith-rich bedding and manure, and underlying phosphate-stained chalky soil floor, seems to have been removed and disposed of by burning at White Horse Stone. Models for the management of animals/animal dung can be found in various reviews cited above and in Macphail *et al*. (1997) and Viklund *et al*. (1998), for example. The character of the burned stabling waste suggests that both cattle and some omnivores (pigs) were present. No obvious sheep/goat coprolites or faecal spherulites were noted, as for instance found in highly burned (and phosphatic) middle Saxon midden deposits on chalk at West Heslerton, and ash-rich LBA/EIA Chisenbury, Wiltshire (Macphail *et al*., forthcoming). The ash-rich deposits in pits at LBA/EIA Battlesbury are also comparable (Macphail and Crowther, 2002).

Sample 145, from the lower part of pit 2214, shows not only a fill containing anthropogenic materials that have been already described (animal trampled? turf; burned chalky and Quaternary 'soils', omnivore? coprolitic material, and phosphate-stained chalk soil and phosphate-embedded phytoliths, as indicated by BL autofluorescence)(Figs 15 and 16), but also dominant amounts of burned cereal processing waste (straw?, chaff, grain). Again, these findings are mirrored by the extremely high χ_{conv} (52.6%) and clear signs of phosphate enrichment (phosphate-P, 6.02 mg/g).

Overall, the early-middle Iron Age feature fill data provide a wide insight into the lifestyle of the settlement, with the following being recognisable:

- Beaten, domestic house floor formation,
- A hearth(s) attaining near-*industrial* level temperatures,
- Animal stables,
- Cereal processing, and
- Outside areas where natural grassland soils were affected by low intensity animal trampling, dung inputs, 'middening' and related scavenging by animals and possible disposal of 'latrine' waste.

It can be noted that many of these activities were, and continue to be, replicated (apart from middening *sensu stricto*) at Butser Ancient Farm, and are ubiquitous to numerous late prehistoric and historic sites, and as also recorded at Potterne, Wiltshire (Lawson, 2000; Macphail, 2000; Reynolds, 1979, 1981, 1987, 1994).

6 CONCLUSIONS

6.1 Hunter-gatherers

Although only the merest trace of a possible human impact (e.g., fine charcoal) was noted in the Pleistocene soils, people were certainly present in the UK, e.g. Goughs Cave (Stringer, 2000). A *c*. 600 year long(?) period of soil stability and 'temperate' climate during the Allerød can be recognised from the formation of mature rendzina soils, even though these became eroded and reworked during the Younger Dryas (Appendix 1, Table 10). The long held view that the Allerød was marked by cool episodes severe enough to cause Allerød soils to form mud-flows into valleys cannot be proven on the basis of the evidence at White Horse Stone. Moreover, the suggested maturity of the rendzina soil fragments would argue better for a lengthy period of slope stability, before becoming eroded in the Younger Dryas. In fact, there is an undisturbed and *in situ* pararendzina formed in Older Dryas limestone talus at King Arthur's Cave where there was a definite human presence (Barton, 1997; Macphail *et al*., 1999; Stringer, 2000), again indicating a lack of severe climatic 'working' before the Younger Dryas – which at King Arthur's Cave caused the palaeosol to be buried by another talus deposit.

6.2 Early agriculturists (the Neolithic)

As the only soil evidence for this period is from posthole and 'gully' fills, most of the findings concern the use of the structure. Nevertheless, the fills suggest that humic rendzinas are locally present. The 'natural' soil that contributed to the infills can be as humic (e.g. M473) as the 'later' mature rendzina soil found in the subsoil hollow at Pilgrim's Way. This shows that the local soils had not been eroded, or were little eroded, in the early Neolithic period.

Sample M529 also demonstrates that humic rendzinas were also present locally in the late Neolithic.

As far as can be confidently determined, the structure was used primarily for domestic occupation, with the micromorphology and bulk data consistent with the formation of a trampled/beaten soil floor enriched with rare fine bone fragments, small artefacts and burned material from a combustion zone – no location for a definitely contemporary hearth being found. As shown at Butser, these posthole fills likely formed during the early history of the structure (first 15 years). There was no evidence of animals being stabled in the structure, although one highly burned and phosphate rich fill could possibly have the same origin – dumped burned dung – as shown at the early-middle Iron Age settlement. Unfortunately there was not a thin section study of this Neolithic fill to support this highly conjectural theory.

'Soils' between the Neolithic and early-middle Iron Age: The only clue to this period comes from the subsoil hollow at Pilgrim's Way, which shows a mature rendzina soil fill formed out of soil that had been influenced by a moderate amount of occupation. This soil certainly developed during a stable period before the main episode of early-middle Iron Age ploughing, which led to the formation of the ploughsoil colluvium. Without recourse to other soil samples from the intervening periods it is impossible to attempt reconstruct the landscape history between the Neolithic and the Iron Age. All that can be stated is that a ploughed (arable) colluvial rendzina soil was present by the early-middle Iron Age, and grassland (mull) humic rendzinas were extant in and around the settlement, upslope of the prehistoric palaeosol (see below).

6.3 Farming communities – Early-middle Iron Age landscape

Analyses of late prehistoric palaeosols and early-middle Iron Age feature fills yield a rich array of evidence to aid the reconstruction of the landscape. Firstly, the settlement deposits show evidence of mixed farming – arable (cereal processing) and stock raising (e.g. use of stables/byres for over-wintering of cattle?, presence of pigs?, animal trampled turf) – with a hearth(s) employing possible near-industrial temperatures, and typical domestic structure occupation. It seems likely that some manuring of the arable soils down slope took place, employing settlement waste, but not at high intensities although chemical measurements of phosphate may reflect the diluting effects of colluviation in the palaeosol. This probably helped maintain organic matter levels and biological activity and associated soil stability. Nevertheless, the palaeosol shows increasing evidence of slope soil instability, probably through rill and gully erosion that have been recorded across the chalk of southern England. The consequent concentration of run-off caused soils to slake, and led to the removal of rendzina topsoils. This also resulted in the erosion of gravel size chalk as the chalk substrate became exposed.

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APPENDIX 1: TABLES 2-10

Table 2: Micromorphology counts

Sample	Profile (Layer) / Feature	Rel. depth	Microfacies	Voids	Flint gravel	Chalk gravel	Biogenic calcite grains	Earthworm/slug granules	Root pseudomorphs	Burrowing	Intercalations etc	Secondary CaCO3	Excrements <100 um	Charcoal	Flint flake?	Pottery/daub	Bone	Coprolite	Exotic rock material?	Phytoliths	P-stained material	Burned soil	Anthropogenic soil	Dung?
142	Pit 4164	150-230	G4	25%		+++	++++	++	+++	+++++		++++	++	++			+*			+++	?	+++++	+++	
143a	Pit 4164	270-350	G3	40%		+++++	+	++		+++++		+	+++	+++			+5	+2	+1		?		+++++	+*
143b	Posthole 4350	250-330	G2	20-30%	++	++++	++++	++	+++	+++++		++++	+	++					+++	+	+	+++++	+++	+*
144	Pit 2214	540-660	G1	30-40%			++	+	+	+++		+++		(+++)						+++++	++	+++++	+++++	+*
145	Pit 2214	700-780	G1	40%		++++	++	+	+++	+++	(+++)	+++		+++++		+			+	+++++	+	++	+++++	+*
112	B (4144)	0-75	C	30-40%	+	++++	+	+	+	+++++	+*	+	+	++		+*	+1							
113	B (4144)	0-75	C	30%	+'*	++++	++	+	+++++	++++	+*	++	+*	+										
115	B (4144)	0-75	C	25% (60%)	+	+++++	++	+	+++++	++	+++	++	+*	+*		+-2			+4					
114	B (4144)	0-50	C	20-30%	++	+++++	+	++	+*	+++	+++	+	+	+*			+1							
114	B (4151)	50-75	C	30%	+'*	+++++	+	++	+*	+++++	+	+	++	+*										
104	A (4149/4960)	180-255	C	30-40%	++	++++	++	+		+++++	+++	++	+	+*					+1					
302	G (4935)	110-127	D2	30-40%		+++++	+	+	+	+++	++	++++	+	+*										
302	G (4935)	127-137	D1	20-25%		+++	+	+'*	+*	+	+++	+++	+	+*										
302	G (4935)	137-185	D2	30-40%		+++++	+	+	+	++++	++	++++	+	+			+2							
298a	F (4144)	140-215	C	30-40%		+++++	+	++	+*	+++	+*	+++++	+	+++			+3							
298b	F (4144)	215-290	C	30-40%		+++++	+	++	+*	+++	+*	++++	+	+++										
299	F (4933)	400-475	C	10%		+++++	+	+	+		+++	+++++	+*	+*										
300a	F (4934/4935)	530-605	D2	10-20%		+++++	++	+*	+++	+++++	++	+++++	++	++										
300a	F (4935)	565-585	D1	10-15%		+++	+	+*	+	++	+++	+++++	+	+*										
300a	F (4935)	585-605	D2	10-20%		+++++	++	+*	+++	+++++	++	+++++	++	++										
300b	F	605-680	A1/D	20%		+++++	++	+*	+++	++++	+++	+++++	+	+										

Sample	Profile (Layer) / Feature	Rel. depth	Microfacies	Voids	Flint gravel	Chalk gravel	Biogenic calcite grains	Earthworm/slug granules	Root pseudomorphs	Burrowing	Intercalations etc	Secondary CaCO3	Excrements <100 um	Charcoal	Flint flake?	Pottery/daub	Bone	Coprolite	Exotic rock material?	Phytoliths	P-stained material	Burned soil	Anthropogenic soil	Dung?
	(4935/4936)		1																					
301	F (4936)	680-755	A1	10-20%		+++++	+	+*	+++	+++	+++++	+++++	+	+*										
98a	Ib (857)	0-75	C	50-60%		++	++	++		+++++	++		+	++		+1								
98b	Ib (960)	23-25	A1	25%		++	+++	+*	+++	++++	+++++	+++	+	+*										
98b	Ib (960)	25-28	B	25%	+	++++	+++	++	+	++	+++	+++	+*	+*	+1									
98b	Ib (960)	28-30.5	A1	20%		++	+++		+++	++++	++++	+++	+	+*										
98c	Ib (961)	30.5-31.5	A1	20%		++	+++		+++	++++	+++++	+++++	+	+*										
98c	Ib (961)	30.5-38.0	A1	20-30%		+	+++		+++	++++	+++++	++++	+	+*										
98d	Ib (920)	38-45.5	A1	20-30%	+*	+	+++		+++	++	+++++	++++	+	+*										
92a	Ia (857)	0-75	C	30-40%	+	++	+	+	+	+++	++	+	+	+++		+1	+3							
92b	Ia (857)	75-150	E/C	30-40%	+	++	+	+	+	++++	+	+	+	+++			+3		+*					
92c	Ia (923)	360-435	E	20%	+*	++	+++	++	+++	+++++		++	+	+++			+1							
473	Posthole 4886		F1	25-30%	++	+++++	++	++	++	+++++		+	+	++++	+1	+1	+2							
529	Posthole 4830		F3	25-30%	++	+++++	++	++	++	+++++		+	+	+++			+2							
618	Gully' 5155		F2	30-40%	+	+++++	++	++	++	+++++	+	+	+	+++			+1							
625	Posthole 4834		F2	25-30%	+*	+++++	++	++	+++	+++++		+	+	+++++			+4							

+ - rare <2% (+* - trace 1%; +1, single occurrence etc.), ++ - occasional 2-5%, +++ - many 5-10%, ++++ - abundant 10-20%, +++++- very abundant >20%

Table 3: Soil micromorphological descriptions and associated bulk data

Fieldwork event	**Feature/ sequence**	**Facies/SMT**	**Sample No./Unit**	**Soil Micromorphology (SM), Bulk Data (BD)**	**Comments and *Interpretation***
ARC PIL98	Profile Ib	Facies C (SMT 1 and 3)	M98a	0-75 mm SM: heterogeneous, with SMT 1 and SMT 3; *Microstructure* open fine prismatic and coarsely burrowed microstructure, 50-60% voids, very dominant poorly accommodated macro-planar voids (3 mm) and chambers; *Mineral*: Coarse: Fine, C:F 60:40; *Coarse Mineral*: as SMT 1, with very few chalk gravel (max. 6 mm); *Coarse organic, biogenic and anthropogenic*: an example of fine sand size burned (blackened) soil; frequent biogenic calcite (earthworm granules, slug plates and calcite crystal (30 µm) burrow-liners?), and mollusc shell – some possibly humic stained/burned; occasional fine charcoal, an example of pottery (6 mm; clay and clay clast matrix, with fine sand size flint and quartz temper); *Fine fabric*: SMT 3: dominant, speckled and dotted darkish brown and areas of yellowish brown (PPL), heterogeneous – patches of low and high interference colours (close porphyric, speckled and crystallitic b-fabric, XPL), dark yellowish brown with black inclusions (OIL); abundant humic staining, many fine charred and amorphous organic matter (rounded fine charcoal); *Pedofeatures*: *Textural*: rare thin (60 µm) dusty 'chalky' void coatings; rare relict (biologically worked) fragments of intercalations/infills; *Fabric*: very abundant fabric mixing/burrowing (max. 6 mm); *Excrements*: strongly excremental fabric with very abundant very broad (2-6 mm) organo-mineral excrements and rare very thin (100 µm) excrements. BD: LOI = 3.95%, = 43.8 x 10^{-8} SI, $_{max}$ = 778 x 10^{-8} SI, $_{conv}$ = 5.63%, phosphate-P = 1.16 mg/g, phosphate-P_i:P = 53.4% – possibility that soil may have been affected by burning.	Layer 857 – Iron Age ploughsoil Heterogeneous soil formed out of humic topsoil, more clayey subsoil and inwashed and burrow mixed calcareous hillwash. Presence of fine charcoal, pot and biologically mixed textural pedofeatures testify to likely ploughsoil colluvial origin; and subsequent burial by further colluvium. *Ploughsoil colluvium with strong anthropogenic signal.*
ARC PIL98	Profile Ib	Facies A1 Facies B Facies A1 (SMT 1a)	M98b	230-305 mm: 230-250 mm (Facies A) – fine prismatic with few included coarse material; rare slug and earthworm biogenic calcite. 250-280 mm (Facies B) – fine prismatic with common coarse inclusions (such as slug plates and earthworm granules, flint flake?), and horizontal/platy? junction to, 280-305 mm (Facies A) – massive with few included coarse material, strongly $CaCO_3$ cemented, as M98c SM: as Facies A, but with Facies B at 250-280 mm: common coarse inclusions of gravel-size chalk (max. 6 mm), some angular, a single angular flint fragment (flake)(3 mm), also many whole and fragments of earthworm granules (max. 0.5 mm) and slug plates; possible browned/burned slug plates, humus-stained or burned mollusc shell; rare charcoal (150 µm); SMT 1a – as SMT 1, but with occasional to many fine amorphous and charred organic matter; coarse silt infills – elutriated fill/wash of quartz and biogenic calcite grains?; very abundant intercalations, void infills and secondary micrite. BD: LOI = 2.29%, = 16.4 x 10^{-8} SI, $_{max}$ = 437 x 10^{-8} SI, $_{conv}$ = 3.75%, phosphate-P = 0.631 mg/g, phosphate-P_i:P = 61.0% – shows no evidence of enhancement or phosphate enrichment, though values are slightly higher than in samples below.	Layer 960 – Periglacial As below, but with a 30 mm thick coarse soliflual deposit containing chalk and flint gravel (flake?) and earthworm granules and slug plates, along with slightly higher amounts of organic matter and fine charcoal. This wash helped cause the calcitic cementation of the lower part of 98b and upper 98c. *Cool Interstadial deposit with relatively high energy coarse wash deposit eroding coarse material from local area, including possible anthropogenic materials.*

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
ARC PIL98	Profile Ib	Facies A1 (SMT 1 with SMT 2)	M98c	305-380 mm SM: As M98d, but with very few fine sand-size quartz, 3 mm size soil clasts in addition to chalk gravel; mixing of SMT 1 and 2; marked cementation – secondary deposition of micritic calcite in uppermost 10 mm. BD: LOI = 1.71%, = 10.2 x 10^{-8} SI, $_{max}$ = 372 x 10^{-8} SI, $_{conv}$ = 2.74%, phosphate-P = 0.530 mg/g, phosphate-P$_i$:P = 69.4% – shows no evidence of enhancement or phosphate enrichment.	Layer 961 - Periglacial As below, with major calcitic cementation of 305-315 mm. *Cool-temperate Interstadial soliflual-colluvial chalky soil.*
ARC PIL98	Profile Ib	Facies A1 (SMT 1 with SMT 2)	M98d	380-455 mm SM: slightly heterogeneous (very few SMT 1 and very dominant SMT 2); *Microstructure*: dense massive with relict channel microstructure; 20-30% voids, very dominant fine (1 mm) vughs, with very few vesicles – formed out of relict very dominant fine to medium (2-3 mm) channels and chambers; *Mineral*: Coarse:Fine, C:F 40:60; *Coarse Mineral*: dominant coarse silt to very fine sand size angular to subangular quartz, with common coarse silt and fine sand size calcite (biogenic?; in 600 µm concentrations) and fossil fragments, very few fine sand-size quartz and chalk, very few to few silt-size mica, glauconite and opaques (limonite etc); rare traces of fine gravel size flint (2 mm), fine sand-size brown clay and rare subrounded chalk (5 mm; some weathered); *Coarse organic, biogenic and anthropogenic*: rare traces of charcoal, many calcitic root pseudomorphs (some with relict humic staining); *Fine Fabric*: SMT 1: very few coarse sand-size patches of, speckled yellowish brown (PPL), very low interference colours (close porphyric, speckled (with rare patches of crystallitic) b-fabric, XPL), darkish orange (OIL); occasional humic staining and fine amorphous organic matter, rare traces of phytoliths; SMT 2: very dominant speckled and cloudy darkish grey brown (PPL), high interference colours (close porphyric, crystallitic b-fabric, XPL), yellowish orange (OIL); rare amorphous and charred organic matter; *Pedofeatures*: *Textural*: very abundant calcitic intercalations and void infills/coatings merging with calcitic hypocoatings (200 µm) and forming closed vughs and vesicles; *Crystalline*: very abundant 60-150 µm wide micritic void coatings merging with void hypocoatings, sometimes containing silt indicative of calcitic soil inwash; occasional development of microcrystalline calcite edges to infills; rare traces of pseudomycelia, many 'root' cell pseudomorphs; *Amorphous*: occasional very fine Fe/Mn impregnations; *Fabric*: fabric mixing by burrowing mesofauna (1 mm), including possible local working of calcite root pseudomorphs; *Excrements*: rare very thin (90 µm) calcitic excrements, but many concentrated in root channels. BD: LOI = 1.46%, = 12.4 x 10^{-8} SI, $_{max}$ = 558 x 10^{-8} SI, $_{conv}$ = 2.22%, phosphate-P = 0.512 mg/g, phosphate-P$_i$:P = 75.6% – shows no evidence of enhancement or phosphate enrichment.	Layer 920 - Periglacial Highly calcareous soil containing much chalky material – fine to gravel; and silt-size quartz etc. ('loess'?); evidence of structural collapse (calcitic intercalations and infills producing closed vughs and vesicles) pene-synchronous with high biological activity (rooting and burrowing); later rooting (large number of root channels with relict 'root' material), effected by further inwash and meso-faunal activity. Rare mixing of poorly calcareous 'loessic' soil. Further secondary cementation by micritic (pseudomycelia) occurred. *Bio-active generally fine 'colluvial' soil, with rooting and faunal activity interspersed with soil collapse and soil sedimentation – with inwash of calcareous water. Erosion/colluviation affecting rare non-calcareous 'loessic' soils. Cool-temperate Interstadial soliflual-colluvial soil.*
ARC PIL98	Profile Ib	Facies C (SMT 3)	M92a	0-75 mm SM: homogeneous crumb to subangular blocky microstructure 4 mm size charcoal, semi-rubefied fragment of clayey daub (4mm) with indications of being slaked, with included organic matter and likely cereal phytolith; trace amounts of bone/nightsoil; very dominant SMT 3; occasional intercalations and associated matrix void coatings (20 µm); generally total excremental fabric with broad organo-mineral excrements. BD: LOI = 4.69%, = 54.2 x 10^{-8} SI, $_{max}$ = 927 x 10^{-8} SI, $_{conv}$ = 5.85%,	Layer 857 – Iron Age ploughsoil Organic matter and fine charcoal-rich soil, with coarse anthropogenic inclusions of charcoal and burned daub, and textural feature indications of past ploughsoil origin (cf. Butser Ancient Farm and Balksbury Camp). *Ploughsoil colluvium and topsoil formation with strong anthropogenic signal. (Iron Age)*

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
				phosphate-P = 1.75 mg/g, phosphate-P_i:P = 60.1% – possibility that soil may have been affected by burning.	
ARC PIL98	Profile Ib	Facies E/C (SMT 3)	M92b	75-150 mm SM: as M92c, subangular blocky and crumb microstructure, with SMT 3, with many areas of non-calcareous soil; occasional chalk gravel, mainly many very fine charcoal with rare traces of coarse charcoal (1 mm), very fine bone/nightsoil; example of ferruginous inclusion (4 mm) – rust flake/hammerscale?; rare intercalations and thin (100 µm) thick dusty clay void coatings; almost total excremental fabric.	Layer 857– Iron Age ploughsoil Colluvial ploughsoil with moderate anthropogenic signal; here a strongly biologically worked and moderately mature soil.
ARC PIL98	Profile Ib	Facies E (SMT 3)	M92c	360-435 mm SM: homogeneous with dominant channel and coarse subangular blocky microstructure; 20% voids, dominated by fine to medium channels; occasional chalk gravel and traces of charcoal and bone; SMT 3 (mainly speckled b-fabric) with rare traces of phytoliths; very abundant fine amorphous and charred organic matter; very abundant earthworm granules, slug plates, landsnail shell and biogenic calcite from root pseudomorphs and fragmented root pseudomorphs; total excrement fabric; very abundant medium (500 µm) and broad (3-5 mm) organo-mineral excrements. BD – Sample 923a (360-410 mm): LOI = 5.61%, = 58.3 x 10^{-8} SI, $_{max}$ = 893 x 10^{-8} SI, $_{conv}$ = 6.53%, phosphate-P = 1.71 mg/g, phosphate-P_i:P = 53.7% – possibility that soil may have been affected by burning. BD – Sample 923b (410-440 mm): LOI = 4.05%, = 45.9 x 10^{-8} SI, $_{max}$ = 632 x 10^{-8} SI, $_{conv}$ = 7.26%, phosphate-P = 1.31 mg/g, phosphate-P_i:P = 57.5% – possibility that soil may have been affected by burning.	Layer 923 – base of hollow Highly humic, totally biologically worked soil containing few chalk clasts compared to soils elsewhere indicating a relatively mature topsoil (once decalcified); large amounts of fine charcoal and traces of very fine bone indicate a likely mid-Holocene origin. *Mature late prehistoric humic rendzina topsoil with moderately strong anthropogenic signal (charcoal and traces of bone) in subsoil hollow.*
ARC WHS98	Profile F	Facies C (SMT 3)	M298a	140-215 mm SM: mainly homogeneous, with SMT 3 (and more humic variants); *Microstructure* open fine prismatic and coarsely burrowed (fine blocks and crumbs) microstructure, 30-40% voids, very dominant poorly accommodated medium planar voids (0.5-1 mm) and chambers (2 mm); *Mineral*: Coarse:Fine, C:F 60:40; *Coarse Mineral*: as SMT 1, with dominant chalk gravel (max. 5 mm); *Coarse organic, biogenic and anthropogenic*: examples of fine sand size burned (blackened) soil; frequent biogenic calcite (earthworm granules, slug plates), and mollusc shell – some possibly humic stained/burned; occasional fine charcoal (1 mm); 3 examples of very fine (200 µm) bone; *Fine fabric*: SMT 3: dominant, speckled and dotted darkish brown and areas of yellowish brown (PPL), mainly high interference colours (close porphyric, speckled and crystallitic b-fabric, XPL), dark yellowish brown with black inclusions (OIL); very abundant humic staining, abundant fine charred and amorphous organic matter (rounded fine charcoal); *Pedofeatures*: *Crystalline*: very abundant micritic impregnation of microfabric; loose pseudomycelia infills and root pseudomorphs; *Fabric*: very abundant fabric mixing/burrowing (max. 1-3 mm); *Excrements*: almost total excremental fabric, with very abundant very broad (2-6 mm), many thin (500 µm) and occasional very thin (100 µm) organo-mineral excrements.	Layer 4144 Highly humic, fine charcoal and coarse chalk-rich soil, containing trace amounts of bone, and displaying very high levels of biological activity; subsequently 'cemented' by secondary $CaCO_3$. *Accretionary ploughsoil colluvium, with high levels amorphous and charred organic matter and possible bone fragments, as further likely evidence of manuring.*

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
ARC WHS98	Profile F	Facies C (SMT 3)	M298b	215-290 mm SM: as Facies C, SMT 3, and as M98a, but without obvious bone fragments.	Layer 4144 Accretionary humic and charcoal-rich ploughsoil containing chalk stones, and with fine structures reflecting ploughing and high levels of biological activity
ARC WHS98	Profile F	Facies D1 (SMT 1, with 2)	M299	400-475 mm SM: Homogeneous facies D1, massive and extremely compact (10%) and cemented with dominant chalk gravel (max. 10 mm); occasional Fe/Mn staining of chalk margins; rewelded clasts and intercalations with secondary micrite; inclusions of fragmented land snail and other biogenic calcite.	Layer 4933 *High energy soliflual (mudflow/solifluction) deposit, rich in gravel to stone-size chalk; little biological working. cool climate deposit (upper dryas)*.
ARC WHS98	Profile F	Facies D1 and D2 (SMT 1, 2, 3 and 4)	M300a	530-605 mm 530-565 mm: Facies D2 – chalk gravelly humic soil (as upper M300b). 565-585 mm: Facies D1 – fine calcareous layer. 585-605 mm: Facies D2 – chalk gravelly humic soil (as upper M300b). SM: Heterogeneous with 20-40 mm beds and coarse mixing – infilling of fissures in D2 with D1; D2: *Microstructure*: massive with relict blocky structure, burrows and channels; 10-20% voids – closed vughs and relict channels (2 mm); *Mineral*: as SMT 3, with frequent chalk gravel, common SMT 1a soil mixtures, occasional non-calcareous SMT 2 and strongly humic SMT 2, along with occasional fine charcoal; SMT 4, generally speckled and dotted darkish brown and cloudy greyish brown (PPL), moderate interference colours (close porphyric, crystallitic b-fabric, XPL), brown and grey with many brown and black specks (OIL); many fine charred and amorphous organic matter; *Pedofeatures*: as facies A1 and A2; intercalations and secondary micritic hypocoatings and thin infills, sometimes pseudomorphic of roots; abundant burrowing and very thin to very broad organo-mineral excrements. D1: as SMT 1, calcitic C:F 40:60; 10-15% voids, closed vughs, few to frequent chalk gravel; rewelded earthworm excrements; base of D1 layer above lower D2 layer, is marked by a up to 1 mm thick calcitic pan in places.	Layer 4935 Composed of several layers/beds; lowermost and uppermost are relatively high energy chaotic chalk gravel- and soil-rich (humic to calcitic soils) fan deposits that show burrowing and rooting; followed by lower energy chalky mud flows? *Intermittent cool-temperate (seasonal) Interstadial valley deposits reflecting relatively high and low energy soliflual deposition, interspersed with high biological activity; local eroded soils showing an anthropogenic impact (fine charcoal).*
ARC WHS98	Profile F	Facies A1 and D1 (SMT 1 and 1a [and 2])	M300b	605-680 mm SM: as below, but more open (20% voids) relict of burrowing; similarly chalk gravel-rich, with humic stained and weathered chalk clasts (part right way-up), and occasional to many fine amorphous organic matter and rare traces of charcoal (SMT 1a); rare clasts of sand-size humic SMT 2 and major relatively humic soil burrow fill.	Layers 4936/4935 Moderately cemented biologically worked soliflual (periglacial) soil, with evidence of near in situ humic soil formation and burrowing from above.
ARC WHS98	Profile F	Facies A1 (SMT 1)	M301	680-755 mm SM: Homogeneous; *Microstructure*: massive and compact; 10-20% voids, dominant closed vughs and relict root channels and burrows; *Mineral*: as SMT 1, with common angular to subangular chalk gravel (max. 8 mm); *Pedofeatures*: as Facies A, calcitic intercalations, infills, cemented with micrite and root pseudomorphs.	Layer 4936: $CaCO_3$ cemented biologically worked soliflual (periglacial) soil.
ARC WHS98	Profile G	Facies D (SMT 1, 2, 3 and 4)	M302	110-185 mm 110-127 mm: Facies D2 – chalk gravelly humic soil (possible soil clasts up to 5 mm); frequent root fine and medium (max. 1 mm) channels and common	Layer 4935 Very similar to as 4935 in Profile F; represents chaotic

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
				burrowing. 127-137 mm: Facies D1 – fine calcareous layer; very dominantly burrowed. 137-185 mm: Facies D2 – chalk gravelly humic soil; dominant coarse (3mm)(root) channels, that do not connect with overlying layers; 2 x very fine sand-size 'bone' fragments; rare fine charcoal (max 2 mm); example of fine sand-size amorphous and cellular OM (dung?). SM: Heterogeneous with 10 mm beds and coarse mixing; D1 – SMT 1; D2 (mixed SMT 1, 2, 3 and 4).	soil, chalk and biogenic (landsnail, earthworm and slug granules) material deposition D2 (along with rare charcoal, and traces of bone and 'dung'(?)), and soil formation (including major rooting); then major truncation and deposition of finer D1; followed by a further coarse chaotic deposition and soil formation again. *Moderate high energy colluviation; pedogenesis; truncation and fine chalky deposition; further moderate high energy colluviation; soil formation.*
ARC WHS98	Profile A	Facies C (SMT 3)	M104	180-255 mm SM: homogeneous, with SMT 3; *Microstructure* open fine prismatic and coarsely burrowed (fine blocks and crumbs) microstructure, 30-40% voids, very dominant poorly accommodated medium planar voids (0.5-1 mm) and chambers (2 mm) with partially infilled (root) channels now 0.7 mm wide and examples of fine closed vughs and vesicles; *Mineral*: Coarse:Fine, C:F 60:40; *Coarse Mineral*: as SMT 1, with dominant chalk gravel (max. 13 mm) and frequent flint (max. 11 mm) and example of sand-size sandstone (exotic?); *Coarse organic, biogenic and anthropogenic*: frequent biogenic calcite (intercalary crystals, earthworm granules, slug plates), and mollusc shell – some possibly humic stained/burned; occasional fine charcoal (2 mm); *Fine fabric*: SMT 3: dominant, speckled and dotted darkish brown and areas of yellowish brown (PPL), mainly high interference colours (close porphyric, speckled and crystallitic b-fabric, XPL), dark yellowish brown with black inclusions (OIL); very abundant humic staining, abundant fine amorphous organic matter and occasional charred and rounded fine charcoal; *Pedofeatures*: *Textural*: occasional to many apparent intercalations associated with closed vughs etc; *Crystalline*: occasional micritic impregnation of microfabric and associated thin hypocoatings; rare traces of loose pseudomycelia infills; *Fabric*: very abundant fabric mixing/burrowing (max. 1-3 mm); *Excrements*: strong excremental fabric, with very abundant very broad (2-6 mm), many thin (500 µm) and occasional very thin (100 µm) organo-mineral excrements.	Layers 4149/4960 *Ploughsoil colluvium showing anthropogenic inclusions (flint and charcoal) and features of structural collapse.*
ARC WHS98	Profile B	Facies C (SMT1 and 3)	M112	SM: moderately homogeneous with mainly humic and moderately charcoal-rich SMT 3 and frequent SMT 1; occasional very fine (0.5-1 mm) rounded pot fragments and charcoal (<1 mm); example of sand-size charred dung? associated with and including fine charcoal; mainly total excremental fabric with thin to very broad organo-mineral excrements.	Layer 4144/4144(4160) *Strongly biologically worked prehistoric ploughsoil colluvium with strong anthropogenic signal (charcoal, pot and manure); topsoil formation.*
ARC WHS98	Profile B	Facies C (SMT 1)	M113	SM: as M155 below, homogeneous SMT 1, with abundant root pseudomorphs and an almost total excremental fabric; rare fine charcoal present.	Layers 4144/4144(4160) *Strongly biologically worked prehistoric ploughsoil colluvium with weak anthropogenic signal.*
ARC WHS98	Profile B	Facies C (SMT 1)	M115	SM: generally homogenous with mainly SMT 1 and few SMT 3, but with a relatively compact (25% voids) lowermost part (40-75 mm) and a much more open (up to 60% voids) upper part; *Lower part*: as SMT 1 with very abundant chalk gravel, shows many intercalations, pan-like fills and closed vughs, and very abundant biogenic fine (40-50 µm) calcite	Layers 4144/4144(4160) Dense colluvial chalk soil affected by fine rooting and associated secondary $CaCO_3$ deposition, latterly very coarsely burrowed?/ploughed which mixed in 'exotics' including ferruginous material and a

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
				crystals often apparently pseudomorphic of roots and clustered roots generally 1 mm in width, and often with humic matter on the outside of the 'root' channel effectively decalcifying the surrounding soil – with a 50 µm wide depletion hypocoating; thin, later calcitic wash around some root pseudomorphs. *Upper part*: very abundant chalk gravel with rare flint and several 'exotic' ironstone/weathered 'hammerscale' and a single example of sand-size pottery; again abundant root pseudomorphs in compact (25% voids), but with a 40 mm wide burrow (or plough mark) of loose chalk gravel, 'exotics' and soil (60% voids).	fragment of pot. Ploughsoil colluvium, with indications of disturbance (ploughing) and manuring.
ARC WHS98	Profile B	Facies C (SMT 1 and 3):	M114	SM: 0-50 mm (4144): heterogeneous with SMT 1 and 3, fine organic inclusions, very abundant chalk gravel, with occasional flints (max. 9 mm), traces of charcoal (1 mm) and one 500 µm size brown-stained bone/coprolitic fragment (nightsoil?); very abundant biogenic remains, but some of the granules appear part-weathered; although generally biologically open, some areas have rather low porosity – 20% - due to many intercalations forming from calcareous inwash up to 3 mm wide and characterised by closed vughs (e.g., 200 µm wide); very coarse (5 mm) mixing burrowing in evidence. 50-75 mm (4151): relatively homogeneous SMT 1 and more humic SMT 3, with very abundant chalk gravel (max. 7 mm) and high levels of biological activity (abundant humus-stained land snail shell, earthworm granules, slug plates and earthworm intercalary crystals) and trace amounts of charcoal; open with 30% voids – medium planes and chambers and frequent closed vughs associated with rare intercalations and thin (20 µm) matrix coatings; very abundant very thin (50-100 µm) to very broad (4 mm) organo-mineral excrements. Burrowed and mixed boundary to 4144 above.	Layers 4151/4144 Two layers formed in ploughsoil colluvium, with 4151 showing a rather long period of biological topsoil formation prior to renewed ploughsoil colluviation and burial, co-eval with continuing ploughing and biological activity; with evidence of manuring. *Ploughsoil colluviums with moderate anthropogenic signals, and intermittent strong biological working.*
ARC WHS98	4886	Facies F1 (SMT 5a and 5b)	M473	0-75 mm SM: Moderately homogeneous; *Microstructure*: fine crumb and complex packing/vughy microstructure; 25-30% voids, dominant fine vughy developed from complex packing voids (secondary carbonate infills) with frequent poorly accommodated fine planar voids; *Mineral*: Coarse:Fine, C:F 70:30; *Coarse Mineral*: as SMT 1, with dominant chalk gravel (max. 11 mm); *Coarse organic, biogenic and anthropogenic*: many landsnail shells; occasional earthworm and slug biogenic calcite with many calcitic root pseudomorphs; rare coarse charcoal (max. 3 mm), 11 mm edge of larger pottery fragment (silty clay with sand-size angular mainly burned flint temper), 1x likely fine sand-size flint flake and rare traces of very fine sand-size brown-stained bone (x2); *Fine fabric*: very dominant SMT 5a: black dotted very dark reddish brown (PPL), non-birefringent, very low to moderately high interference colours (open and close porphyric, isotic and crystallitic b-fabrics, XPL), yellowish brown with many areas of dark yellowish brown and blackish brown, with many black and rare red specks (OIL); humic with humic staining and amorphous organic matter with very abundant very fine charcoal; few SMT 5b, as SMT 5a, but speckled and dotted reddish brown (PPL), with (only) many to abundant fine amorphous and charred organic matter; *Pedofeatures*: *Crystalline*: very abundant micritic impregnation and many pseudomycelia and fibrous micritic infills and cementation; very abundant moderately thin to very broad organo-mineral excrements.	Posthole fill 4887, early Neolithic structure 4806. Earthworm-worked posthole fill of humic rendzina/brown rendzina soil, that contains very high amounts of fine charcoal that probably originated from the trampling of scattered combustion zone debris – as also implied by relatively high % χ_{conv}. A flint flake, a pot fragment and two very fine bone fragments indicate domestic use. A posthole fill of much trampled humic and fine charcoal-rich domestic (?) occupation surface soil.

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
				BD: LOI = 4.09%, = 99.8 x 10^{-8} SI, $_{max}$ = 413 x 10^{-8} SI, $_{conv}$ = 24.2%, phosphate-P = 0.937 mg/g, phosphate-P_i:P = 53.0% – relatively high LOI, strong signs of burning, and possible indication of phosphate enrichment (cf. other posthole fills; Table 5).	
ARC WHS98	4834	Facies F1 (SMT 5b with 5a)	M625	0-75 mm SM: moderately homogeneous with more SMT 5a than 5b, with very abundant chalk gravel and a large (15 mm) flint; fewer anthropogenic materials compared to M473, with only many very fine charcoal and two coarse silt-size bone. *Pedofeatures*: as M473. BD: LOI = 2.57%, = 48.9 x 10^{-8} SI, $_{max}$ = 247 x 10^{-8} SI, $_{conv}$ = 19.8%, phosphate-P = 0.850 mg/g, phosphate-P_i:P = 62.9% – strong signs of burning, and possible indication of phosphate enrichment (cf. other posthole fills; Table 5).	Posthole fill 4835, early Neolithic structure 4806 As 473, but with fewer included fine charcoal and anthropogenic materials, but all seemingly domestic in origin. A posthole fill of trampled poorly humic and fine charcoal enriched domestic (?) occupation surface soil.
ARC WHS98	5155	Facies F2 (SMT 5b with 5a)	M618	0-75 mm SM: moderately homogeneous with more SMT 5a than 5b; very abundant chalk gravel; more (30-40%) void space compared to M473 and M625, with large (3-4 mm) and partially root pseudomorph-infilled complex packing voids being dominant, and fewer fine closed vughs and fine vesicles in places; rare anthropogenic materials (1 coarse silt-size bone fragment) although some concentrations of very fine charcoal present; 'whole' snail shell present; *Pedofeatures*: as M473, but with occasional intercalations and associated coatings forming closed vughs and vesicles of SMT 5b. BD: LOI = 2.19%, = 37.5 x 10^{-8} SI, $_{max}$ = 170 x 10^{-8} SI, $_{conv}$ = 22.1%, phosphate-P = 0.642 mg/g, phosphate-P_i:P = 56.1% – strong signs of burning, but no evidence of phosphate enrichment.	Gully fill 5156, early Neolithic structure 4806 Similar to posthole fills, but more open and biologically worked, in addition to showing some structural collapse/inwash of chalky soil (SMT 5b). Mixing of more anthropogenic SMT 5b. *Possibility of original 'gully' being affected by chalky soil inwash, and later biological mixed infill from charcoal-rich trampled soil. Overall anthropogenic signature being a little lower than M473 and 625, because floor less intensively 'used' by wall?*
ARC WHS98	4830	Facies F3 (SMT 5c with 5a)	M529	0-75 mm SM: moderately homogeneous; *Structure*: loose crumb and subangular blocky microstructure; 20-30% voids, medium channels and complex packing voids; *Coarse Mineral*: as SMT 1, with dominant chalk gravel (max. 7 mm); *Coarse organic, biogenic and anthropogenic*: (biogenic as M627) rare coarse charcoal (max. 4 mm), with several (x4) fine sand-size grey coloured (PPL) burned bone fragments; possibility of phosphate stained matrix in places (blue light autofluorescent); *Fine material*: frequent SMT 5a, with very dominant SMT 5c: blackish to dotted very dark brown (PPL), non-birefringent (open porphyric, undifferentiated b-fabric, XPL), very dark brown and black (OIL); very abundant fine charred organic matter with rare rubefied mineral grain; *Pedofeatures*: as M627. BD: LOI = 4.28%, = 80.1 x 10^{-8} SI, $_{max}$ = 247 x 10^{-8} SI, $_{conv}$ = 29.2%, phosphate-P = 4.34 mg/g, phosphate-P_i:P = 84.1% – very strong signs of burning and clear indication of phosphate enrichment.	Hearth, fills 4831/5202 late Neolithic. A biologically-worked posthole fill with a marked anthropogenic signature – fine charcoal-rich with burned bone, of likely domestic occupation/combustion zone /trampled floor origin. Anthropogenic signature reinforced by marked phosphate-P concentration – although % χ_{conv}. is similar for all Neo fills. *Late Neolithic hearth fill with very strong anthropogenic signature of domestic (?) occupation.*
ARC WHS98	4164	Facies G1 (SMT 9 with 6 and 7)	M142	150-230 mm SM: heterogeneous; *Microstructure*: coarsely (max. ~10mm) burrowed massive; 25% voids, very dominant complex packing voids; *Mineral*: as M144, with frequent chalk gravel (max. 9 mm): *Coarse organic, biogenic and anthropogenic*: many patches (e.g., 12 mm across) of articulated phytolith dominated fabric with scatter	Upper fill of Iron Age pit 4164 Highly burrowed (small mammal and earthworm and insect?) cereal ash and burned subsoil (Pleistocene) and turf deposit. *Biologically worked pit fill of burned cereal*

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
				of residual micritic ash ('burned cereal waste' as Facies G1), many burned shell, and biogenic calcite (granules and plates), fine charcoal-rich, blackened and black 'occupation turf' (SMT 8; worked in as burrow and earthworm burrow fills) and very abundant weakly rubefied soil (see SMT 9); with rare examples of included spores and limpid clay clasts; *Fine fabric*: SMT 9: bright orange to grey yellowish brown, speckled (PPL), generally medium to high interference colours with edges and parts that are isotic (close porphyric, crystallitic and undifferentiated b-fabric, XPL), brown to bright yellowish brown (OIL); rare to many amorphous organic matter and staining – calcitic and non-calcitic soil (strongly to unburned soil originating from mainly from Pleistocene levels/subsoils?); burned soil associated with cereal ash/phytoliths; *Pedofeatures*: *Crystalline*: very abundant calcitic (sparitic) root pseudomorphs and scattered pseudomorphic material; *Fabric and Excrements*: very abundant coarse (10 mm) and very broad (2-4 mm) burrowing with with very thin (<100 µm), thin (<500 µm) and broad to very broad (1-4mm) organo-mineral excrements. BD: LOI = 3.34%, = 202 x 10^{-8} SI, $_{max}$ = 502 x 10^{-8} SI, $_{conv}$ = 40.2%, phosphate-P = 3.92 mg/g, phosphate-P_i:P = 89.8% – extremely strong signs of burning and clear indication of phosphate enrichment.	*processing waste and burned subsoil and 'occupation turf'.*
ARC WHS98	4164	Facies G3 (SMT 8)	M143a	270-350 mm SM: moderately homogeneous; *Microstructure*: broadly layered with crumb to subangular blocky; 40% voids, complex packing voids, very poorly accommodated planar voids, some coarse (1-2 mm) channels; *Coarse Mineral*: as SMT 1, with dominant chalk gravel (max. 14 mm), some showing partial dissolution; *Coarse organic, biogenic and anthropogenic*: many land snail shell, commonly organic stained, with slug and earthworm biogenic calcite; very dominant 'occupation turf' and subsoil (see below SMT 8), with embedded silt-size coprolitic(?) bone (x6) and 2 pale colourless coprolites (300 and 600 µm) containing cereal(?) plant material (human?); *Fine fabric*: SMT 8: dotted and speckled very dark reddish brown (PPL), isotic with patches of high interference colours (close porphyric, undifferentiated and crystallitic b-fabric, XPL), very dark brown with black specks (OIL); very abundant charred and amorphous organic matter and strong humic staining in places; rare examples of fungal bodies and coarse amorphous organic matter; *Pedofeatures*: *Excrements*: almost total biological fabric, with very thin (<100 µm), thin (<500 µm) and broad to very broad (1-4mm) organo-mineral excrements. BD: LOI = 9.02%, = 120 x 10^{-8} SI, $_{max}$ = 763 x 10^{-8} SI, $_{conv}$ = 15.7%, phosphate-P = 2.13 mg/g, phosphate-P_i:P = 61.9% – notably high LOI, clear signs of burning, but only limited evidence of phosphate enrichment.	Lower fill of Iron Age pit 4164 Turf and chalk gravel 'dump' in lower pit fill. Very biologically active turf is highly humic (dung-stained?) with high amounts of fine charcoal and a scatter of very fine likely coprolitic bone, and two possible small human coprolites. *A layer of mainly 'occupation turf' showing ubiquitous inclusion of fine likely human and scavenging animal coprolitic material, with colour of turf and high levels of bioactivity suggesting waste inputs from stock.*
ARC WHS98	4350	Facies G2 (SMT 6 and 7)	M143b	250-330 mm SM: Heterogeneous, massive with burrowed microstructure; 20-30% voids, very dominant complex packing voids; *Mineral*: as M144; *Coarse organic, biogenic and anthropogenic*: very abundant biogenic calcite including root pseudomorphs, earthworm and slug biogenic calcite, with several burned pieces; thin section dominated by anthropogenic material – mainly burned; occasional white burned small gravel size flint, browned and darkened burned chalk gravel (some chalk has been phosphatised (BL autofluorescent); dominant burned (partially rubefied with 'red' iron-rich minerals) daub – composed of sandy loam and calcareous sandy	Iron Age posthole (-pipe) fill 4351. Posthole fill showing early infill of very strongly (vesicular slag-like siliceous material) to strongly burned (various plant and dung-tempered) daub, flint and chalk – along with some small pieces of charcoal; and later burrowed-in chalky beaten(?) floor soil. Two phase infill of 1) burned daub, soil, chalk, flint and vitrified material, and 2) later burrowed-in occupation beaten floor deposits.

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
				loams tempered with straw(?) other monocotyledonous plant (daub up to 13 mm long; also dung-tempered daub showing weak phosphate content (BL autofluorescent), and loams with added clay clasts; occasional charcoal (max. 2.5 mm); rare (x5) vitrified soil/slag, siliceous with vesicles and embedded silt size quartz; abundant (earthworm and small mammal burrowed-in) chalky occupation soil (as SMT 6), containing fine charcoal, earthworm and slug granules, organic fragments, land snail shell fragments (possible beaten floor origin); *Pedofeatures*: *Crystalline*: all calcite seems to be secondary – biogenic of roots (as in the site as a whole); very abundant (*fabric*) burrowing, with 13 mm wide (small mammal) burrow fill (with secondary broad earthworm and likely very thin Collembola organo-mineral excrements) and many very broad (3 mm) earthworm excrements. BD: LOI = 3.31%, = 160 x 10^{-8} SI, $_{max}$ = 405 x 10^{-8} SI, $_{conv}$ = 39.5%, phosphate-P = 3.05 mg/g, phosphate-P_i:P = 84.2% – extremely strong signs of burning and clear indication of phosphate enrichment.	
ARC WHS98	2214	Facies G1 (SMT 7)	M144	540-660 mm SM: layered microstructure; with central charcoal-rich layer and ash layers; 30-40% voids, complex packing voids; *Mineral*: few 'natural' mineral in the form of silt-size quartz; *Coarse organic, biogenic and anthropogenic*: very dominant well-sorted sand to coarse sand-size rubefied anthropogenic chalky soil (SMT 6); occasional sand-size yellow stained (PPL), phosphate-rich (BL autofluorescent) fragments of articulated sheets of phytoliths and embedded bran/omnivore-like coprolitic and stabling crust-like material (3-4 mm in length), occurring in phytolith-rich fine fabric (SMT 7); many biogenic calcite; *Fine fabric*: SMT 7: blackish, dirty grey with yellow-stained areas (PPL), generally isotic with low and patches of high interference colours (open porphyric, isotic and crystallitic b-fabric, XPL), whitish to yellowish grey with rare black and red specks (OIL); very abundant , often long articulated phytoliths, with abundant blackish (burned) amorphous organic matter staining, with rare calcitic ash; rare traces of fungal bodies present; *Pedofeatures*: very abundant (fabric) burrowing (fine to broad – 2 mm). BD – Sample 144a: LOI = 3.53%, = 95.5 x 10^{-8} SI, $_{max}$ = 257 x 10^{-8} SI, $_{conv}$ = 37.2%, phosphate-P = 49.7 mg/g, phosphate-P_i:P = 96.0% – extremely strong signs of burning and phosphate enrichment (exceptionally high phosphate-P concentration, suggesting concentrated mineralised phosphate present). BD – Sample: LOI = 1.64%, = 81.1 x 10^{-8} SI, $_{max}$ = 298 x 10^{-8} SI, $_{conv}$ = 27.2%, phosphate-P = 9.97 mg/g, phosphate-P_i:P = 91.8% – extremely strong signs of burning and phosphate enrichment; low LOI may be a result of burning.	Iron Age pit 2214 Fill of well-sorted sand-size fragments of burned anthropogenic occupation soil and ashed Poaceae material – that is extremely phytolith-rich, and contains phosphate-stained long articulated phytoliths, and possible omnivore and herbivore dung fragments. *Enigmatic, but possible burned dung heap/stabling waste and included occupation soil waste, that was washed into the pit base(?).*
ARC WHS98	2214	Facies G4 (SMT 6 and 7)	M145	700-780 mm SM: heterogeneous with coarse layering – e.g., central 25 mm thick charcoal layer; massive with subangular blocky microstructure; 40% voids, dominant complex packing voids; *Mineral*: Coarse:Fine, C:F 60:40; *Coarse Mineral*: dominant subangular and sub-rounded chalk gravel (max. 18 mm); with frequent coarse silt and sand-size angular to subangular quartz, calcite and fossil fragments, with silt-size mica, glauconite and opaques (limonite etc) and flint; *Coarse organic, biogenic and anthropogenic*: many to very abundant charcoal (fragmented, with likely inclusions of straw stem(?), chaff and grains), often associated with very abundant	Iron Age pit 2214, charred grain and ash. Complicated anthropogenic pit fill giving dominant evidence of cereal processing (straw, chaff and grain charcoal, ash and siliceous remains – including articulated phytoliths), with the inclusion of enigmatic phosphate-stained material (organic coprolitic/stabling crust material and phosphatised chalk) and dung-enriched chalky soils, anthropogenic (muddy) trampled chalky soils (weakly rubefied), and

Fieldwork event	Feature/ sequence	Facies/SMT	Sample No./Unit	Soil Micromorphology (SM), Bulk Data (BD)	Comments and *Interpretation*
				phytoliths, many grouped and articulated ~0.5-1 mm in length (SMT 7), and with totally ashed sections through 'straw' showing central void and phloem void system (max. 0.5 mm), with scatter of occasional to many fine calcitic ash – mainly calcite with rare calcium oxalate (druses); rare enigmatic phosphate-stained (non-birefringent but strongly BL autofluorescent) materials, including yellow-stained articulated sheets of phytoliths (coprolitic-bran?/stabling floor crust?) and BL autofluorescent chalk and chalky soil fragments, with non-birefringent, non-fluorescent edges (burned phosphatised chalk?); occasional burned soil, including highly humic turf (max. 2 mm) and 'exotic' clay-with-flints-like subsoil; very abundant 'anthropogenic' chalky soil (SMT 6) with many charcoal, amorphous organic matter, sometimes a vesicular and vughy/intercalatory ('trampled') fabric, and with amorphous and plant fragment characterised ('dung'-enriched) fabric; example of fine sand-size charred amorphous organic coprolite? (pig type?); biogenic calcite (earthworm granules, slug plates and root pseudomorphs present; *Fine fabric*: SMT 6 – dotted and speckled cloudy yellowish to pinky grey (PPL), moderately high interference colours (open porphyric, crystallitic b-fabric, XPL), yellowish grey, with many black and rare red inclusions (OIL); many charred and amorphous organic matter; *Pedofeatures*: very abundant (fabric) burrowing and abundant very broad organo-mineral excrements. BD: LOI = 3.06%, = 112 x 10^{-8} SI, $_{max}$ = 213 x 10^{-8} SI, $_{conv}$ = 52.6%, phosphate-P = 6.02 mg/g, phosphate-P_i:P = 92.0% – extremely strong signs of burning and phosphate enrichment.	fragments of burned humic turf and clay-with-flints-like subsoil. All has been biologically worked *Iron Age pit fill showing evidence of purposeful discard of cereal processing waste, along with the accidental inclusion of anthropogenic occupation soils (sometime pink-burned), local and 'exotic' soils mixed up with burning, and traces of soils and phosphate-stained material of likely to possible animal management origin.*

NB:

Microfacies Type A1 (SMT 1 with SMT 2): *Bio-active generally fine 'colluvial' soil, with rooting and faunal activity interspersed with soil collapse and soil sedimentation – with inwash of calcareous water. Erosion/colluviation affecting rare non-calcareous 'loessic' soils. Cool-temperate Interstadial soliflual-colluvial soil – so-called solifluction 'diamict'.*

Microfacies Type B (SMT 1a): *Cool Interstadial deposit with relatively high energy coarse wash deposits showing erosion of coarse material from local area, including possible anthropogenic materials – mass-movement erosion of slope (Allerød) palaeosols formed under temperate conditions.*

Microfacies Type C (SMT 1 and 3): *Generally bio-active ploughsoil colluvium with weak to strong anthropogenic signal, e.g., structures from ploughing and sometimes with high levels amorphous and charred organic matter and possible bone fragments, as further likely evidence of manuring. Sometimes interspersed or buried by massive high-energy chalky subsoil colluvium.*

Microfacies Type D1 and D2 (SMT 1, 2, 3 and 4): *Intermittent cool-temperate (seasonal) Interstadial valley deposits reflecting relatively high and low energy soliflual deposition, interspersed with high biological activity; local eroded soils showing an anthropogenic impact (fine charcoal) – Upper Dryas erosion of Allerød soils and valley sediments.*

Microfacies Type E (SMT 3): *Mature late prehistoric humic rendzina topsoil with moderately strong anthropogenic signal (charcoal and traces of bone) in subsoil hollow.*

Microfacies Type F1 (SMT 5a and 5b): Early Neolithic posthole fill of much trampled humic and fine charcoal-rich domestic (?) occupation surface soil.

Microfacies Type F2 (SMT 5b with 5a): *Possibility of original 'gully' being affected by chalky soil inwash, and later biological mixed infill from charcoal-rich trampled soil. Overall anthropogenic signature being a little lower than M473 and 625, because floor less intensively 'used' by wall?*

Microfacies Type F3 (SMT 5c with 5a): *Late Neolithic posthole fill with very strong anthropogenic signature of domestic (?) occupation.*

Microfacies Type G1 (SMT 6 and 7): *Iron Age pit fill material, variously containing phytolith-rich ashed cereal processing waste, charcoal, highly phosphate rich ashed stabling debris and burned soil of local rendzina (turf)- SMT 7 and trampled chalky occupation soil – SMT 6.*

Microfacies Type G2 (SMT 6): Iron Age posthole fill, dominated by burned chalk, flint, and various plant- and dung-tempered daub, along with strongly burned (vesicular slag-like) soil; and showing later burrowed-in occupation (beaten floor?) chalky soil.

Microfacies Type G3 (SMT 8): A layer of mainly 'occupation turf' showing ubiquitous inclusion of fine likely human and scavenging animal coprolitic material, with colour of turf and high levels of bioactivity suggesting waste inputs from stock.

Microfacies Type G4 (SMT 9): Biologically worked pit fill of burned cereal processing waste, with debris from and burned (Pleistocene) subsoil, stabling waste and 'occupation turf'.

Table 4: Analytical data for samples from Pilgrim's Way subsoil hollow and later contexts from White Horse Stone

Sample	Context	Description	LOI (%)	χ (10^{-8} SI)	χ_{max} (10^{-8} SI)	χ_{conv} (%)	Phosphate-P_i (mg/g)	Phosphate-P_o (mg/g)	Phosphate-P (mg/g)	Phosphate-P_i:P (%)	Phosphate-P_o:P (%)
Pilgrim's Way											
92a	857	IA ploughsoil	4.69	54.2	927	5.85	1.05	0.696	1.75	60.1	39.9
98a	857	IA ploughsoil	3.95	43.8	778	5.63	0.62	0.542	1.16	53.4	46.6
92c	923a	Hollow fill: 36-41 cm	5.61	58.3	893	6.53	0.918	0.790	1.71	53.7	46.3
92c	923b	Hollow fill: 41-44 cm	4.05	45.9	632	7.26	0.751	0.554	1.31	57.5	42.5
98b	960	Periglacial deposit	2.29	16.4	437	3.75	0.385	0.246	0.631	61.0	39.0
98c	961	Periglacial deposit	1.71	10.2	372	2.74	0.368	0.162	0.530	69.4	30.6
98d	920	Periglacial deposit	1.46	12.4	558	2.22	0.387	0.125	0.512	75.6	24.4
White Horse Stone											
142	4164	IA pit fill	3.34	202	502	40.2	3.52	0.398	3.92	89.8	10.2
143a	4164	IA pit fill	9.02	120	763	15.7	1.32	0.813	2.13	61.9	38.1
143b	4351	IA posthole fill	3.31	160	405	39.5	2.57	0.483	3.05	84.2	15.8
144a	2214	IA pit fill	3.53	95.5	257	37.2	47.7	2.01	49.7	96.0	4.0
144b	2214	IA pit fill	1.64	81.1	298	27.2	9.16	0.813	9.97	91.8	8.2
145	2214	IA pit fill	3.06	112	213	52.6	5.54	0.484	6.02	92.0	8.0
529a	4831/5202	L Neo posthole fill	4.28	80.1	274	29.2	3.65	0.668	4.34	84.1	15.9

Table 5: Analytical data for samples from posthole fills of early Neolithic structure 4806

Sample	Context	Description	LOI (%)	χ (10^{-8} SI)	χ_{max} (10^{-8} SI)	χ_{conv} (%)	Phosphate-P_i (mg/g)	Phosphate-P_o (mg/g)	Phosphate-P (mg/g)	Phosphate-P_i:P (%)	Phosphate-P_o:P (%)
473a	4887	Posthole 4886?	4.09	99.8	413	24.2	0.497	0.440	0.937	53.0	47.0
625a	4835	Posthole?	2.57	48.9	247	19.8	0.535	0.315	0.850	62.9	37.1
367	5118	Posthole 5117?	2.53	33.3	201	16.6	0.304	0.269	0.573	53.1	46.9
368	5116	Posthole 5115	2.52	34.4	166	20.7	0.321	0.238	0.559	57.4	42.6
372	4849	Posthole 4848	1.94	21.8	235	9.28	0.388	0.184	0.572	67.8	32.2
373	4856	Posthole 4855	1.52	13.7	183	7.49	0.355	0.159	0.514	69.1	30.9
376	4816	Posthole 4815	2.32	28.4	243	11.7	0.523	0.252	0.775	67.5	32.5
380	4858	Posthole 4857	1.85	22.0	126	17.5	0.385	0.203	0.588	65.5	34.5
400	4823	Posthole 4822	1.79	13.9	226	6.15	0.313	0.349	0.662	47.3	52.7
408	5004	Posthole 5003	2.35	26.2	177	14.8	0.357	0.272	0.629	56.8	43.2
414	5114	Posthole 5113	1.86	12.9	128	10.1	0.297	0.304	0.601	49.4	50.6
423	4906	Posthole 4905?	2.37	29.4	136	21.6	4.96	0.581	5.54	89.5	10.5
519	5021	Posthole 5019	1.87	25.1	151	16.6	0.330	0.167	0.497	66.4	33.6
535	5206	Posthole 5205	2.28	37.5	224	16.7	0.355	0.215	0.570	62.3	37.7
545	5146	Posthole 4809	2.31	30.3	137	22.1	0.482	0.237	0.719	67.0	33.0
548	5133	Posthole 4811	2.59	39.6	191	20.7	0.586	0.218	0.804	72.9	27.1
583	5030	Posthole 5028	1.60	18.7	95.0	19.7	0.350	0.158	0.508	68.9	31.1
640	5269	Posthole 5268	1.83	13.2	328	4.02	0.360	0.172	0.532	67.7	32.3
693	5292	Posthole 5291	2.58	35.4	100	35.4	0.356	0.193	0.549	64.8	35.2
694	5295	Posthole 5294	2.60	27.2	246	11.1	0.474	0.277	0.751	63.1	36.9
741	5328	Posthole 5327	2.06	22.9	173	13.2	0.421	0.248	0.669	62.9	37.1
781	5370	Posthole 5369	1.73	6.5	85.4	7.61	0.300	0.174	0.474	63.3	36.7

Table 6: Analytical data for samples of bedding gully fills of early Neolithic structure 4806

Sample	Context	Description	LOI (%)	χ (10^{-8} SI)	χ_{max} (10^{-8} SI)	χ_{conv} (%)	Phosphate-P_i (mg/g)	Phosphate-P_o (mg/g)	Phosphate-P (mg/g)	Phosphate-P_i:P (%)	Phosphate-P_o:P (%)
618	5155?	Bedding gully 5156	2.19	37.5	170	22.1	0.360	0.282	0.642	56.1	43.9
429	5155	Bedding gully	1.82	18.5	128	14.5	0.427	0.283	0.710	60.1	39.9
444	5031	Bedding gully	2.88	41.8	201	20.8	0.303	0.239	0.542	55.9	44.1
609	5155	Bedding gully	1.58	11.9	105	11.3	0.338	0.184	0.522	64.8	35.2
610	5155	Bedding gully	2.03	18.7	177	10.6	0.405	0.209	0.614	66.0	34.0

Table 7: Summary of LOI and magnetic susceptibility data

	n	Minimum	Maximum	Mean	Std dev
LOI (%)					
PW: Iron Age ploughsoils	2	3.95	4.69	4.32	0.523
PW: Base of hollow fills	2	4.05	5.61	4.83	1.10
PW: Periglacial deposits	3	1.46	2.29	1.82	0.426
WHS: IA pit fills	4	3.06	9.02	4.68	2.89
WHS: IA posthole fills	2	1.64	3.53	2.59	1.34
WHS: L. Neo posthole fill	1			4.28	
WHS: E. Neo posthole fills	22	1.52	4.09	2.23	0.544
WHS: E. Neo bedding gully fills	5	1.58	2.88	2.10	0.492
χ (10^{-8} SI)					
PW: Iron Age ploughsoils	2	43.8	54.2	49.0	7.35
PW: Base of hollow fills	2	45.9	58.3	52.1	8.77
PW: Periglacial deposits	3	10.2	16.4	13.0	3.14
WHS: IA pit fills	4	112	202	149	41.4
WHS: IA posthole fills	2	81.1	95.5	88.3	10.2
WHS: L. Neo posthole fill	1			80.1	
WHS: E. Neo posthole fills	22	6.5	99.8	29.1	18.8
WHS: E. Neo bedding gully fills	5	11.9	41.8	25.7	13.1
χ_{max} (10^{-8} SI)					
PW: Iron Age ploughsoils	2	778	927	853	105
PW: Base of hollow fills	2	632	893	763	185
PW: Periglacial deposits	3	372	558	456	94.4
WHS: IA pit fills	4	213	763	471	229
WHS: IA posthole fills	2	257	298	278	29.0
WHS: L. Neo posthole fill	1			274	
WHS: E. Neo posthole fills	22	85.4	413	191	77.7
WHS: E. Neo bedding gully fills	5	105	201	156	38.9
χ_{conv} (%)					
PW: Iron Age ploughsoils	2	5.63	5.85	5.74	0.156
PW: Base of hollow fills	2	6.53	7.26	6.90	0.516
PW: Periglacial deposits	3	2.22	3.75	2.90	0.778
WHS: IA pit fills	4	15.7	52.6	37.0	15.4
WHS: IA posthole fills	2	27.2	37.2	32.2	7.07
WHS: L. Neo posthole fill	1			29.2	
WHS: E. Neo posthole fills	22	4.02	35.4	15.8	7.24
WHS: E. Neo bedding gully fills	5	10.6	22.1	15.9	5.33

Table 8: Summary of phosphate data

	n	Minimum	Maximum	Mean	Std dev
Phosphate-P (mg/g)					
PW: Iron Age ploughsoils	2	1.16	1.75	1.46	0.417
PW: Base of hollow fills	2	1.31	1.71	1.51	0.283
PW: Periglacial deposits	3	0.512	0.631	0.558	0.0641
WHS: IA pit fills	4	2.13	6.02	3.78	1.66
WHS: IA posthole fills	2	9.97	49.7	29.8	28.1
WHS: L. Neo posthole fill	1			4.34	
WHS: E. Neo posthole fills	22	0.474	5.54	0.858	1.05
WHS: E. Neo bedding gully fills	5	0.522	0.710	0.606	0.0764
Phosphate-P_i:P (%)					
PW: Iron Age ploughsoils	2	53.4	60.1	56.8	4.74
PW: Base of hollow fills	2	53.7	57.5	55.6	2.69
PW: Periglacial deposits	3	61.0	75.6	68.7	7.33
WHS: IA pit fills	4	61.9	92.0	82.0	13.8
WHS: IA posthole fills	2	91.8	96.0	93.9	2.97
WHS: L. Neo posthole fill	1			84.1	
WHS: E. Neo posthole fills	22	47.3	89.5	63.6	8.91
WHS: E. Neo bedding gully fills	5	55.9	66.0	60.6	4.73

*Table 9: Pearson correlation coefficients (*r*)*[†] *for relationships between LOI, magnetic susceptibility and phosphate in posthole fills from the early Neolithic structure 4806 (*n *= 22)*

	χ	χ_{max}	χ_{conv}	**Phos-P$_i$**	**Phos-P$_o$**	**Phos-P**	**Phos-P$_i$:P**
LOI	0.873**	0.471*	0.588*	ns	0.588*	ns	Ns
χ		0.461*	0.696**	ns	0.444*	ns	Ns
χ_{max}			ns	ns	ns	ns	Ns
χ_{conv}				ns	ns	ns	Ns
Phos-P$_i$					0.634*	0.978**	0.724**
Phos-P$_o$						0.779**	ns
Phos-P							0.563*

[†] All variables except χ_{conv} and Phos-P$_i$:P have been $\log_{10}$ transformed to reduce skewness; only statistically-significant r values are shown: ns = not significant, * p≤0.05 (i.e. significant at 95% confidence level), ** p≤0.001 (i.e. significant at 99.9% confidence level).

Table 10: White Horse Stone: summary of Late Glacial stratigraphic history based upon soil micromorphology

Period	***WHS and Pilgrims Way valley floor***	***Local hypothetical valley slopes etc***
'Younger Dryas' phase 3	Cool climate down-slope solifluction and 'down-valley' soliflual accretionary deposition of chalk gravel-rich calcareous sediment and *seasonal* formation of very immature calcaric lithosols; *seasonal* post-depositional rooting and burrowing, but little evidence of earthworms.	Inferred cool climate erosion
'Younger Dryas' phase 2	Cool-climate solifluction deposition of inferred valley slope (Allerød) soil fragments; *seasonal* post-depositional rooting and burrowing, but little evidence of earthworms; coarse solifluction sedimentation interspersed with likely down-valley soliflual deposition of calcareous mud(s) containing chalk gravel.	Inferred cool climate erosion
'Younger Dryas' phase 1	Cool climate down-valley erosion of any *in situ* Allerød soils. (HIATUS)	Inferred cool climate erosion
Allerød	No preserved deposits or soils. (HIATUS)	Inferred temperate humic and brown rendzina formation, earthworms present; possible traces of human activity (fine charcoal)
'Older Dryas'	Cool climate down-slope solifluction and 'down-valley' soliflual accretionary deposition of chalk gravel-rich calcareous sediment and *seasonal* formation of very immature calcaric lithosols; *seasonal* post-depositional rooting and burrowing, but little evidence of earthworms.	Cool climate erosion