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The geoarchaeology of White Horse Stone and Pilgrim's Way, Aylesford, Kent

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1 INTRODUCTION

This report investigates the deposits contained within two dry valleys exposed during the excavation of the White Horse Stone group of sites (ARC WHS97, ARC WHS98, ARC PIL98 and ARC BFW98). Extensive excavations within these valleys identified significant Neolithic, Iron Age and later settlement evidence in close association with well preserved pedo-sedimentary sequences dating from the late Glacial period and to various periods within the Holocene. Detailed recording and sampling of the stratigraphy of the valley infills has provided the opportunity to study the soils and sediments with the view to elucidating environmental change and aspects of prehistoric landuse. Particular emphasis has been placed upon clarifying the processes of erosion and deposition operating within the valley over the last 14,000 years. Such processes are often complex and maybe naturally and anthropogenically induced. The effect of such processes on the preservation of the environmental and archaeological record at White Horse Stone can be seen to be extensive.

1.1 Geoarchaeological background

The sediment sequences at White Horse Stone are, on a broad level, fairly typical of dry valley deposits found on the chalklands of the south and southeast. Dry valleys or 'coombes' are a characteristic feature of the chalklands and occur in large numbers on the North Downs in Kent. The morphology of the valleys are described by Kerney *et al* (1964) ranging from significant landscape features, in places breaching the Downs escarpment, to smaller funnel like features dissecting the face of the escarpment from the crest. The valleys exhibit a high degree of variability, inferring a complex history of formation and subsequent infilling. Several workers have emphasized the role of fluvial action and spring sapping to explain their formation (Sparks and Lewis 1957, Small 1965), though periglacial processes, frost shattering and solifluction, are also cited (Kerney *et al*. 1964). It is most likely a combination of fluvio-glacial processes are responsible, the emphasis of each varying according to local environmental conditions (Ballyntayne and Harris 1994, Jones 1981). The deposits contained within the valleys are largely colluvial in origin. They often show a twofold division between material of Pleistocene periglacial origin forming the lower part of the sequences, and later deposits, predominantly hillwash of Holocene age.

The periglacial deposits frequently comprise coarse flint and chalk rubble, or 'coombe rock', resulting from frost-shattering of bedrock under intensely cold climates (Ballyntayne and Harris 1994, Kerney 1963), overlain by finer chalk silts and muds deposited by solifluction processes. Intercalated buried soils have occasionally been recorded indicative of periods of increased slope stability and climatic amelioration that occurred during the late Glacial period. Two periods of warmer climatic conditions, the Bølling and the Allerød

Interstadials, have been recognised in the southeast of England and in mainland Europe. These are separated by periods of intense climatic deterioration where temperatures east of England and mainland Europe may have returned to arctic conditions (the Older and Younger Dryas Stadials). Following from this there was then a gradual amelioration of climate approaching the Holocene. Much of the work on dry valleys in Kent has been concentrated on the sedimentology and biostratigraphy of the late Glacial deposits. Work was carried out in the 1960s, on the west side of the Medway gap at Holborough and Upper Halling (Kerney 1963, Preece 1994) Further south sites include Brook, Dover Hill and Castle Hill (Kerney *et al* 1964), and more recently work at Holywell Coombe near Folkstone (Preece and Bridgland 1998). Late Glacial buried soils have been identified at a number of these sites. Outside Kent sequences are rarer, but have been recorded in Dorset (Hearne and Birbeck 1999), Buckinghamshire (Evans 1966, Evans and Valentine 1974) West Sussex (Allen *forthcoming*) and on the Isle of Wight (Preece *et al* 1995).

As opposed to natural environmental processes inferred from earlier sequences, the overlying Holocene colluvial deposits are thought to have formed largely as a result of anthropogenic activities such as forest clearance and cultivation increasing the susceptibility of soils to erosion through the breakdown of structure and loss of nutrients. Only a small number of Holocene hillwash sequences have been investigated in detail from Kent and few of the published sites, with the exception of Holywell Coombe, appear to be associated with significant archaeological remains. This is in stark contrast to the substantial work that has been carried out on the chalklands of Wessex (Allen 1992, French *et al* 2003), the Chilterns (Evans 1966, 1972, Evans and Valentine 1974) and the South Downs (Wilkinson 2003, Bell 1983, Ellis 1986).

1.2 Site location, topography and land-use

The White Horse Stone group of sites are located on the eastern side of the Medway gap at the foot of the North Downs escarpment (Hayden 2006, figure 1). The plateau of the North Downs at this location reaches heights of up to 190m OD. The solid geology is middle chalk, though extensive drift deposits, predominantly clay with flints, cap the higher ground. The general trend of the escarpment in the vicinity of the site is aligned northwest to southeast, with steep southwest facing slopes incised by a series of dry valleys or ‘coombes’.

The ARC WHS98 and ARC PIL98 excavation areas lay within a large dry valley immediately below Bluebell Hill (referred to as the White Horse Stone dry valley). The head of the valley originates and cuts into the crest of the escarpment with the axis running broadly northeast southwest before veering southwards towards the plain below. The form of the valley is generally scalloped shaped although there is a marked asymmetry at the head in the northwestern sector where it appears to fork into two. The asymmetry of the valley is not unusual and has been noted in other dry valleys along the North Downs escarpment. Steeper west or south west facing sloped may be related to aspect ascribed to enhanced frost weathering as a result of greater frequency and deep thawing (Bridgland 1999:25). The steepest slopes are to be found on the back south-facing wall and on the eastern, west facing flanks. The angle of slope averages 15-20 degrees over approximately 50m in these areas, although locally there is much variation in some places reaching up to 35 degrees. From this point the valley is gently concave with the angle of slope much reduced averaging 4 degrees down the valley axis, although steeper slopes are noted on the eastern flanks. On the western flanks the angle of slope shallows, creating a plateau, between 86m and 88m OD for before dropping away again relatively steeply towards the valley bottom at approximately 70m OD (Hayden 2006 Figure 4).

Landuse in recent times on the middle and lower slopes has been largely arable cultivation, except for the northwestern area, which has been used as rough pasture. The steeper slopes towards the crest of the escarpment are currently under woodland. The modern line of the Pilgrim's Way trackway crosses the lower slopes of the valley east-west, perpendicular to the axis at approximately 75m OD before ascending the west facing flanks to 100m OD and following a route south-eastwards. The excavation areas were located on the upper western flanks of the valley at a maximum of 105m OD, extending south-eastwards crossing the valley axis just to the north of the Pilgrim's Way trackway (ARC WHS98), terminating towards the base of the valley to approximately 55-60m OD (ARC PIL98).

2 METHOD

2.1 Field recording and sampling

During the excavations a number of principle sections were cut specifically to investigate and sample the soils and sediments in detail. The 'late Glacial Section' was located on the lower slopes at the foot of the eastern flank of the valley immediately north of the Pilgrim's Way trackway. (Hayden 2006, figures 4-7). The 'Dry Valley Section' was aligned perpendicular to the valley axis approximately 60m to the north and ran from the eastern edge of the White Horse Stone site almost to early Neolithic structure 4806 (Hayden 2006, figures 5 and 7). A further section was cut through a large subsoil hollow in the base of the valley (Profiles Ia and Ib).

The sediment sequences were recorded in the field by measured section drawings, with each major stratigraphic unit allocated an individual context number. Detailed descriptions and sampling were carried out by the onsite geoarchaeologist , Dr Martin Bates, University of Lampeter, and Elizabeth Stafford (Oxford Archaeology). Where section logging was required standard geological terminology was used to record sequences used in Quaternary science

(Jones *et al*, 1999). As part of this work a large number of monolith, kubiena and incremental bulk disturbed samples were recovered to allow for further specialised investigation.

2.2 Assessment

Assessment of the site sequences and recommendations for further work was carried out by Dr Martin Bates (Bates 2001), Dr Richard Macphail (UCL) and Dr John Crowther (University of Lampeter)(Macphail and Crowther 2001). The aims and objectives of the geoarchaeological input focused on identifying and interpreting stratigraphy and buried soil horizons within contexts associated with the late Glacial and Holocene environments.

2.3 Analysis

All soil and sediment data collected during the both the excavation and evaluation at White Horse Stone has been considered during the analysis stage. Stratigraphical data, comprising a total of 219 individual location points was collated and inputted into geological modelling software (©Rockworks2004) in order map the spatial extent of major stratigraphical units and create surface elevation models of the areas of investigation (Hayden 2006, figures 3 and 4).

Individual profiles located at various points along these sections and considered to representative of the overall site sequences were selected for detailed analysis of micromorphology, chemical and magnetic properties (Macphail and Crowther 2006). Sediment descriptions have been made from monolith tins collected from open sections during the excavations, supported by the original field and assessment records.

2.3.1 Loss on ignition and magnetic susceptibility

Magnetic susceptibility (low and dual frequency) and loss on ignition (LOI) samples for each representative sediment profile were processed by Mark W. Hounslow and Vassil Karloukovski (Centre for Environmental Magnetism and Palaeomagnetism, Geography Dept., Lancaster University).Estimates were carried out on sub samples extracted from the monoliths and bulk disturbed samples. Sampling intervals comprised 5-10cm for the thick sequences of Holocene deposits, and 1-2cm for the late Glacial. For the LOI estimates 15-20 g of each sample were air dried, ground using a pestle and mortar, and sieved to < 2 mm. Two to 4 g of each sample were then placed in (already weighed) ceramic pots and placed in a drying cabinet at 40^{o}C overnight. Their mass was then measured immediately after taking them out of the cabinet. They were subsequently put in a pre-heated furnace, where they stayed for 4 hours at 550^{o}C. Afterwards they were allowed to cool down in a hermitically sealed dry-air cabinet and weighed again. In each case the weighing on an electronic balance was done with an accuracy of 3 decimal places. From these values the percent organic matter (%OM) was determined.

For the magnetic susceptibility estimates 10 g of the air-dried, ground and sieved material from each sample were placed in 10 cc plastic pots, wrapped in two 10x10 cm layers of cling film in order to immobilise the particles. We used 10 g rather than 5 g of material in order to increase the accuracy of the magnetic measurements – we suspected quite low values of the magnetic susceptibility, especially for the chalk-rich samples. The magnetic susceptibility was measured using a dual-frequency MS 2B susceptibility meter (Bartington Instruments Ltd.). In order to achieve the highest possible precision, we used a 6-measurement cycle routine using the 0.1 scale on the meter (see Chapter 4.4 in Walden *et al,* (1999)), which allowed for a linear correction of the drift of the meter. All measurements were also corrected for the (paramagnetic) susceptibility value of the plastic pots and the cling film. This blank-correction does not vary significantly between pots and so an average value of 0.42×10^{-10} m^3 was used (on the basis of values for 9 pots).

2.3.2 Particle size analysis

A broad % estimate of the stoniness of deposits has been obtained by weighing the residues from 2kg samples processed for molluscan analysis for Profiles C, F, Ia and J. Additional particle size estimations for the finer size grades (<2mm – 0.04 μm) carried out as part of a previous study on Profile F have been incorporated into this report. The data was calculated on 2g of sediment by laser granulometry (Coulter LS 230 Particle size Analyser). The results are expressed as percentages of the <2mm fraction based on volume. The datasets have also been compared to values for molluscan shell and in the case of the late Glacial sequence (Profile F) calcite granules, as these can provide useful evidence for detecting changes in the rate of sediment deposition. Calcite granules may be a product of the slug family Arionidae, or in the case of the crystalline form derives from the gut of earthworms, excreted as castings on the surface of the ground (Canti 1998) Concentrations of these granules often occur in soils forming under stable conditions (Canti 1998, Preece and Bridgland 1998, Preece *et al* 1995).

2.3.3 Micromorphology, phosphates, organic carbon and magnetic properties

Micromorphology thin sections and supporting bulk magnetic and chemical analysis (χ, χ_{max}, χ_{conv}, Total P, LOI) were processed from Profiles A and B (the Dry Valley section), F and G (the late Glacial section) and I (the subsoil hollow) along with a number of deposits from archaeological features. Further details can found in the report on micromorphology (Macphail and Crowther 2006).

2.3.4 Data presentation

The representative sample profiles are illustrated in figures 1-8. The location and profiles of the major dry valley sections are illustrated in the site report (Hayden 2006, Figs. 5, 6 and 7).

The sediment descriptions for each profile together with the tabulated results of the magnetic susceptibility, LOI and particle size data are presented in Tables 1-6.

3 RESULTS

3.1 Overview of site stratigraphy

The sediment sequences at White Horse Stone are fairly typical of dry valley deposits described above. On the upper western slopes within the excavation area topsoil directly overlay chalk bedrock. The middle and lower slopes were however blanketed by various thicknesses of chalky colluvium marked on the British Geological Survey maps as 'head' (Sheet no. 288 and 272). These deposits thicken considerably down the valley and towards the centre of the valley axis and form fans spreading out onto the plain below. The 'head' deposits can be divided into four broad groups:

- Late Pleistocene chalk rich slope deposits
- Late Pleistocene palaeosol
- Mid-late Holocene palaeosols
- Mid-late Holocene slope deposits

However within these broad groups there is much local variation, particularly within the slope deposits. The formation processes associated with these deposit types has been inferred from previous work undertaken on similar dry valley deposits (Allen 1992, Wilkinson 2003, Kerney 1963, Kerney *et al* 1964, Preece and Bridgland 1994).

The late Pleistocene slope deposits include:

1. Coarse flint and chalk rubble in a silty matrix (Coombe rock). Frost shattering of bedrock followed by mass movement under intense cold climate conditions (Ballyntayne and Harris 1994, Kerney 1963).
2. Fine calcareous and non-calcareous silts crudely stratified with lenses of chalk pellets. A result of pulsed input of sediment by solifluction/alluvial processes derived from erosion of chalk bedrock and other superficial deposits (loess?) from upslope.
3. Unstratified calcareous granular rich chalk silts/marls. Pulsed input of sediment by solifluction/alluvial processes derived largely from the erosion of chalk bedrock upslope under cold climate conditions.

The Holocene slope deposits include:

4. Beds of crudely stratified flint gravels of cobble to pebble sized clasts located on footslopes and valley axis. Sediments washed out of erosional gullies and larger rills to form fans in valley bottoms.

5. Thinly bedded granular and pebble sized chalk and or flint in silt matrix. Products of high energy rill erosion of gravel rich soils.
6. Poorly sorted unstratified calcareous and non-calcareous silts containing chalk and flint granules and small pebbles Sediment derived from sheet wash and rill erosion modified by post-depositional processes and possibly tillage. Originating from thin chalk soils on cultivated fields adjacent to valley bottom.
7. Moderately well sorted, stone-free silts and clay silts Inwash from sheet wash/rill erosion of adjacent arable fields or sediment deposited through low energy alluvial processes along valley axis.

3.2 Distribution and extent of deposits

It was not possible to map precisely the extent and thickness of the various Pleistocene sediments within the excavation areas since invariably only the surface of these deposits was exposed. A basal coarse flint and chalk gravel or coombe rock (Type 1) was noted to occur on the middle slopes and lower around the valley axis, overlying chalk bedrock. These deposits appeared to thicken down the valley axis and were noted to be approximately 3m thick in the vicinity of the Pilgrim's Way Trackway when the cutting for the tunnel portal was excavated. Overlying the coombe rock on the lower west facing slopes and in the base of the valley were deposits of finer chalky silts (Type 2 and 3). Intercalated within these silts at the base of the eastern flanks of the valley was a distinctive humic horizon interpreted as a redeposited late Glacial palaeosol. It was recorded in Evaluation Trench 3035, during the main phase of excavations in Profiles F and G (layer 4934, 4935), and during the cutting of through the Pilgrim’s Way trackway. It was not identified westwards towards the centre of the valley axis or to the south of the trackway (ARC PIL98).

Of particular note was the presence of large sarsen boulders occurring in numbers on the lower slopes and in base of the valley concentrated around the north-south axis (Hayden 2006, figure 3). Such a phenomenon has been observed at numerous localities either side of the Medway gap (Jessup 1970). It is thought they are formed through the cementation of sands aided by deposition of silica in solution. Their formation is dependent on the presence of a valley or landscape depression (Ullyott *et al*. 1998). The sarsens at White Horse Stone may have originally formed as localised (seasonal pool) deposits or as duricrust sheets (both associated with groundwater or drainage-line activity) but exist now as ‘silcrete fragments’ displaced by periglacial and solifluction events. The date of origin for silcrete formations is the subject of debate. Until recently work on these formations had indicated a Oligocene or earlier date, but now it is generally accepted that silcrete formation can occur under a variety of climates, and could have occurred much later, possibly even in the Quaternary (Ullyott *et* *al*. 2000). At White Horse Stone sarsens were particularly common in the south-eastern side of the site, in the base of the dry valley, where around 70 such boulders were found. There is no reason to suspect that these sarsens were anything other than local in origin. It is likely that the sarsen stones found in later, post-glacial deposits on the site have been moved from their original locations to clear the land for agriculture. It is thus difficult to be certain of the extent to which they would have been evident in the later prehistoric landscape. It is, however, possible that some were visible, and that others lay just below the ground surface (eg late Neolithic pit 911).

Within large subsoil hollow in the valley bottom (Profiles Ia and Ib) an undisturbed dark brown humic stone free silty loam was recorded. Worked flint from the base of the profile has been identified as diagnostically of late Neolithic date. The soil within the hollow was sealed by a more disturbed, stoney soil that extended over a much greater area around the valley axis between 64.75 and 82.50m OD (Profiles A, B, C, F, Ia, Ib). The evaluation trenching however identified this deposit extending eastwards but thinning markedly against the eastern slopes of the valley (Evaluation Trench 3035, layer 1124) beyond the areas of excavation. The northern limit was probably reached during the excavation as no corresponding unit was noted in Evaluation Trench 1117 at approximately 81-82m OD. Pottery sherds from the surface of the soil suggests it was extant up until the Roman period after which it was buried by slope deposits. Apart from where it overlies the subsoil hollow in the base of the valley this soil directly overlies late Glacial sediment and seals archaeological features dating to the Neolithic period. These features include the early Neolithic structure 4806, and later Neolithic pits and postholes. On the western slopes, immediately below the early Iron Age settlement this soil appeared to be more significantly disturbed than in other areas. It was lighter in colour, stonier and less humic. It likely at this location it been subject to a greater degree of disturbance and erosion. Towards the top of the slope a wide, shallow linear feature was has been interpreted as the remains of negative lynchet.

Apart from deposits contained within features, no deposits could be identified with certainty within the main dry valley sequences dating to the early-mid Holocene. On the edge of the western plateau a very localized deposit of fine-grained colluvial type material was identified truncated by ditch 4048 that was dated to the middle Bronze Age. These deposits contained molluscan species that did not arrive in Kent until after c. 5000BP (Stafford 2006), suggesting a pre-middle-Bronze Age date for deposition.

The Iron Age palaeosol was sealed by an extensive sequence of deposits. These deposits were thickest on the lower slopes of the valley and around the valley axis, reaching up to 2m in the vicinity of the Pilgrim's Way trackway. Within the areas of excavation they reached up to the 85m contour although the evaluation trenches identified these deposits up to 87m OD (Evaluation Trench 1118). In the valley bottom however, to the south of the

Pilgrim's Way trackway these deposits thin markedly to approximately 0.50m. The artefactual assemblages suggest the earliest deposits date to the Roman period, the latest the Medieval to Post-medieval period. Although the depositional processes associated with these deposits mean pottery dating may not be a reliable indicator it does provide a *terminus post quem* for the date of deposition. Archaeological features stratified within the upper levels of the colluvium within section 140 (Profiles A, B, C) on the lower slopes of the valley include a series of linear ditches interpreted as a trackway, possibly the line of the Rochester to Hastings Roman road. They were identified at the northern limit of the excavation area and ran parallel and continuously, aligned roughly north south down the valley axis to the valley bottom. Artefactual material suggests a Roman *terminus post quem* for the infilling of these features. This implies a large part the of the colluvial sequence cut by these features was deposited between the late Iron Age and Roman period in the vicinity of section 140. A relatively thin layer of colluvium sealing these features contained pottery of medieval and post medieval date. The colluvium overlying the buried soils in the subsoil hollow in the base of the valley, although thinner, also contained medieval and post medieval pottery in the upper levels. No dating however was retrieved form the lower levels directly overlying the later prehistoric buried soils. During the cutting through the Pilgrim's Way trackway, the Medieval trackway levels directly overlay and truncated thick deposits of colluvium. A human inhumation to one side of the trackway and cut into the top of the colluvium was dated to the Saxon period. No colluvium dating to the medieval period was identified at this location, as would be expected if the trackway was in continuous use from the medieval period onwards.

Overall the colluvial deposits varied greatly in texture both spatially and with depth and are interpreted as the product of various erosional processes, soil creep, sheet wash, rilling and gullying resulting from episodes of ploughing further upslope (see Type description above). Most notable within the colluvial deposits was the presence of distinctive flinty concentrations (Type 4) indicative of higher energy erosive events. Such lens were identified truncating the surface of the later Holocene buried soil when it was exposed in plan during the excavation. These appeared to be particularly concentrated at the foot of the western slope to the south of the Iron Age settlement. To the north of the excavation area in Evaluation Trench 1118, at c.87m OD, a localized 22 x 24m deposit of dark brown silt containing Beaker and Iron Age pottery, was noted overlying Pleistocene deposits. This unit contained a very high percentage of uncorticated poorly sorted flint and was interpreted as a gravel lag deposit. The description of the silt matrix however suggests the fines may represent reworked soil material possibly equivalent to the insitu palaeosol lower down the valley.

3.3 Representative sections

3.3.1 White Horse Stone late Glacial section (ARC WHS98)

The late Glacial section (Hayden 2006, Fig 5) was located on the lower slopes at the foot of the western flank of the White Horse Stone dry valley immediately north of the Pilgrim's Way trackway (Hayden 2006, Fig. 7). The deposits were recorded from an open face stepped section measuring 3.11m in depth. The modern ground surface lay at approximately 74.70m OD. The upper part of the section, comprising approximately 0.30m of topsoil and 2.01m of Holocene slope deposits, was not recorded in detail or sampled. Two Profiles were sampled through late Glacial sequence, Profiles F and Profile G.

Profile F

Profile F (Fig.1) was selected for detailed analysis. The lower part of Profile F, layers 4936, 4935, 4934 and 4933, represent the late Glacial sequence. This has been confirmed by radiocarbon dating and the analysis of the molluscan assemblages from these deposits which are unmistakably late Glacial in character. The overlying layer 4144 is equivalent to the later Holocene buried soil.

The earliest deposit was a layer of compacted, structureless, poorly sorted coarse, angular, chalk and flint rubble or 'coombe rock' (Type I). This top of this deposit marked the limit of excavation and was not sampled. The boundary between the coombe rock and overlying deposits was abrupt although undulating, probably as a result of frost heave.

Overlying the coombe rock, between 72-90cm, was a pale orangey brown chalky silt slope wash deposit (layer 4936 Type 2). The particle size data demonstrates a high percentage of coarse silt and fine sand in the <2mm fraction. A selected number of samples were decalcified using HCL and their subsequent particle sizes estimated. The results show that a high percentage of coarse silt and fine sand was non-calcareous. Although the mineralogy of the deposits was not examined in detail this does suggest are large component of reworked loessic material. However concentrations of chalky pellets, recorded as convoluted lenses running laterally within the main unit, suggest some exposure and frost shattering of chalk bedrock upslope under cold climate conditions. Values for $\chi_{lf,}$ χ_{fd} and LOI were very low along with shell numbers suggesting rapid deposition, limited vegetation cover and soil formation. The presence however of sub-vertical voids, possibly root channels, filled with secondary carbonate suggests the growth of some vegetation concurrent with sedimentation. In addition, shell abundance, although low, did vary somewhat up-profile. It is possible that although sedimentation was rapid it occurred incrementally. The fine-grained texture and relatively low clast concentration suggests alluvial deposition perhaps during seasonal spring thaws. In the intervening periods incipient pedogenesis may have occurred.

Overlying this unit, between 0.64-0.72m (layer 4935), was an undulating lens of dark greyish brown silt, intercalated with discontinuous thin laminae of white chalky silt. At its thickest this deposit measured 8cm. Both χ_{lf} and LOI values rose to a maximum of 2.27 and 3.84 respectively at the top of the unit. χ_{fd} values also rose to 3.84% along with mollusc shell and calcite granules. Together this suggests a period surface stability and increased pedogenesis. A radiocarbon date from charcoal fragments retrieved from this unit produced a date of 11,130±48 yr BP, which is consistent with other 'Allerød soils' investigated across southern Britain. The chalky laminae however, together with the sharp nature of the upper and lower contacts and undulating discontinuous morphology of the unit, indicate a degree of disturbance/truncation of the soil. This is in concurrence with the micromorphological evidence suggesting the soil was eroded from higher up slope and redeposited lower down the valley. This event may be related to climatic changes occurring towards the end of the Allerød period and the beginning of the Younger Dryas cold stage.

Between 0.45-0.64m there was a marked increase in the frequency and thickness of chalky lenses intercalated with lenses of more humic material. This is equivalent to layer 4934. It is likely that these deposits represent the continued disturbance and redeposition of the Allerød soil horizon into the base of the valley. The increase in chalky minerogenic material up-profile may represent an increase in the extent bare ground in the vicinity and the frequency and intensity of erosion as a result of deteriorating climatic conditions. χ_{lf}, χ_{fd}, and LOI values fluctuate markedly throughout these levels, the lowest values corresponding with the chalky lenses. The general trend however demonstrated decreasing values up-profile. Between 0.24-0.45cm (layer 4933, Type 3) the lithology changes markedly to a pale grey to white chalky diamict. Shells numbers drop significantly from 92 individuals at the base of the deposit to 19 at the top suggesting a hostile environment for molluscan life and rapid deposition of sediment. The χ_{lf} and LOI decrease consistently up-profile from 0.98 and 3.07 to a minimum of 0.42 and 2.40 respectively, although they do show a slight rise towards the top of the unit. The abrupt interface between the diamict and the lower more humic deposits represents a significant erosional contact. The increase in chalk pellets in the lower part of this unit also suggests higher energy deposition and an increase in the erosion of chalk bedrock upslope.

The later prehistoric palaeosol (layer 4144), between 0.00-0.24m, comprised a friable very dark greyish brown, almost black, silty loam (layer 4144). χ_{lf}, LOI and χ_{fd} values rose dramatically up-profile. Shell numbers also increased to a maximum of 355 individuals. There was no obvious B-horizon or worm-sorted zones within this soil and the abundance of chalk pellets throughout the profile and the abrupt interface with the underlying deposit suggests disturbance. The micromorphology report identifies this as a humic rendzina, disturbed possibly by tillage.

Profile G

Profile G (Fig, 2) and was located immediately adjacent to Profile F aligned north/south. Sample Profile G comprised 0.82m of late Glacial deposits. The sequence was very similar to that described above. Additional thin sections were processed through the palaeosol horizon for comparative purposes (Macphail and Crowther 2006).

3.3.2 White Horse Stone Holocene dry valley section (ARC WHS98)

The dry valley section (Hayden 2006, Fig. 7) was one of the principle sections excavated and recorded. It was aligned perpendicular to the valley axis, approximately 50m north of the late Glacial section, at the northern edge of the sarsen boulder distribution. Three profiles were sampled (A, B, C). Profile C (Fig.5) has been examined in detail for this report, as it is the sequence analysed for molluscan remains. Thin section analysis was undertaken on the buried soils in Profiles A (Fig.3) and B (Fig.4).

The overall stratigraphy comprised Pleistocene deposits at the base of the section, coarse flint and chalk rubble (Type 1) overlain by a light brown sandy silt (Type 2) Directly overlying this was the later prehistoric palaeosol, a very dark, humic silty loam (layer 4144). The upper part of this soil (layer 4960) appeared to be significantly disturbed with possible colluvial inputs. This was sealed by substantial thicknesses of slope deposits. In the western part of the section the overall thickness of Holocene deposits thinned against the rise of the underlying late Glacial deposits. The thickness of layer 4144 was markedly reduced westwards in Profile B and was completely absent in Profile A with a corresponding increase in the thickness of layer 4960. A discrete area of flint gravel (layer 4152, Type 4) occurred, overlying and probably truncating the palaeosol in the western part of the section. It consisted of up to 80% large (5-10cm) clasts and very little matrix. In plan this deposit appeared to be aligned with the valley axis and represents the product of gullying during a high-energy erosional event. Pottery recovered from the lower part of the deposits was predominantly of early-middle Iron Age date. Intercalated within the slope deposits two linear features 4004, 4006 were recorded. These features are interpreted as defining a trackway and Roman pottery was identified from the fills of these features. The overlying slope deposits produced pottery of medieval and post medieval date.

Profile C

Between 120-145cm (layer 4551 Type 2) a light brown sandy silt was recorded directly overlying coarse flint and chalk rubble (Type 1). Overlying this between 92-120cm was a very dark, humic silty loam (layer 4144). χ_{lf}, and χ_{fd} values shell numbers where high within this unit increasing up-profile to a maximum of 8.18, 11.76 and 353 individuals respectively at 95-100cm. These levels are comparable to those recorded in layer 4144 in Profile F. The soil however did appear to be slightly less humic with LOI values reaching 5.75% compared to 7.01% in Profile F. The interface between this soil and the Pleistocene deposits was very abrupt and the consistently stony character throughout and the lack of obvious worm sorted zones suggest it has been substantially disturbed.

Between 82-92cm (layer 4960) the deposit appeared to be increasingly disturbed. χ_{lf}, χ_{fd} and LOI values drop slightly along with shell numbers. It may be that this may be due to colluviation, possibly soil creep as a result of continued disturbance although the generally high values for the majority of the datasets suggests this was low energy and soil formation processes continued concurrently with accumulation.

In the overlying colluvium values for most of the datasets were relatively low when compared to those of the buried soil (4144). The lower part of the deposits between 34-82cm (layers 4145 and 4146 Type 7) consisted of a fine silty matrix with significantly fewer clasts than any other deposit. The lower part of the deposits appeared to be slightly clayier. Between 60-82cm (layer 4145) χ_{lf}, LOI and χ_{fd} values drop to 2.63, 2.63 and 9.1 respectively. Shell numbers also decrease dramatically to only 48 individuals at a depth of 60cm. Together this suggests a rapid deposition of sediment by colluvial processes, possibly sheet wash/rill erosion. The fine generally stone free nature of the deposits indicates they may well have been buried rapidly by overlying deposits, deeply enough to prevent mixing by biological activity or cultivation (Allen 1992:44). This would also account for the preservation of the buried soil 4144 beneath.

Between 34-60cm (layer 4146) the deposits remained very silty in character, although the percentage and size of clasts increased slightly and LOI and χ_{lf} values rose gradually along with shell numbers This possibly represents the effects of disturbance perhaps by cultivation and biological reworking. At the top of the deposit between 0.34-0.40m there was a marked rise in values in the majority of the datasets. χ_{lf} rose to 3.59 and LOI to 4.03% along with shell numbers to 165 individuals. This may indicate a decrease in the rate of sedimentation and possibly an increase soil formation coincident with accumulation. Although the datasets rise they are still relatively low which suggest a lack of a mature or stable topsoil horizon.

This trend is marked between 34-24cm (layer 4147 Type 6) LOI values remained at about 4% along with shell numbers. χ_{lf} drop slightly to 2.7% although χ_{fd} readings reach peak at around 10%. Stoniness increases in this deposit to a concentration of 40% at 34cm, decreasing up-profile to 22%.

3.3.3 Subsoil hollow (ARC PIL98)

This section was located south of the Pilgrim's Way trackway in the valley bottom (Hayden 2006 Fig. 7). The deposits comprised a sequence of buried soils preserved within a large hollow cut into late Glacial silts similar to the basal deposits in Profile F (Type 2) and sealed by a later ploughsoil and colluvial deposits. It is not clear precisely how this hollow was formed. It could be of periglacial origin or it could represent the remains of a very large tree hole. Two profiles were recorded and sampled. Profile Ia (Fig. 6) largely comprised the soils filling the subsoil hollow and overlying colluvial sequence. Profile Ib (Fig. 7) sampled the Pleistocene sequence and later ploughsoil.

Profile Ia

In base of the hollow between 1.20 and 1.70m was a very dark, almost black, humic slightly clayey silt loam (layer 910) with a few clasts of chalk and flint. Abundant worked flint dated on technological grounds to the late Neolithic, along with smaller amounts of animal bone and charcoal was recovered. Unfortunately these deposits were not sampled by monolith tins. A snail sample was however analysed which produced a diverse woodland fauna consistent with relatively mature but open canopy deciduous woodland with much leaf litter.

Between 65-120cm (layer 923), the soil was very similar in character although contained fewer stones and appeared to be slightly clayier. No finds were recovered at this level although charcoal flecks were apparent throughout suggesting anthropogenic activity in the vicinity. Between 80-90cm a concentration of flint and chalk clasts was noted which may represent the base of a worm-sorted zone formed under stable conditions. χ_{lf} , LOI and χ_{fd} values were relatively high and remained fairly consistent throughout the sampled profile. These values were very comparable to those for the buried soil (4144) in Profile F. All values however decreased slightly above the stoney lens. The micromorphological analysis has identified this soil as a mature buried rendzina topsoil that has been totally biologically worked and contains few chalk clasts compared to the overlying deposits. It reflects a possibly lengthy period of stability after a moderately strong anthropogenic impact. Anthropogenic activity is evidenced by large amounts of fine charcoal, traces of very fine bone, and possible magnetic susceptibility evidence of burning. The snail assemblages from these levels suggest clearance of woodland environments in the lower parts of the profile followed by the creation of open country with strong evidence at the top of the sequence for dry short-turfed, but not intensively grazed grassland.

Between 50-65cm (layer 857) there was a marked increase in the stone content. This deposit, a greyish brown humic silty clay loam, extended over the top of the hollow and over a large part of the site to the south of the Pilgrim's Way Trackway. A Roman ditch 863 was recorded truncating this deposit. The micromorphology report indicates co-eval biological topsoil activity and physical soil disturbance within this deposit and interprets it as a ploughsoil colluvium of similar character to the buried soil (4144) to the north. There was evidence within this deposit of fragments of burned soil and occasional to frequent fine charcoal, pottery fragments, burned daub, bone and cereal phytoliths suggesting manuring. The relatively low phosphate-P concentration however suggested that this was of low intensity.

In the overlying colluvium (layer 856 Type 5) Medieval and Post Medieval pottery sherds were identified above 40cm, although between 40-55cm only undiagnostic prehistoric and Iron Age pottery was identified. As expected values for most of the datasets were relatively low when compared to those of the buried soils. The deposits consisted of greyish yellow brown clayey silt with occasional small pebbles to granule sized chalk clasts.

Profile 1b

The Pleistocene deposits, comparable to deposits examined in Profile F, were recorded as a series of sterile soft mid yellowish brown fine-grained clay silts (layers 970, 960 and 961 Type 2), possibly containing a high loessic content. Layer 960 was characterized by a hard pan of secondary carbonate deposition. All deposits had low LOI values and showing no signs of magnetic susceptibility enhancement or phosphate enrichment. Thin section analysis identified a possible 'Allerød' soil horizon within layer 960, which displayed displays peaks in LOI, P and Xconv. Shells in the late Glacial sediments are sparse, but as might be expected, tolerate cold open conditions.

3.3.4 West of Borley Farm dry valley section

The sediment sequence within the smaller dry valley to the south at Borley Farm were recorded in Profile J (Fig. 8). Although archaeological features of Roman and Saxon date were identified on the higher ground to the north, unfortunately none of these were stratified with the sediment sequence in the base of the valley. Dating of the sequence is therefore limited. No monoliths were available for examination, however bulk sediment samples were retrieved along with the molluscan samples through the profile taken at 5cm increments. The section measured 1.85m in depth. The deposits comprised a basal Pleistocene deposit overlain by a rather ephemeral Holocene buried soil horizon consisting of a dull brown clayey silt with occasional flint clasts. Two small sherds of early-middle Iron Age pottery was recovered from this layer. The soil was overlain by up to 1.55m of Holocene slope wash deposits.

Profile J

At the base of the sequence, between 1.75-1.85m, a compact dull yellow orange grading to light grey powdered chalk and silt (layer 1167 Type 2) was recorded, similar to the late Glacial those recorded in Profiles F and I at White Horse Stone. This was overlain between 1.55-1.75m by a mid to dark reddish brown clayey silt that contained occasional small clasts of flint (layer 1157). This layer produced the highest LOI, χ_{lf}, and χ_{fd} values suggesting increased soil formation processes at this level. This deposit produced was very abundant in snail fragments, but evidence of anthropogenic inclusions such as charcoal flecks and pottery fragments was absent. The character of the snail assemblages suggested an environment free of shade although shade- loving elements in the base of the profile are likely to represent a previous landscape phase when conditions were more enclosed.

Between 0.30-1.55m lay a thick sequence of colluvial deposits. Between 1.45-1.55m, overlying layer 1157, was a 0.10m thick deposit of coarse, poorly sorted flint gravel with a clayey silt matrix (layer 1152, Type 4). This is likely to represent an erosional gravel lag deposit similar to that recorded in Profile B.

Between 0.80-1.45m deposits comprised a relatively homogenous sequence of fine-grained clayey silts (Type 6) with very occasional medium and large pebble sized clasts of flint and chalk and frequent sub-rounded small pebble to granule sized clasts. At the base of the sequence the deposits were dark brownish grey (layer 1156), although graded up-profile to a mid-light brownish grey (layer 1151). Between 0.60-0.80m, layer 1155 comprised a darker reddish brown very clayey silt with few clasts (type 7). This was overlain between 0.60-0.30m by a stoney mid to light greyish brown very clayey silt (layer 1150 type 6).

When compared to the other sequences analysed at White Horse Stone overall identifiable shell fragments were very high and >2mm clast % low, within the colluvial sequence below 0.60m suggesting low energy deposition perhaps over a considerable time period. χ_{lf} and χ_{fd} values were fairly consistent although the LOI values were a little higher when compared to Profile C, but consistent with Profile Ia.

4 DISCUSSION

To summarise, the earliest deposits identified infilling the valley at White Horse Stone comprise a coarse chalk and flint rubble or coombe rock (Type 1) that directly overlay chalk bedrock. The character of these deposits suggests rapid physical weathering by frost action resulting in the mass movement of semi-frozen rockwaste over permanently frozen subsoil during full glacial conditions. Overlying this in profiles F, G, Ia and Ib were various deposits of fine-grained silts and chalky diamicts (Type 2 and 3). The character of the deposits suggests deposition occurred under periglacial cold climate conditions probably during the

Older and Younger Dryas stages. Active slope erosion of chalk bedrock and other superficial deposits was rapid, perhaps seasonally, resulting in redeposition of sediment from upslope into the base of the valley. Analysis has shown that there is a high coarse silt component in the deposits, possibly of loessic origin. Loess is an aeolian deposit consisting of predominantly silt-sized grains of quartz, feldspar and other minerals, and in temperate regions is usually of periglacial origin. Extensive deposits of late Pleistocene loess occur in Kent and have been mapped by Catt (1978). The structural breakdown of loess can be rapid and it would be especially susceptible to erosion during periods of snowmelt during the late Glacial and early Holocene (ibid: 18). Common to all these deposits are the networks sub vertical voids, also identified under thin section analysis, filled with inwashed sediment and secondary carbonate. This suggests vegetation grew concurrently with accumulation throughout. Kerney (1963) noted a similar phenomena on other late Glacial sequences and suggested in the spring and summer the ground, frozen and frost-shattered during the preceding winter, thawed and a slurry of chalk mud and fine rubble was washed down onto the lower slopes. Vegetation comprising grasses and small herbs probably grew on these surfaces, dying off towards the end of the year and subsequently buried during the next thaws by further thin sheets of chalk debris. These deposits were not produced by the mass movement of large bodies of semi-frozen ground but grew by increments. In this sense they should be considered chalk meltwater muds as opposed to solifluxion deposits in the strictest sense (ibid 1963:205).

The late Glacial interstadial soil horizon that is widely recognized in south eastern England has been given the name the Allerød soil (Kerney, 1963) and this terminology is widely used today (e.g. see Preece and Bridgland, 1998). Within the Medway catchment area the site at Upper Halling has recently been designated as the regional stratotype for the late Glacial sequences (including both the late Glacial soil horizon and the solifluction deposits above and below the soil horizon). This is known as the Upper Halling Bed and forms part of the Brook Formation (Gibbard and Preece, 1999). All deposits discussed in this report and assigned to the late Glacial period would therefore be equated with the Upper Halling Bed. Other terms may also be used to describe the late Glacial soil horizon including the Windermere Soil. However, this term is inappropriate due to chronological discrepancies at the type site (Prof. Mike Walker pers. comm. July 2000). The sequences at White horse Stone are generally consistent with Upper Halling. Radiocarbon dates of 10,900±120 yr BP and 11, 240±110 yr BP obtained from charcoal from the upper and lower portions of the soil (Preece 1998) are consistent with the White horse Stone date of 11,130±48 yr BP. The soil in profile F at White Horse Stone exhibited clear evidence of disturbance and appears to represent a soliflucted rather than insitu soil. The thin section analysis identified layer 4935/4 as an immature: calcaric lithosol, or grey rendzina or parendzina (Avery 1990) although soil fragments within the matrix are derived from earlier-formed more mature and humic rendzinas. At Halling and Holborough (Kerney *et al* 1980), the soils are described as chalky colluviums, where mass-movement has produced a 'soil' composed of coalesced eroded soil fragments (Macphail and Scaife 1987).

No deposits, either buried soils or colluvial deposits, relating to the early-Mid Holocene were identified within the principal dry valley pedo-sedimentary sequences. This includes any contemporary soil horizons that may have been directly associated with early Neolithic structure 4809. The earliest Holocene deposit was an extensive buried soil dated to the later prehistoric period which directly overlay late Glacial sediments, and sealed archaeological features of Neolithic date. This implies a major unconformity within the sediment sequences spanning several thousand years. The only evidence of deposits relating to earlier periods derives from discrete archaeological features. The micromorphological evidence from these features, and indeed from the subsoil hollow in the base of the valley at the Pilgrim's Way site, has suggested the natural soils from the Neolithic period onwards were humic rendzinas. Two reasons for the absence of soils and sediments within the main sequences dating to this period may be suggested:

1. Colluvial deposits and soil were removed by an episode of erosion prior to the formation of the later prehistoric soil.
2. Under relatively stable conditions the soils were simply biologically worked over a long period up until the late Iron Age or Roman period when they were buried by colluvium.

It is impossible to say with certainty when and if erosion episodes removed the early-mid Holocene soils. In general preservation of early former Holocene soils in dry valley situations on the chalklands of the south and southeast appears to be rare. Many investigated colluvial sequences appear to date to the Bronze Age or later and the absence of former basal soil has often been interpreted as a result of extensive and severe truncation. For example, at Fordington Bottom in Wessex basal deposits comprised gravel fans which sealed a ditch of a least Bronze Age date, and at Whitesheet Hill a humic basal deposit proved to be of Iron Age date indicating, total removal of all former soils before pedogenesis and stabilization (Allen 1992). It is a commonly held view that the soils of the early-mid Holocene on the chalklands of the south and southeast in many cases derived from loess deposits which formed various brown earths under woodland cover. As previously noted the structural breakdown of loess can be rapid and soils formed on loess during the early-mid Holocene would be vulnerable to sheet erosion and wind dispersal when forest cover was disturbed by man (Sheldon 1982). Previously Catt (1978) and others have argued for a ubiquitous thick blanket of loess across southern England, although recent research suggests that blanket may have been intermittent and in areas highly localized, for example in valleys and the base of hillsides (M.J Allen pers comm 2004). At White Horse Stone the high silt content of many of the sequences examined suggests much of the sediment contained a high loessic component, though it would appear that significant erosion of such deposits occurred during the late Glacial period. It is possible that in the absence of loess in some areas, and with no other mineral material other than calcium carbonate for soil formation, organic rendzinas may have predominated (Catt 1978). Consequently, the presence of humic rendzina soils within the early Neolithic features does not necessarily suggest disturbance and erosion.

If erosion was confined to episodic, localized events prior to the formation of the Iron Age palaeosol, the question remains as to the fate of the occupation horizons and artefacts associated with structures such as the early Neolithic structure 4809. The Neolithic features were directly sealed by the Iron Age palaeosol, a colluvial ploughsoil. The closest profile examined to the longhouse was Profile A, located less than 10m to the southeast. Here the soil is represented by layer 4960, which appeared in thin section to be chalk gravel fans/chalk slurry-like colluvial deposits, more sedimentary in character than pedological (Macphail and Crowther 2006). Overall this suggests that any occupation surfaces associated with the Neolithic features and artefact distributions that may have survived would certainly have been truncated or mixed within the plough zone and suffered lateral movement from slope processes at least from the early Iron Age period onwards. Extensive spatial sampling of the Iron Age palaeosol produced a moderate assemblage of worked flint of Neolithic and Bronze Age date. However no significant spatial pattering could be correlated with the distribution of Neolithic features.

The character of the later Holocene buried soils varied significantly spatially in terms of thickness texture, colour and stoniness. Within a large hollow in the base of the valley a substantial thickness of soil was recorded, overlying Pleistocene deposits and sealed by later Holocene colluvium. (Profile I). The micromorphology suggests this unit, subsequent to significant anthropogenic disturbance, represents a soil formed insitu in an environment of stable grassland over a considerable period of time. This is supported by the relatively high humic content and generally stone free nature of the soil. Artefacts evidence suggests at least part of this profile represents soil formation within the Bronze Age, possibly the early Bronze Age. No other deposits at White Horse Stone have been identified dating to this period. Its preservation is due to its location within this hollow effectively protecting it from later cultivation and erosional processes. Layer 857 overlying layer 923, has been correlated with layer 4144 on the lower slopes of the valley. Both deposits were of similar character in terms of texture, inclusions, and humic content and magnetic susceptibly. The gross morphology of this soil, and thin section analysis identified it as a colluvial ploughsoil showing evidence of plough mixing and structural disturbance, alongside biological working with inputs of anthropogenic material such as worked flint, pottery sherds and burnt dung possibly representing manuring. The thin section analysis indicated the Iron Age palaeosol showed signs of increasing slope soil instability, probably through rill and gully erosion resulting in run-off, slaked soils, and removed rendzina topsoils. This also resulted in the erosion of gravel size chalk as the chalk substrate became exposed.

The paucity of colluvial deposits dating to the earlier prehistoric periods, at White Horse Stone, is all the more salient when considering the clear evidence for erosion and deposition occurring in the later periods. Episodic but intensive colluviation appears to have been initiated sometime in the Roman period possibly due to increased clearance of vegetation within the catchment. The molluscan evidence supports this where distinctive assemblages of open country fauna have been identified suggestive of large established areas of grassland and/or arable land. The bare soils may have been more susceptible to erosion during periods of rainfall and the practise of autumn sowing adopted in many areas during the later prehistoric and Roman periods may have been a significant factor.

Most notable within the colluvial deposits was the presence of distinctive flinty concentrations indicative of higher energy erosive events. Such lens were identified truncating the surface of the later Holocene buried soil when it was exposed in plan during the excavation (e.g. Profile B, layer 4152 and Evaluation Trench 1118).. These appeared to be particularly concentrated at the foot of the western slope to the south of the Iron Age settlement. Boardman (1992), who investigated processes operating in modern valley systems, suggested gravel lag deposits were often a product of gullying upslope resulting in large volumes of soil being stripped and washed away with the stones dropped at breaks of slope while the finer material is transported further down the valley, and Allen (1992) comments further on the considerable erosive force of such events.

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