Ancient Monuments Laboratory
Report 61/93

FERRYBRIDGE HENGE I, W YORKSHIRE: SOILS OF THE PIT ALIGNMENT AND DITCH, INFILL PROCESSES AND LANDUSE

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Summary

The macro/micromorphological and pH characteristics of selected soils from the pit alignment and encircling ditch at Ferrybridge Henge (late Neolithic to early Iron Age) were used to investigate infill processes and interpreted in terms of the environment in adjacent areas. Following a short period of early and rapid infilling, disturbances in the local environment effected the gradual accumulation of soil debris within the pit examined, and gave rise to morphological features indicative of differential erosion, organic matter disruption and possibly burning in adjacent areas. This was followed by a fairly prolonged period of stability during which soil erosion virtually ceased. The accumulation of the present topsoil can probably be related to medieval and later cultivations. The rapid dumping of a biologically active soil over the primary fill of the ditch suggests much more radical disturbances (agriculture?). Organic remains suggest that a predominantly grassland environment had prevailed prior to this. Subsequent infilling through slumping and dumping may have occurred in stages, each accompanied by wind sorting. Vegetation then became established within the ditch, though the vegetated surface was soon buried and the area probably cultivated. An intermittent charcoal rich horizon below the modern plough layer probably reflects the burning of a small man-made fire(s) *in situ*.

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Ferrybridge Henge I:

Soils of the pit alignment and ditch, infill processes and landuse.

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Contents

1. Introduction

Ferrybridge Henge and associated monuments lie on the Magnesian limestone plateau directly west of the flood plain and associated alluvial deposits of the river Aire in West Yorkshire (g.r. SE 474242, sheet 78, Wakefield, Geological Survey of England and Wales). The excavation (1990) undertaken by West Yorkshire Archaeological Service encompasses two areas, one threatened by the extension of a school, the second by the expansion of a cemetery. The associated prehistoric archaeological landscape comprises barrows, a henge and associated ditches and banks, two post hole circles, a concentric pit alignment, intervening pits and an encircling ditch, which range from late Neolithic to Iron Age though precise dates are uncertain. Apart from periglacial features and two post hole circles of uncertain function and age, the school site was devoid of features. The cemetery site included pits of the pit alignment, a number of unrelated pits of uncertain function (possibly Bronze/Iron Age storage pits), though one contained a burial and may have been overlain by a barrow (possibly Bronze Age), and an encircling ditch. Crop marks suggest that Iron Age or Romano-British and later medieval field systems are superimposed over this prehistoric landscape, selected features of which are discussed here.

The Magnesian limestone has been subject to extensive periglacial activity and exhibits a complex pattern of frost shattering and solution features. The soils developed over the drift free bedrock are calcareous brown earths of the Wetherby and Aberford series (Hartnup, 1975), differentiated only in terms of depth to bedrock. These soils are typically calcareous, aerobic, biologically active and freely draining.

2. Sampling and methodology

Undisturbed samples (8*4*1.5 cm^3) were taken from the following features and contexts for thin section preparation:-

i) Infill from pit F353. Samples were taken from the base of contexts 352 (tertiary fill?), 503 (secondary fill), 501 (to the side of the stony central area) and within 502 (primary fill). The location of the samples taken (samples 276, 277, 278 and 279 respectively) are shown in Fig. 1 (drawing S.234).

ii) Ditch M378, segment F585, east facing cross section. Samples were taken from the following: the lower boundary of context 628, ie. upper or tertiary fill, from across the boundary of contexts 526/528, and from the upper and lower boundary of context 582. Samples were not taken from the primary fill. The location of the samples taken (sample numbers 254, 255, 256 and 257 respectively) are shown in Fig. 2 (drawing S.269).

iii) Ditch M378, segment F585, south facing longitudunal section. Samples were taken from the charcoal layer (context 592) at the base of the upper fill (context 628). Sample 274 included both overlying and sub-charcoal soil, contexts 628 and 526 respectively, sample 275 included only the charcoal layer and underlying soil. The location of the samples taken are shown in Fig. 3 (drawing S256).

Thin sections were prepared using air dried samples and standard techniques (Murphy, modified by M. Jones[1] Thin sections were examined using a standard petrological microscope under both plain and cross polarized light (see eg. Cox et al., 1974) and described using the terminology of Bullock et al. (1985). Organic remains and plant tissues were identified with the aid of Babel (1975) and Esau (1965) respectively. Wood fragments were tentatively identified using Jane (1956), Cutler et al. (1987) and Schweingruber (1990). Soils have been described using Munsell colour charts and standard terminology (Hodgson, 1976). Soil morphological characteristics are given in detail in Appendix 2, 3 and 4. Soil pH values were determined using standard procedures (Avery and Bascomb, 1974).

3. Soils of the pit alignment

3.1 Soil macromorphology, textural and chemical characteristics

Pit F353 was selected detailed examination since the profile included the modern topsoil, while the infill shared morphological similarities with the other pits excluding pit F343 which had a layered stony infill. Horizons, contexts (in parenthesis), textures, colours and pH values are given in Table 1. A detailed description is given in Appendix 1.

Table 1. Soils of pit F353

cm		pH in H_2O	pH in $CaCl_2$
0-20	Ap (301) dark brown sandy (silty) clay loam	7.95	7.14
20-44	B_1 (302) dark yellowish brown sandy clay loam	8.07	7.48
44-65	B_2 (302) dark yellowish brown sandy silt/clay loam	8.20	7.52
56-82	Tertiary fill (352) strong brown sandy clay loam	7.95	7.50
82-107	Secondary fill (503) strong brown sandy clay/silt loam	8.18	7.57
107-125	80% stony fill (501) strong brown sandy silt/clay loam	8.16	7.63
125-135	Primary fill (502) yellowish brown sandy silt loam	8.10	7.69
	Lower context of pit F343	8.32	7.82
	Lower context of pit F343	8.43	7.86

The profile is typically highly porous and aerobic throughout. With the exception of the boundary between the more organic plough layer and the underlying B_1, the profile did not appear to be markedly stratified. This reflects mixing via earthworm activity and rooting to depth or perhaps the original mode of infilling. The presence of stony stratified infill elsewhere (pit F343) suggests that earthworms cannot comminute highly calcareous stony

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the infill material (with the exception of context 501) is inherently fine. The presence of marginally humose soil within the stones of context 502 can be attributed to deep earthworm burrowing and is probably modern.

There are a number of interesting points to note, i) silt contents increase with depth from the Ap to the B_2, and subsequently within the infill soils, ii) pH increases with depth within the modern topsoil, subsequently declines within the tertiary fill, again increasing with depth, though declining slightly within the primary fill, and iii) dark yellowish brown and strong brown colours predominate in the upper and infill soils respectively. The profile therefore appears to be bi-modal in terms of texture, pH and colour. pH is slightly higher within the lower fill of pit F343 reflecting probably the slow breakdown and dissolution of limestone in situ and restricted leaching.

Charcoal (visible to the naked eye) was noted in all but the lower fills (501 and 502). This may or may not be attributed to modern agricultural practices such as stubble burning.

3.2 Soil micromorphology (Appendix 2)

i) Context 352, sample 276.

The upper fill is highly porous, with most voids having a clear biotic origin (earthworms and rooting primarily). The soil fabric comprises an intimate mixture of fine earth (clays, silt, calcite and iron oxides) and locally derived limestone and quartzitic debris. The absence of macro-organic residues such as root remains and the presence only of rare microbial or plant cell fragments and degraded or humified organic residues reflect the biologically active and aerobic nature of the soil (past or present), both characteristics combining to enhance the breakdown and decomposition of organic matter with finely divided residues stabilised as calcium humates. The presence of textural features such as earthworm faecal remains within the soil matrix suggests physical re-sorting at some time. The latter can be attributed to i) the physical redistribution of soil by earthworms via burrowing and excretion and ii) the gradual collapse and infilling of bio-pores (root and earthworm channels) with fine aggregates and mineral detritus through desiccation.

There are two morphological features of note, i) iron rich calcite, clay and silt coatings which occur sporadically throughout in association with voids and coarse mineral particles, and ii) dark reddish brown (weathered) relic aggregates or weathered earthworm residues. Rare snail shell fragments and unidentified shelly fragments, the latter thought to be of geological origin, are also distributed randomly throughout.

ii) Context 503, sample 277.

The overall composition and structure of context 503 is closely comparable with the overlying soil. The soil is highly porous with quartz and limestone detritus predominant in the coarse mineral fraction, clays, iron oxides and calcite in the fine, while the presence of loose void infillings suggests a similarly aerobic and biologically active regime. Relic aggregates, simple void coatings and rare snail shell fragments are also present.

It is distinguished from the overlying soil by, i) the presence of recognizable, though distorted plant tissue remains and possibly carbonized woody/seed residues, ii) slightly oriented reddish brown calcitic (crystalline), iron rich clay and silty (organic and mineral) coatings associated with voids and some mineral surfaces (some within the soil matrix), iii) well developed compound layered organic, clay, silt and fine sand (calcitic pendants) coatings (often crescentic), crusts and cappings, often traversed by vertically oriented root or worm channels, some with entrapped plant or microbial residues, and iv) the presence of possibly calcified root remains in situ (calcitic pseudomorphs), some possibly woody fragments were identified very tentatively as Tilia (lime) or Acer (maple).

iii) Context 501, sample 278.

This soil is, like the overlying soils highly porous and clearly aerobic. Much of the matrix reflects a combination of the breakdown of clastic limestone in situ (limestone predominates in the coarse mineral fraction) and the collapse and infilling of earthworm channels. Fresh light yellow brown earthworm faecal residues and fabrics within loose walled voids reflect contemporary earthworm activity noted above. Relic aggregates, non layered as well as complex layered calcitic coarse clay, silt and fine sand coatings are all present, although the latter are less common than above, with some incorporation of complex coatings within the matrix. The latter suggests continued bio-turbation, though incomplete re-sorting.

Despite the absence of observable charcoal in the field, several carbonized woody fragments were noted in thin section (charcoal), sharing some xylem and vessel characteristics with Acer, Carpinus betulus (hornbeam) and Betula (birch). These woody residues appear to be detrital (c.f. residues above which appear to be in situ) and may have been incorporated during the early stages of pit infilling or at any time subsequently. Rare snail shells were observed.

iv) Context 502, sample 279.

This horizon shares morphological, structural and thus biological similarities (mineral composition, porosity, earthworm residues etc.) with the overlying soil (501), while relic aggregates, calcitic clay, silt and fine sand coatings and rare compound calcitic layered coatings were also observed. Some areas however exhibit clear sedimentary structures with banded fabrics and horizontal laminations which may represent shearing processes, slumping or wind sorting. Some of these features are associated with concentrations of fine opaque inclusions, possibly finely divided charcoal, which form irregular and discontinuous micro-pan features. Thus while clearly affected by faunal turbation and illuvial processes, this horizon retains some original structures. Yellowish red structured fragments of possibly humified wood, as well as rare charcoal fragments were also observed, the latter share vessel and perforation plate characteristics with Acer and Aesculus hippocastanum (horse chestnut). Wood fragments were not observed within stratified areas. Rare snail shell fragments are also present.

4. Soils of the ditch

4.1 Micromorphology of segment F585.

Samples were taken across the boundary of contexts as shown in Fig. 2, detailed descriptions are given in Appendix 3.

i) Upper ditch fill, lower boundary of context 628, including context 592 (sample 254).

The upper fill of the ditch is, like the soils of the pit, highly porous with abundant bio-pores, while Magnesian limestone predominates the coarse mineral fraction (like 501 and 502). It lacks textural pedofeatures such as void or mineral coatings, though relic aggregates were observed. Abundant snail shell fragments and elliptical opaque inclusions, possibly charred or carbonized seeds were observed. The latter are distributed randomly throughout.

ii) The lower boundary of context 526, sample 255. Context 528 comprises mainly Magnesian limestone rubble and was not described.

This soil is closely comparable with the upper fill, although some pores are coated with loose calcitic material. The presence of angular limestone fragments and paler soil fabric (less Fe oxides) may simply reflect increasing rubble content with depth (towards context 528).

iii) The upper boundary of context 582, sample 256.

This soil contrasts with both the overlying ditch infill and the soils of the pit. Although there is a fairly well developed pore system of biotic origin, suggesting plant growth and therefore exposure to soil and biotic processes at some time, porosity is much more variable than in the soils above, with fine randomly distributed smooth walled voids predominating in less porous areas. Although non woody plant remains are common and often occur within bio-pores ie. in situ, most are reddened, degraded and humified or impregnated with iron or calcite. These characteristics combine to suggest rapid burial, while the general lack of preferred orientation suggest that they might even be inherited.

Many voids are coated with often coarsely crystalline calcite and rarely, with silt sized organic debris. Linear fabric orientations and rounded clusters of coarse mineral grains suggest slumping during deposition or dumping and wind blowing/rolling/sorting prior to the establishment of a vegetative surface respectively. Snail shells fragments are particularly abundant.

iv) Lower boundary areas of context 582, sample 257. Context 583 comprises mainly Magnesian limestone rubble and was not described.

This soil is closely comparable with the sample 256 as might be expected although it is slightly more porous with some loose walled voids reflecting perhaps its higher stone content. Many coarse mineral grains are rounded, some are clustered, suggesting a greater wind sorted or windblown component. Silt sized mineral and fine organic particles are particularly abundant within the fine fraction. The following features were also observed:
i) abundant calcitic crystal outgrowths associated with void surfaces, but also occurring

within the matrix, some infilling fine vertically oriented channels; ii) common reddened clay and organic (silt sized) coatings and concentrations within the matrix, some outer edges of calcite out growths are yellowish red, some blackened with organic residues reflecting possibly the degradation of woody roots in situ or the deposition of illuvial (transported) organic fragments or charcoal; iii) abundant elongated shelly fragments, thought to be of geological origin but mostly horizontally oriented; iv) rare calcite root replacement pseudomorphs (< 133 μm), most were non woody with root hairs clearly visible, rare fragments exhibited spiral thickenings and had very slightly oblique simple perforation plates (possibly Tilia); v) concentrations of reddish brown rimmed isotropic residues (@ 25 μm), possibly pollen grains.

There are also abundant inclusions of unidentifiable humified plant tissue some of which may be burnt. Some appear to be iron impregnated and occur within voids, ie. in situ. Snail shells are also particularly abundant.

4.2 Micromorphology of the upper fill associated with context 592 (contexts 628/592/526, Appendix 4)

The soil overlying the charcoal rich horizon shares many similarities with the upper infill material within section 269, as might be expected. It is highly porous, biotically active and generally lacks illuviation features or void coatings, while relic aggregates and reddish brown degraded/humified but unresolvable organic matter occur throughout. The charcoal rich horizon is also loose and porous, and while its upper boundary is diffuse and irregular suggesting at least some mechanical and biological disturbance, its lower boundary is largely intact and sharp. It may be that such charcoal deposits were more widespread than at present and are preserved here by chance. The sub-charcoal soil is generally less porous than the overlying soil with smooth walled voids and thus differs from analogous soils in section 269. This supports suggestions that the charcoal rich layer has been preserved through lack of disturbance. The few earthworm and root channels continuous with 592 are loosely infilled with carbonized debris which comprises upto 5% of the total soil matrix, while some voids are associated with weathered clay/silt concentrations. Relic aggregates are present as above, while a few reddened accumulations may be attributed to burning. Coatings comparable with the pit soils are absent.

Carbonized or humified woody fragments and fine silt sized organic particles are distributed throughout these three horizons, while unresolvable carbonized material comprises up to 50% of the fine matrix of 592. Identifiable fragments are concentrated within the charcoal horizon, though Acer, Corylus and Fraxinus (ash) were very tentatively identified within the upper fill (628). Undoubted fragments (including diagnostic perforation plates and vessels) of Corylus avellana (hazel) were observed within 592, sample 1, while fine fragments of Quercus (oak), Ulmus (elm) and Fraxinus were all tentatively identified within sample 2. Some of these fragments were degraded and ashy rather than carbonized.

Many carbonized and humified woody fragments lack diagnostic features while reddened, disrupted non woody tissue remains also occur throughout. Charcoal, humified and other tissue remains may comprise up to 30% of 592, though all of these organic components occur throughout the over and underlying horizons. Rare mollusc fragments only were observed.

5. Interpretation and conclusions

There are two micromorphological features described in sections 3 and 4 which require some comment.

i) Finely crystalline calcite coatings, cappings, pendants and pseudomorphs (preserving plant structures through replacement by calcite).

ii) Calcitic, clay, silt and fine sand void coatings and cappings, sometimes oriented, often associated with silt sized organic and fine opaque or carbonized debris.

One of the principal processes acting in calcareous soils is the dissolution of calcium (and magnesium) carbonate mainly as a result of the action of dissolved CO_2 in soil solution. The latter may originate in rainwater or as a bi-product of plant root and microbial respiration in the rhizosphere. Dissolution processes are also enhanced by organic acids produced during the breakdown of plant material and also by nitrification (the biological oxidation of inorganic forms of N to nitrate). De-carbonation processes are therefore most active in the topsoil and are associated with a concomitant decline in pH and a relative increase in the proportion of silicates (or silica) present. Cultivations act against these processes via enhanced mechanical weathering and the inhibition of organic matter production, losses tending to increase in the direction, cultivated soils, grassland to woodland soils (see eg. Dixon and Weed, 1977; Duchaufour, 1977). Regardless of landuse or vegetation, precipitation (neo-formation) can be effected in situ in the rooting zone or lower in the profile as solution concentrations increase through drying or as pH or dissolved CO_2 increase and decline respectively.

Many of the void coatings described here comprise clay and often crystalline calcium (magnesium) carbonate. It seems likely that while some of the well developed crystalline carbonate features may originate through the percolation of carbonate rich solutions from elsewhere in the profile, most clay and calcite features (hypocoatings) can be attributed to in situ solution of carbonates adjacent to biotically active voids, with local translocation and re-precipitation leading to a relative enrichment in clay minerals within the adjacent soil. They therefore reflect local CO_2 production and by implication a biotically active soil environment.

The origin of the more complex textural infill and capping features described in point ii) above is however the subject of much debate, and their interpretation remains problematic. 'Dusty' clay coatings (comprising fine and coarse clay $< 3\ \mu m$) and coarser textural features (coarse clay, silt and fine sand) have been variously linked with soil disturbance, woodland clearance (eg. Slager and Van der Wettering, 1970; Macphail, 1987; Macphail et al., 1990) and palaeocultivations (eg. Macphail et al., 1987) respectively. There is however general agreement that concentration features comprising primarily silt, fine sand, fine organic and charcoal debris can result from long continued tillage and arable practices (Jongerius, 1970, 1983; Soil Survey Staff, 1975). Although these features (agricutans) most commonly occur within and directly below the plough layer they have been observed at depth (up to 70 cm) in macroporous soils (Jongerius, ibid). Their development is linked with the decline in organic matter and structural status concomitant with cultivations, the physical disruption (slaking) of a bare soil surface by rainsplash, the translocation of particles as water moves through the soil profile and subsequent re-deposition within voids or coating mineral particles as the soil dries. It should be stressed however, that **any disturbance leading to the exposure of a bare soil surface or continued deposition of soil debris over a vegetated profile with continuous voids could lead to their development.** It is also conceivable that the rapid burial of a slaking soil could also lead to their preservation.

5.1 Soils of the pit alignment

It is clear from the previous discussion that textural features, including calcitic clay, silt, fine sand and organic coatings, cappings etc. within the pit fill can be attributed to cultivation of the modern topsoil (medieval to modern tillage?). However, the maximum expression of textural features at 80 to 125 cm below the present soil surface (contexts 503 and 501) and the profile bi-modality noted above suggest the presence of a relic soil profile within the pit, which retains some of its original characteristics despite earthworm activity and cultivation practices. The depression of pH within 352 suggests de-carbonation processes acting at the surface, while enhanced clay contents within the Ap and context 352 may reflect weathering within the topsoil or silt losses through physical disruption of the soil surface. It seems likely that morphological features within the pit soils therefore provide some indication of environment and disturbance following pit excavation.

The following sequence can be proposed, though clearly suggestions are at best tentative:-

The silty primary fill (context 502) represents fine material eroded locally either from the pit sides or adjacent areas immediately following pit excavation (or abandonment?). Its enhanced silt content and slightly depressed pH might reflect a general aeolian component, while charcoal micro-pan features can probably be attributed to windblown additions of locally burnt material. Sedimentary structures suggest additional wind sorting, probably in situ. The presence of carbonized woody debris (tentatively identified as Acer and Aesculus hippocastanum) suggests local wood burning, though their absence in stratified areas suggests that incorporation may have taken place at some later stage. Textural features may reflect slaking and disruption of the recently deposited soil, though their association with calcite void coatings suggest deposition following the development of biotic void network.

The stony detritus of context 501 probably represents primary weathering of the loosened pit sides prior to the establishment of vegetation. Such processes were clearly limited in duration, perhaps taking place over one seasonal cycle and during which additional fine soil was able to accumulate. The presence of fine wood charcoal detritus (possibly Acer, Carpinus betulus and Betula) suggests local burning as above, while their absence in 503 suggests that these activities were contemporary with deposition. The association of textural features with calcitic coatings suggests similarly, a biotically active environment during particle translocation.

Three mechanisms of subsequent soil accumulation can be envisaged:- i) rapid infilling (anthropogenic), ii) gradual accumulation in a largely stable environment, and iii) gradual accumulation accompanied by disturbance in the adjacent area. In the first instance, textural features indicative of instability at the soil surface must have developed prior to the establishment of vegetation and therefore extremely rapidly. In the second, the principal mechanism of infilling, aeolian deposition, can be discounted on the basis of both textural and morphological considerations. It seems more likely that debris resulting from local soil disturbance accumulated gradually over a vegetated surface within the pit. The translocation of soil debris deposited at the surface in rainwater via continuous voids is easily envisaged, while the survival of some as micro-pan features suggests occasional and rapid burial. This mechanisms of infilling would account for the varied composition of depositional features, individual deposits reflecting changes in the local environment (erosion, organic matter/topsoil disruption and burning), although a chronology cannot be given. It would also account for the occurrence of relic aggregates throughout the infill soils.

The depression of pH within the upper fill (context 352) suggests fairly prolonged exposure (de-carbonation) as a surface soil horizon and by implication, a period of stability during which depositional features, if originally present, were lost through faunal turbation and rooting activity. Iron released as a result of weathering (Dixon and Weed, 1977, p. 145) including the solution of carbonates, during this period would account for the strong brown colour of the infill soils. The presence of calcified plant root remains (some of which may be woody) and well developed crystalline calcite feature within the underlying soil may reflect de-carbonation within the upper infill during this period. The predominance of quartz over calcite in the coarse mineral fraction could reflect carbonate losses in both 352 and 503. The absence of well developed complex layered textural features within the upper fill suggests that subsequent soil accumulation (the modern topsoil) and cultivations have not effected the development of 'agricutans' lower in the profile.

In summary, following a shortlived period of early and rapid infilling (contexts 502 and 501), fairly stable conditions prevailed within the pit. During this unspecified period, disturbances in the local environment effected the gradual accumulation of soil debris and gave rise to morphological features indicative of differential erosion, organic matter disruption and possibly burning. This was followed by a fairly prolonged period of stability during which soil erosion virtually ceased and carbonates were removed from the surface horizon and complex depositional features were lost. The accumulation of the present topsoil can probably be related to subsequent arable cultivations which apparently have not led to the rejuvenation of the upper fill (in terms of carbonates) or the development of agricutans. Pit F343 has not been discussed here, although its layered stony infill and the absence of fine soil at its base combine to suggest that it was backfilled soon after excavation or abandonment.

5.2 Soils of the ditch

The micromorphological characteristics of the upper ditch fill (context 628 and 526) observed in section 269, provide little indication of function or processes and probably reflect modern (medieval to present day) tillage etc. In section M378, a well defined charcoal deposit (context 592) has survived between contexts 628 and 526, presumably through a chance lack of disturbance. The presence of a relic void system within the underlying soil confirms this latter suggestion, although by implication, the charcoal rich deposit may have been more widespread than at present (or dumped locally). There are two points to note, i) the presence of wood ash debris and reddened residues within the underlying soil favour <u>in situ</u> burning, and ii) the undoubted variety of wood species present (tentatively identified as <u>Corylus avellana</u>, <u>Quercus</u>, <u>Ulmus</u>, <u>Fraxinus</u>, <u>Fagus</u> and <u>Acer</u>) suggests wood foraging rather than the burning of trees or bushes growing <u>in situ</u>.

Fill 582 exhibits a variety of interesting morphological features. The general absence of textural coatings etc. as well as the abundance of snail remains and depositional calcite suggest that infill processes were very different from those acting on the pit alignment. The abundance of crystalline calcite suggests slow precipitation or crystallization from a concentrated carbonate solution, possibly reflecting the incorporation of limestone during deposition and/or the rapid burial of an actively respiring soil. The abundance of humified, degraded, iron and calcite impregnated plant remains often occurring within bio-pores within the upper part of 582, tends to support the latter suggestion, while a general lack of preferred void orientation suggests that perhaps some of these features may be inherited. Fabric orientations within 582 (both samples) suggest slumping or dumping, subsequent wind sorting, blowing and rolling prior to the establishment of a vegetated surface, although the aeolian component tends to increase with depth towards the lower boundary. Here the abundance of illuvial (transported) carbonized/organic coatings, reddened clay coatings and possibly burnt humified plant debris combine to tentatively suggest burning, probably prior to deposition, while the presence of pollen grain clusters implies the burial of a vegetated soil surface.

The following sequence may tentatively be proposed:-

i) Primary infilling?
ii) The rapid dumping of a biologically active soil over the primary fill as a result of perhaps ploughing in adjacent areas?. This soil may have been subject to burning, although the general absence of wood charcoal (one fragment of Tilia tentatively identified) suggests a grassland environment prior to disturbance.
iii) Infilling through slumping and dumping may have occurred in stages, each accompanied by wind sorting within the ditch. The general absence of coatings etc. suggests that gradual accumulation over a vegetated surface did not take place (cf. section 5.1).
iv) The establishment of vegetation within the ditch (or within an immediately overlying soil). This period must have been shortlived since both depositional and aeolian structures persist.
v) Subsequent burial and continued cultivation of the modern topsoil (Medieval to present).

Remains of a fire adjacent to the ditch can probably be attributed to the burning of small fire in situ. The diversity of species present suggest that this wood was collected.

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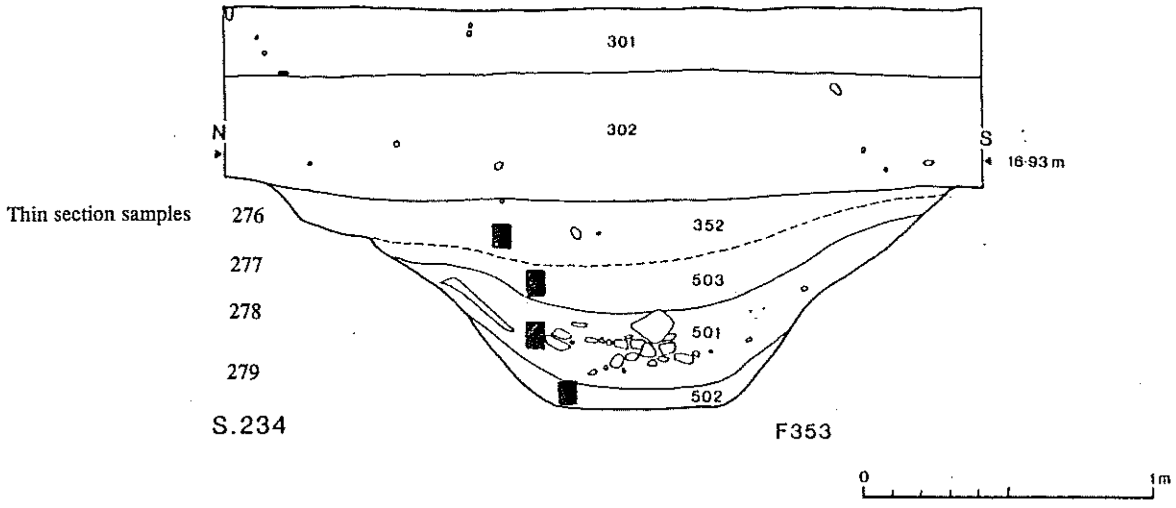

Fig. 1. Pit F353: contexts and location of thin section samples

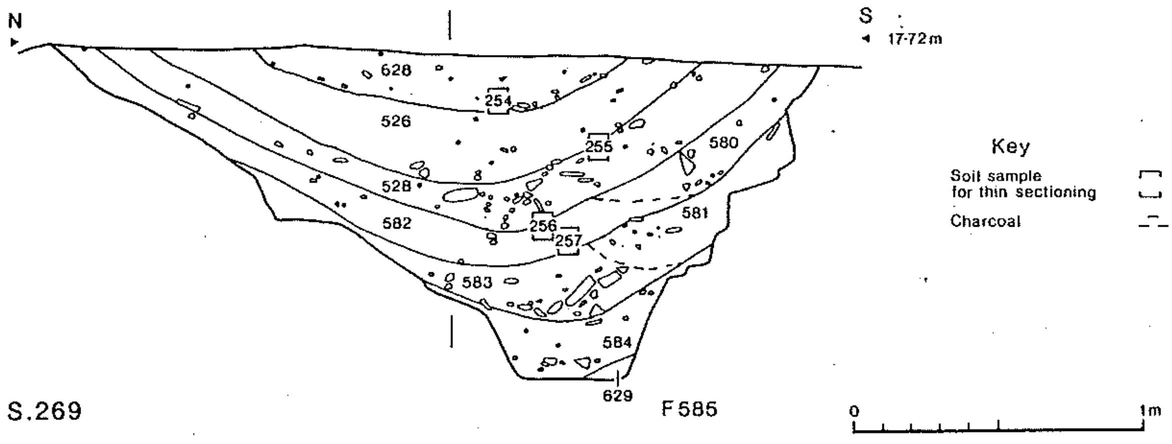

Fig. 2. Ditch M378, segment F585, east facing cross section: contexts and location of thin section samples

Fig. 3. Ditch M378, segment F585, south facing longitudinal section: contexts and location of thin section samples.

Appendix 1.

Pit F353, soil profile description

cm

0-20 (Ap, modern topsoil, context 301) Dark brown (10 YR 3/3) sandy silt (organic matter) to sandy clay loam; common fine to medium, platy to subangular inclusions of yellowish red magnesian limestone (5 YR 5/6); common fine charcoal inclusions; few pottery fragments; well developed compound medium subangular to angular blocky/fine granular structure; friable when moist; very porous with abundant root channels and structural fissures; boundary smooth and sharp.

20-44 (B_1, context 302) Dark yellowish brown (10 YR 3/4) sandy clay loam, abundant dark brown (10 YR 3/3) inclusions associated with common coarse earthworm burrows; abundant fine charcoal inclusions; abundant fine to medium angular magnesian limestone inclusions (gravel sized); common roots preferentially exploiting earthworm channels; moderately to very porous with abundant root and earthworm channels; medium angular to fine prismatic structure; boundary wavy and clear.

44-56 (B_2, context 302) Dark yellowish brown (10 YR 4/4) sandy silt (clay) loam; abundant fine angular to platy inclusions of magnesian limestone; very dark grey (10 YR 3/1) organic inclusions associated with earthworm burrows; well developed fine angular blocky structure; very porous, abundant fine to medium root channels, coarse earthworm burrows; common roots; abundant fine charcoal inclusions; boundary smooth and gradual.

56-82 (pit infill, context 352) Strong brown (5 YR 4/6) sandy clay loam; very dark grey organic inclusions (10 YR 3/1) associated with abundant earthworm burrows; compound medium subangular blocky to very fine granular structure; very porous, abundant fine root, coarse earthworm channels; rare to common roots, preferentially following earthworm channels; rare to common fine charcoal inclusions; coarse gravel sized magnesian limestone inclusions; boundary smooth and gradual.

82-107 (pit infill, context 503) Strong brown (7.5 YR 4/6) sandy clay to clay loam; very dark grey organic inclusions associated with earthworm burrows; coarse angular blocky to fine/medium prismatic blocky structure; very porous, abundant fine, rare coarse earthworm channels; rare to common roots; common inclusions of Magnesian limestone; common charcoal inclusions; boundary defined by stones, elsewhere smooth and clear.

107-125 (pit infill, context 501) 80 % Magnesian limestones in the central area; interstitial and peripheral material is strong brown (7.5 YR 5/6) sandy silt to clay loam; very dark grey inclusions (10 YR 3/1) associated with earthworm burrows, some of which penetrate stony areas; moderately porous, abundant medium root channels, mostly void; few roots; moderate, medium angular to subangular blocky structure; interstitial material comprises fine magnesian limestone fragments, @ 40% very dark grey (10 YR 3/1) earthworm burrow infill material and strong brown (7.5 YR 4/6) soil; boundary smooth and clear except where defined by stones.

> 125 (primary infill, context 502) Dark yellowish to yellowish brown (10 YR 4/4, 4/6, 5/6) sandy silt loam; common medium subangular magnesian limestones; fine angular blocky structure; moderately to very porous, common fine root and medium earthworm channels; boundary smooth and sharp, over firm magnesian limestone.

Appendix 2.

Pit F353 thin sections, contexts 352, 503, 501 and 502.

2.1 Sample 276

Microstructure

Moderately to very porous (10-30% total area). Complex structure loose vughy, channel to granular structure.

Coarse vertically oriented continuous root and worm channels (0.2 to 5 mm) comprise up to 30% total pore space in parts (channel structure); occasionally associated with fresh, cellulose rich plant tissue and earthworm faecal remains respectively; generally rough walled and partially infilled by very fine crumbs or microaggregates; some partially infilled with earthworm faecal residues. Abundant irregular vughs (0.1-0.9 cm), fine interconnecting randomly oriented channels and fine chambers (loose vughy structure); some associated with or partially infilled by fine granular to crumb like aggregates separated by simple packing voids. Fine textural pedofeatures (@ 2%) are massive (coalesced earthworm detritus).

Basic mineral components

c/f limit varies from 25 μm at 30:70 to 40:60, 5% of these areas have an upper limit of 60 μm; 20:80 within recent worm channel infillings; subsidiary limit where very coarse particles cluster of 100 μm at 20:80 to 10:90. Poorly sorted, mostly gefuric, ie. coarser particles linked by braces of finer material, some areas chitonic, ie. coarser particles rest on each other.

Coarse:- 30 to 40% subangular to subrounded quartz (rare angular), abraded and cracked, subsidiary chalcedony, some calcareous (mostly < 600 μm); 45% subangular to subrounded (to elongate) magnesian limestone, variable calcite content, variably shelly, clastic, siliceous, calcitic, ie with crystalline calcite inclusions (25 μm to 1.5 cm); 5% rounded to subrounded opaques, possibly Fe oxides or degraded, humified or carbonized woody (seed) fragments (20 to 500 μm); rare (< 2%) subangular Ca-plagioclase (100-750 μm), pyroxenes and rutile. Rare inclusions of Fe rich sandstone, up to 4 mm; many particles of 25 to 100 μm are abraded, weathered and partially coated by clay minerals and/or Fe oxides.

Fine:- 50 to 80% yellowish to reddish brown, calcite, iron oxides/clay minerals and silt sized microcontrasted punctuations (possibly organic); 50 to 20% abraded and weathered calcite and limestone fragments with subsidiary quartz and calcareous chalcedony (6 to 25 μm).

Basic organic components

Coarse:- common subrounded reddish brown to black isotropic inclusions (25 μm to 100 μm), may be burnt or partially humified wood or seed fragments (weathered earthworm residues); rare reddened structureless organic residues; rare (cellulose rich) root remains partially infilling root channels; rare fungal sclerotia and spores and cell residues (10-16 μm).
Fine:- contributes to the isotropic component of the fine groundmass.
Organic matter content very low.

Groundmass

c/f as above.
Coarse:- overall random distribution; occasional clustering of particles > 100 μm (80% quartz, 15-20% limestone, rare feldspars, pyroxenes and rutile); some clustering associated with loose worm sorted areas, coarse particles have a random orientation, others cluster randomly within soil matrix and exhibit a banded or concentric orientation (may be faunal turbation features)
Fine:- stipple speckled to crystallitic b-fabric, clays are randomly distributed.

Pedofeatures

i) Fine textural pedofeatures largely lacking a coarse component, earth worm faecal residues, these may coalesce to form fine yellowish brown groundmass.
ii) Common rounded to cylindrical dark reddish brown largely isotropic (Fe and organic matter rich) inclusions (c/f 13 μm of 20:80: coarse comprises quartz and limestone residues) present as infilling within worm channels and the matrix, some are (upto 2 mm), may be earth worm faecal residues or relic aggregates.
iii) Rare to common, very slightly oriented (very fine stipple speckled to crystallitic b-fabric) reddish brown calcitic (microcrystalline) silty (organic) Fe oxide and clay hypocoatings and coatings associated with mineral grains and vughs (up to 100 μm thick), moderately developed. Similar materials occur within the soil matrix forming fine groundmass which lacks a coarse component (infilled voids or weathering in situ). Most void hypocoatings are associated with microcrystalline calcitic pendants or outgrowths. These features probably reflect in situ weathering, but also possibly illuviation, particularly in the case of the silt component. Some fine (5 μm) outer coatings comprise unresolvable or fine silt sized organic/carbonized materials, these may reflect illuviation or decomposition in situ, probably the former.
iii) Faunal turbation features (see above, coarse groundmass orientation).
iv) Rare shell fragments (3 * 0.5 mm) observed in transverse section, some are molluscan, other non crescentic shells may be inherited from the limestone.

2.2 Sample 277

Microstructure

Very porous, ranging from 10 to 30%. Complex structure.
Coarse channel structure: abundant coarse (2 to 5 mm) earthworm and root channels (channel structure), many vertically oriented, though horizontal orientations are common. Many infilled with very fine aggregates (@ 0.2 mm, crumbs or granules), separated by complex packing voids. 85% of voids comprise coarse irregular vughs (up to 5 mm) partially or completely infilled by fine crumbs and granules as above, these areas represent partially or totally collapsed earthworm/root channels. Soil textural pedofeatures (5%), are massive (earthworm channel infillings, void coatings and infillings).

Basic mineral components

c/f limit at 10 μm of 30/40:70/60 (recent earthworm channel infillings 10:90 with an upper limit f 120 μm); some areas 10:90 with all particles < 60 μm (see textural pedofeatures) ; poorly sorted; gefuric to chitonic, ie. coarser units linked by braces of finer material or coarse particles are surrounded by a cover of smaller units.

Coarse:- 40% quartz (10 to 700 μm), particles > 30 μm are subrounded to subangular and coated with fine silt and clay, particles < 30 μm are subrounded, abraded and partially obscured by clay finer material, subsidiary calcareous chalcedony; @ 40% magnesian limestone, mostly < 50 μm, variable calcite content, some intact fragments up to 1 cm, these are weathering to clay minerals at the edges; subsidiary (< 5%) microcline and calcium plagioclase (@ 60 μm); pyroxenes (40 to 60 μm); rutile.

Fine:- 50 to 80% reddish brown calcitic clays and silts, microcontrasted punctuations (organic?); 50 to 20% abraded and weathered calcite and limestone fragments with subsidiary quartz and calcareous chalcedony (6 to 15 μm).

Basic organic components

Coarse:- Rare reddened fine tissue remains, partially distorted and swollen, cells clearly visible, others lack any cell structures; common subrounded reddish brown isotropic inclusions (25 μm to 3 mm) may be partially burnt, abraded an degraded seeds or humified woody remains (weathered earthworm residues).
Fine:- contributes to the isotropic component of the fine groundmass (microcontrasted punctuations).

Groundmass

c/f 10 μm
Coarse:- overall random distribution.
Fine:- weak stipple speckled b-fabric, some calcitic areas are crystallitic.

Pedofeatures

i) Common dark reddish brown cylindrical, isotropic inclusions associated with some voids but occurring also within the matrix (c/f 13 μm of 20:80, coarse comprises quartz and some limestone residues), may be weathered earthworm faecal remains or relic aggregates.
ii) Very common (ubiquitous, random distribution) slightly oriented (very fine stipple speckled to crystallitic b-fabric), reddish brown calcitic silty clay hypocoating and coatings (clay weathering in situ, illuviation or a combination of both) associated with mineral grains and vughs (up to 100 μm thick). Surfaces are often roughened by calcitic outgrowths, particularly upper surfaces (pendent). This material is also found within the soil matrix forming fine groundmass which lacks a coarse component (infilled voids?).
iii) Well developed layered calcareous impure clay, silty void coatings (often crescentic), crusts and cappings, often traversed by vertically oriented root channels. These often exhibit the following sequence from coating surface: a) fine (< 5μm) black isotropic organic coating, b) calcitic silt (mineral and organic), c) calcitic clay, fine silt and iron oxides, d) silty (like b), and e) clay and iron oxides (like c) (stipple speckled to crystallitic b-fabric). Some continue laterally as micro-pans.
iv) Common fine reddish brown organic inclusions, randomly distributed, c/f 10:90, upper limit of 60 μm, may be faunal but are often associated with features described above (ii and iii).
v) Calcitic root pseudomorph (200 by 700 μm), may be non woody but some simple oblique perforation plates and spiral thickenings observed (Acer or Tilia).
vi) Discrete shell fragments (@100 μm), some are crescentic (snail) others straight and elongate (inherited/geologic).

2.3 Sample 278

Microstructure

Very porous, 20 to 30%. Complex structure.
Coarse channel structure, common earthworm and root channels (up to 4 mm), vertically and horizontally oriented. Non coated channels infilling with very fine crumbs or granules (@ 0.2 mm), separated by complex packing voids. Some channels are coated with stipple speckled impure clay and silty coatings, these have rough surfaces. Predominantly complex vughy structure (collapsed channels), irregular vughs (up to 5 mm) are partially or totally infilled with crumbs and granules.

Basic mineral components

Heterogeneous:- c/f limit at 20 μm varies from 60:40 to 30:70, these areas appear to be randomly distributed and may reflect a combination of the fragmentation of clastic limestone in situ and worm activity; moderately to poorly sorted (depending on the abundance of quartz); random distribution and orientation; gefuric/chitonic to porphyritic.

Coarse- 60 to 70% magnesian limestone fragments up to 1.5 cm, mostly < 150 μm, most silt sized (< 60 μm) are weathering and partially coated by clay minerals; 30% subrounded, subangular to angular quartz 20 to 200 μm (80% < 66 μm), subsidiary calcareous chalcedony; 10 % feldspars (40 to 600 μm), subangular plagioclase, microcline and subsidiary coarse (300 μm) orthoclase; subsidiary (< 2%) amphiboles, perfect basal section @ 150 μm; fine pyroxenes (< 50 μm); fine opaques; iron rich sand stones (> 600 μm).

Fine:- 80% fine calcite and limestone fragments; reddish brown clay minerals, silt sized particles, microcontrasted punctuations (may be organic).

Basic organic components

Coarse:- Rare charcoal fragments (300 * 650 μm), xylem is diffuse porous, vessels solitary, in clusters of up to 5 and in radial chains of up to 4, may be Acer, Carpinus betulus or even Betula; common dark reddish brown, opaque and isotropic possibly organic fragments (up to 133 μm), maybe humified or carbonized wood, seeds, weathered earthworm residues.
Fine:- present as fine surface coatings within voids, microcontrasted punctuations.

Groundmass

c/f as above
Coarse:- mostly random distribution, some clustering and parallel/concentric orientation, probably due to worm sorting and infilling of channels with san-sized particles.
Fine:- crystallitic b-fabric, impure silty coatings - stipple speckled b-fabric

Pedofeatures

i) Common dark reddish brown, fine groundmass opaque and isotropic possibly organic fragments (up to 133 μm), weathered earthworm residues or relic aggregates (c/f at 60 μm of 50:50, coarse, mostly quartz.
ii) Prominent yellow brown earthworm faecal pellets, joining to form fine groundmass infilling large vughs.
iii) Common clay/silt and organic (punctuations) coatings of minerals and hypocoatings and coatings of voids, random distribution/orientation, some have calcitic outgrowths.
iv) Rare compound layered clay, silt and organic coating, preferentially lateral, one large continuous (over 1 cm) crescentic and convoluted coating is now relic and lies within the soil matrix.
v) Rare snail shell fragments and inherited shelly fragments.

2.4 Sample 279

Microstructure

Moderately to very porous (10 to 30%), complex channel/vughy structure.
50% medium non-coated horizontally and vertically oriented channels (@ 0.2 to 2 mm), some channels coated with dark reddish brown impure clay and silt, most partially or completely infilled by loose fine crumbs. Abundant coarse to vughs to medium, partially collapsed and infilled, some fine vughs coated (like channels).

Basic mineral components

Heterogeneous:- c/f limit at 20 μm varies from 60:40 to 30:70, these areas generally randomly distributed, reflect a combination of the fragmentation of clastic limestone in situ and worm activity, other areas are clearly banded; moderately to poorly sorted (depending on the abundance of quartz); gefuric/chitonic to porphyritic.

Coarse:- 60 to 70% limestone and limestone fragments, 60% are < 60 μm, weathering and clay coated, clasts up to 1.5 cm, variable calcite content;
rare inclusions of sandstone (@ 600 μm, 90% quartz, 5% muscovite); 30% subrounded to subangular quartz (20 to 600 μm, 80% < 150 μm), subsidiary calcareous chalcedony; 5% opaques (60 to 150 μm), clustered; < 5% feldspars, plagioclase only seen, rare pyroxenes.

Fine:- Calcite and reddish brown, Fe impregnated clay minerals, impure clay coatings and silt, microcontrasted punctuations and organic gels ?.

Basic organic components

Coarse:- common dark reddish brown, opaque and isotropic possibly organic fragments (up to 133 μm), may be humified or carbonized wood, seeds (weathered earthworm residues); rare charcoal fragments structures visible, coarse opposite polygonal pits, perforation plates simple and slightly oblique, uniseriate and bi-seriate

rays (1 to 25 cells high), may be Acer or Aesculus Hippocastanum (though rays of latter usually uniseriate) (hornbeam but vessels in sample above more sparse).
Fine:- isotropic component of the groundmass, microcontrasted punctuations.

Groundmass

c/f as above.
Coarse:- mostly random distribution, some clustering and parallel/concentric orientation, probably due to worm sorting and infilling of channels with sand-sized particles; some clustering of opaques.
Fine:- crystallitic b-fabric, impure silty coatings - stipple speckled b-fabric.

Pedofeatures

i) Some areas exhibit micropanning (may be relic void coats) and or a linear/banded/inclined distribution of the coarse component. Some of these areas are associated with linear banded concentrations of opaques, possibly finely divided organic or carbonized material.
ii) Well developed reddish brown impure clay and silt hypocoatings and coatings within voids and coatings around particles, though better developed as crescentic coatings in voids, only sightly anisotropic (crystallitic b-fabric). Fe impregnated, generally non laminated, though rare laminated coatings seen, irregular surface due to calcitic crystal growths.
iii) Common dark reddish brown, fine sand sized isotropic inclusions (up to 133 μm), possibly earthworm residues or relic aggregates (c/f at 60 μm of 50:50, coarse, mostly quartz).
iv) Yellowish brown rugose earthworm faecal remains, these coalesce to form fine stipple speckled infillings (recent)

Appendix 3.

Ditch section M378, segment F585, east facing cross section, samples 254, 255, 256, 257.

3.1 Sample 254

Microstructure

Moderately to very porous, 10 to 30% pore space, loose, abundant channels and vughs most infilling with loosely packed fine aggregates (granules and crumbs). Laminated and/or reddened coatings are generally absent

Basic mineral components

c/f limit at 25 μm of 20:80 to 40:60, poorly sorted, enaulic, chitonic to porphyritic.

Coarse:- 50 to 60% magnesian limestone fragments, upper limit ranging from 2 mm to 1.5 cm, variable clast content, particles < 60 μm weathering and clay coated; 30 to 40% subrounded to subangular quartz upper limit 600 μm, subsidiary calcareous chalcedony; < 5% subangular, relatively unweathered plagioclase feldspar; subsidiary (< 2%) fine opaques, may be Fe oxides or carbonized inclusions (seeds); rare subrounded blackened iron rich (weathering) sandstones (up to 3 mm).

Fine:- 40 to 60% fine weathering limestone and quartz; reddish brown, iron rich clay and silt sized particles, isotropic microcontrasted punctuations may be organic.

Basic organic components

Coarse:- Rare translucent, yellowish/reddened, distorted tissue residues (up to 130 μm), rare dark red partially anisotropic/granular/opaque organic residues (< 60 μm), see also pedofeatures i) and ii) below.
Fine:- isotropic component of the fine groundmass, microcontrasted punctuations.

Groundmass

c/f as above
Coarse:- random distribution, occasional banded clusters, concentric parallel orientation (bio-turbation), occasional clustering of opaque (carbonized) material.
Fine:- stipple speckled to crysallitic (calcitic).

Pedofeatures

i) Rounded to subrounded, dark reddish brown opaque textural pedofeatures, < 50% fine mineral inclusions (< 60 μm) mainly quartz, worm faecal remains, polymorphic organic matter, relic aggregates, impregnated with Fe.
ii) As above but lacking mineral component, may be lignified, degraded or burnt wood or seed residues, some, in contrast with pit examples, are definitely seeds (cereal). Some are limpid, yellow orange to yellow red, decomposing organic matter.
iii) Common shell fragments, snail shells (2-3 mm) in cross section; coarser shell inclusions (7.5 * 2 mm) may be inherited.

3.1 Sample 255

Very similar to 254. Slightly more porous (20 to 30%), loose spongy vughy structure, similarly lacking coatings, though some have linings of loose calcitic material. Slightly more porphyritic. Limestone fragments are slightly more angular, slightly less reddened (lower organic matter and Fe ie. less pedogenesis), rare non woody calcitic root pseudomorphs within root channels, no structure but root hairs visible. Fewer pedofeatures, i) and ii) above. Shell fragments only seen, no obvious snail shell structures, coarser fragments noted may be geological. Several fragments of humified wood also observed towards the base. Structures just visible though not clear enough for identification.

3.2 Sample 256

Microstructure

Very well developed void system with abundant interconnected vughs, channels, chambers, some preferred vertical orientation of channels, though overall distribution of voids is random. Porosity variable, and may vary from @ 5 to 10% within the soil matrix (porphyritic areas, mainly fine vughs and channels) to 30% in looser coarse vughy areas. Vughs and channels range from 1 * 0.5 cm to 1 * 0.5 mm, many coarse voids are loosely infilled by fine detritus and aggregates, crumbs and granules (like recent profile), most fine voids within the soil matrix have smooth, undulating accommodating walls which are not coated. No evidence of recent worm activity.

Basic mineral components

c/f at 16μm of 40:60, poorly sorted, gefuric to porphyritic, some areas of the matrix appear dense.

Coarse:- @ 80% limestone and calcite fragments, 20 to 30% subangular limestone fragments > 1mm, upper limit 1.5 cm, ; 20% angular to subangular quartz, mostly > 60 μm, subsidiary calcareous chalcedony; 5% opaques ranging from 10 μm to 1 mm, may be Fe oxides, carbonized seeds or woody residues??; rare (<2%) feldspars and micas.
Fine:- weathering clay coated calcite, yellow/reddish brown clay minerals and silt sized particles, organic component (see below).

Basic organic components

Coarse:- common tissue remains (0.2 mm), cells swollen and disrupted, rare roots in cross section (not woody),

others not identifiable, all are reddened; rare spores/degraded pollen grains?; limpid yellow red subangular fragments, organic matter decomposition products.
Fine:- the isotropic component of the groundmass, microcontrasted punctuations @ 25 μm are probably organic.

Groundmass

c/f as above.
Coarse:- Varies from random to clustered, some concentric groupings may be bio-turbation features (loosely infilled worm channels) or related to rolling, wind action ie mode of infilling (see also pit infill), other clusters comprise predominantly rounded to subrounded mineral grains; rare areas have linear distribution, inclined orientation, may reflect shearing planes (see below).
Fine:- stipple speckled to crystallitic depending on proportion clay minerals/calcite.

Pedofeatures

i) Common, fibrous calcitic outgrowths associated with void surfaces, individual crystal outgrowths are resolvable and may be @ 16 μm. Other coatings rare, though rare dusty organic/calcitic coatings seen (other coatings rare).
ii) Some evidence of shearing (dumping ??)
iii) Rare fine (0.5 cm) oblong/elliptical textural pedofeatures (c/f 160 μm at 50:50, coarse:- quartz with subsidiary feldspars and muscovite micas, fine:- iron/organic rich clay minerals), some very fine textured inclusions may be weathering Fe rich sandstones
iv) Calcitic root pseudomorphs not identifiable (probably not woody).
v) Common snail shells, often intact and in cross section (0.2 mm), coarser shell fragments may be inherited.

3.4 Sample 257

Microstructure

Slightly more porous than above ie 20 to 30 % pore space. Vughs, channels and chambers, many infilled with loose detritus and fine aggregate, many finer voids are coated by impure clay and silt (see below).

Basic mineral components

c/f limit at 10 μm of 10:90 to 40:60, moderately sorted (excluding clasts), gefuric in parts, mainly porphyritic.

Coarse:- Many rounded to subrounded (wind blown); @ 80% limestone and calcite fragments, 40% subangular limestone fragments (1 mm to 2 cm), most particles < 60 μm are weathered and clay coated; 15% subangular to rounded quartz, subsidiary calcareous chalcedony; @ 5% opaques, Fe oxides, humified or carbonized wood or seed residues; subsidiary micas and feldspars.
Fine:- yellow/reddish brown clays/silts (fine silts particularly abundant), subrounded coated calcite and microcontrasted punctuations (mostly organic), concentrations associated with some void surfaces and also within the matrix, some areas may be Fe impregnated.

Basic organic components

Coarse:- Abundant fragments of carbonized plant tissue, may be burnt, structures just visible though not well preserved (upper limit 160 μm), some appear to be Fe impregnated and occur within channels (in situ); rare to common, fibrous and slightly birefringent reddened tissue and cell residues (fungal?), mostly < 30 μm.
Fine:- isotropic component of the fine groundmass, abundant (more so than above) microcontrasted punctuations.

Groundmass

c/f as above

Coarse:- Random to clustered distribution, clusters are rarely concentric, some may reflect the breakdown of clastic limestone in situ or biotic activity, the infilling of vughs channels etc. Many coarse clustered fragments are rounded and may have been wind blown.
Fine:- stipple speckled to crystallitic, depending on relative proportion of clay and calcite

Pedofeatures

i) Abundant calcitic crystal outgrowths associated with void surfaces, but also occurring within the matrix (as above), are examples are coarsely crystalline and forms accumulations up to 150 μm, some infill fine vertically oriented channels.
ii) Common reddened (Fe impregnated) impure clay and silt coatings (not layered) and concentrations within the matrix, are these product of subsequent dissolution of calcite out growths and associated neoformation of clays, some outer edges of calcite out growths are yellowish red, some blackened organic residues may reflect degradation of woody residues in situ.
iii) Abundant elongated shell fragments (described previously as possibly inherited and therefore geological), most are horizontally oriented or inclined; abundant fine snail shell fragments, often seen in cross section, random distribution.
iv) Rare calcite root replacement pseudomorphs (< 133 μm), most not woody, some root hairs are clearly visible, one seen with spiral thickenings, very slightly oblique simple perforation plates (possibly Tilia).
v) Accumulation of subrounded features (@ 25 μm), outer rims reddish brown (@ 3 μm) look organic, but central areas totally isotropic (are these pollen grains).

Appendix 4

Ditch section M378, segment F585, south facing longitudinal section, samples from contexts 628, 592 and 526 (sample 274) and 592 and 526 (sample 275)

4.1 Sample 274

Includes soil overlying charcoal rich horizon (628), charcoal rich horizon (592) and sub-charcoal soil (526).

Microstructure

Moderately to very porous, ranging from 10% to 30% with coarse and fine vughs, channels and chambers (all indicating high biological activity). Soil overlying the charcoal rich horizon tends to be looser and more coarsely porous (up to 30%), many areas loosely infilled with abundant complex packing voids; loosely infilled vughs predominate within context 592; chambers and channels predominate below (10% to 30%) ie. less mechanically disturbed. Complex loose spongy/vughy/crumb to channel structure.

Basic mineral components

c/f at 15 μm of 40:60 to 50:50 (ie. coarser than previous sections), mainly enaulic, ie. mineral grains may rest on each other, some areas chitonic, moderately to poorly sorted.

Coarse:- 80% limestone of variable crystallinity and state of weathering, 20% coarse subrounded limestone fragments 1 mm to 1.5 cm (random orientation), most fragments < 60 μm are subrounded and weathered; 20% angular to subangular quartz, mostly < 60 μm, upper limit 600 μm, in some areas quartz > 200 μm comprises > 40% (clustering), subsidiary chalcedony; opaques probably carbon debris.
Fine:- reddish brown clay and silts, fine calcite, microcontrasted punctuations, probably organic. In central areas (context 592) fine carbonized material (unresolvable) may comprise up to 50% of the soil matrix. Discrete concentrations of fine carbonized material occur throughout the overlying horizon.

Basic organic components

Coarse:- carbonized or lignified wood fragments (up to 4 mm) occur throughout but are concentrated within charcoal rich horizon, ring porous?, vessels sparse, solitary, slightly angular, in pairs or short radial chains of 3 to 4, may be Acer, Fraxinus (context 628 only); scalariform perforation plates (seven), fine polygonal elongated bordered pits, probably Corylus avellana; some fragments of the latter (roots) are humified orange/brown with perforation elements, pits, rays and axial parenchyma all present; many woody fragments lack diagnostic features; humified, reddened, swollen and distorted, generally non woody tissue remains (up to 150 μm). Charcoal, humified woody and other tissue residues may comprise up to 20% of context 592, though all of these organic components occur throughout the over and underlying horizon (contexts 628 and 526).
Fine:- microcontrasted punctuations, yellow brown to reddened cell residues, carbon residues.

Groundmass

c/f as above
Coarse:- randomly distributed to clustered
Fine:- stipple speckled to crystallitic to undifferentiated depending on clay/silt, calcite and carbon content respectively.

Pedofeatures

i) Textural/impregnation pedofeatures, dark red to brownish red, fibrous, partially anisotropic, may be organic matter decomposition products, some have coarse mineral component (c/f 10:90 limit at 20 μm, coarse component primarily quartz, these occur randomly throughout.
ii) As above but dark brown, largely isotropic textural pedofeatures, higher mineral component (up to 50:50), may be worm faecal residues, relic aggregate etc.
iii) Rare burnt coarse shell fragments occur within charcoal rich areas.
iv) Possible bone fragments, unburnt
v) A few, coarse (1 cm) rounded, textural pedofeatures differentiated only in terms of colour (ie. reddened).

Well defined coatings, either calcitic or impure clay and silt were not observed

4.2 Sample 275 including charcoal rich soil (592) and underlying soil(526).

For basic soil features see above, any additional or relevant features are detailed below.

Basic organic components

Coarse:- possibly some Quercus, Fagus, Fraxinus, Ulmus; these and other woody fragments may comprise up to 30% of total soil area.
Fine:- black to dark reddish brown carbonized and humified debris (non resolvable) may comprise 50% of total soil area.

Pedofeatures

Some slight reddening/brunification associated with void walls, ie. Fe enrichment associated with weathering rather than coatings.

Comments

The lower boundary of the charcoal rich horizon is prominent, sharp and therefore relatively intact, though fine to coarse carbonized debris is distributed throughout 526 (@ 2 to 5% of total soil area). Disturbance has been minimal, what is depth from soil surface, little evidence for contemporary worm activity.