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Textural pedofeatures and pre-Hadrian's Wall ploughed paleosols at Stanwix, Carlisle, Cumbria, UK.

by

M.-Raimonda Usai

Summary

During the last thirty years the value of sandy, silty or dusty textural pedofeatures for identifying past agricultural practices has been the subject of debate, particularly with regard to the applicability of observations concerning features of modern soils to ancient soils.

Macro- and micromorphological analyses were carried out on all the contexts in a series of five trenches containing pre-Roman plough grooves at sites near Hadrian's Wall, Cumbria. Micromorphological observations of 31 thin sections showed that the pedofeatures in question were not preferentially distributed in thin sections of sediments from within or below the plough layers, but were more concentrated in contexts which, as shown by field and archaeological evidence, were unlikely to have been affected by cultivation. Conversely, the pedofeatures were absent in other thin sections of sediments from and below the contexts where past agriculture was documented by field and archaeological features. The analysis also showed that the pedofeatures in question tended to be distributed in parts of the sequence with suitable porosity, soil structure and texture rather than in relation to the position of the cultivated layers. All the results in this case study showed that silty, sandy and dusty pedofeatures were not diagnostic for past agricultural practices, and highlighted the need for more research on the micromorphological evidence of ancient soils with a known record of past agriculture.

Keywords: TEXTURAL PEDOFEATURES, MICROMORPHOLOGY, HADRIAN'S WALL, ANCIENT AGRICULTURE

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Textural pedofeatures and pre-Hadrian's Wall ploughed paleosols at Stanwix, Carlisle, Cumbria, UK.

Introduction

For many years, the value of some types of micromorphological pedofeatures for diagnosing ancient agricultural practices has been the object of assumptions, questions and debate. The first part of this paper summarizes the background to this issue with regard to both present-day soils and geoarchaeological studies, and the second part describes a geoarchaeological investigation of the micromorphological pedofeatures in question in paleosols with plough marks buried under Roman deposits along Hadrian's Wall, in Cumbria.

Background: present-day agriculture and textural pedofeatures

The term *agricutans* was introduced by Jongerius (1970) to describe *illuviation* (mobilization and redeposition) coatings made of sand, silt, clay, organic matter (or one or more of these components) occurring on the surface of certain types of soil voids as a result of agricultural practices. He suggested that separation of soil components occurs in cultivated layers as a result of temporary saturation of a cultivated layer by water, or as a result of microerosion of clods. The separated soil components move downwards in the profile until they are stopped by an obstacle, such as a plough-pan, or until the soil dries up again, after which they form *concentrations* on planes (voids with non-accommodated walls) and channel walls in the form of agricutans characterized by small layers of different texture and composition.

Jongerius suggested that *slaking* (the term used for reciprocal separations of formerly bonded soil particles, and their successive concentration or deposition within the soil) depends on a wide range of factors such as climate, internal soil drainage, pH, base saturation, structural stability, and particularly iron compounds and clay and organic material content. For example, he reported that in the Netherlands slaking occurred mainly in soils with low content of clay and organic matter and with small amounts of iron and calcium; less frequently, it occurred in humus-rich soils. He also suggested that different types of morphology are obtained, depending on where slaking takes place in the soil profile. If slaking occurs in the uppermost few millimetres of the ploughed surface, it usually results only in washing away of soil from the tops of plough ridges and deposition in the furrows or low points of the fields, the extent depending on vegetation cover, time and type of ploughing, and water stability of the soil structure. If, however, slaking occurs throughout the entire ploughed horizon, and the horizon is saturated with water for long enough, soil particles could lose their reciprocal binding and move downwards naturally, accompanied by sorting, producing a compact layer. If there are continuous vertical planes or channels under the ploughed horizon, or below the compacted layer, then part of the sorted material could reach them and cover their walls with coatings – agricutans – darkened by organic matter (these would now be called *dusty coatings,* following the more recent classification of Bullock *et al.*, 1985). In light-textured soils, such agricutans are mostly in layers, whilst they are more homogeneous in heavier soils.

Finally, Jongerius describes how agricutans can also form in the absence of slaking, as a result of water from rainfall or melting snow or ice running downwards along clod surfaces which, as a consequence, become eroded. The eroded material is deposited in the form of agricutans in the lower part of the ploughed horizon.

The mechanism of slaking and formation of agricutans is also summarized in a later paper (Jongerius, 1983). Both papers are based on observations of specific types of soils in the Netherlands, including marine clay soils, loess soils, Knip marine soils and sandy podzolic soils, all generally developed in relatively young sediments.

Since the mid seventies, internationally accepted soil classifications produced by the United States Department of Agriculture (USDA) have described horizons formed under cultivated topsoils as *agric horizons*. The most recent version (Soil Survey Staff, 1997) describes agric horizons as containing significant amounts of illuvial silt, clay and humus, attributing the process of agric horizon formation to long-term cultivation which causes clearly visible changes in the horizon *directly below* the plough layer. The process is explained clearly: 'Large pores in the plow layer and the absence of vegetation immediately after plowing permit a turbulent flow of muddy water to the base of the plow layer. Here the water can enter wormholes or fine cracks between peds, and the suspended materials are deposited as the water is withdrawn into capillary pores. The worm channels, root channels and the surfaces of peds in the horizon underlying the plow layer become coated with a dark coloured mixture of organic matter, silt and clay' (Soil Survey Staff, 1997, 9). It is further explained that coatings on wormholes thicken and can eventually fill them, but if worms are scarce, the accumulations may take the form of lamellae that range in thickness from a few to about ten millimetres. Furthermore, there can be several differences in chemistry and other characteristics depending on climatic and geographical conditions. To summarize, the USDA classification suggests that textural pedofeatures resulting from ploughing can have different textures, that they occur in an horizon directly below ploughed layers, and that their morphology changes depending on the quantity of voids present to the extent that, in absence of worms, lamellae (rather than coatings or infillings) are formed.

Horizons with *agric* properties or pedofeatures have also been mentioned in micromorphological soil classifications (e.g. Kemp, 1985). The accumulations described by the USDA are clearly similar to the agricutans of Jongerius (1970; 1983) and, with some good will, can be classified as specific types of textural pedofeatures on the basis of the current international micromorphological classification (Bullock *et al.*, 1985).

The emphasis given to illuviation features resulting from ploughing clearly explains why it is often assumed that agricutans are diagnostic for ploughing and, in the field of geoarchaeology, of past agricultural practices. In fact, the two articles by Jongerius and the USDA description could be interpreted as suggesting that the effect of agricultural practices on soils always leads to the formation of agricutans in voids or cracks within or below the arable topsoil. However, bearing the high variability of soils in mind, it is very difficult to extrapolate evidence from case studies to the whole spectrum of possible soil types; there could be other causes for the formation of agricutan-like materials. Rain drop impact, for example, can cause the formation of soil crusts and the dislocation and illuviation of material in the soil profile. Since the early eighties it has been observed (e.g. by Tarchitzky *et al.* 1984) that the formation of rain drop impact-induced soil crusts and the resulting concentration, transportation and deposition of particles depended on the quantity of rain and on the speed and type of runoff, but the authors do not mention agriculture as the cause of such particle release.

It could also be argued that agricutans might not be formed in some cultivated soils, and could be formed only under specific conditions. In fact, Jongerius (1970; 1983) himself specified that formation of agricutans was observed under, and favoured by, specific conditions and soil types, profiles and textures, climatic, hydraulic, and chemical conditions as described above. Furthermore, soil slaking is described as typical of the "impact of rain drops and subsequent or partial destruction of aggregates at the surface, followed by washing and sedimentation of separated particles and/or aggregate fragments into holes between clods" (Jongerius, 1983,118). This definition does not necessarily imply that agricultural practices are needed to cause the phenomenon. In the same study, it is observed that slaking depends on the time of the year (autumn or spring), and the kind of tillage, and is favoured by low clay or organic matter content and by small amounts of iron or calcium ions (*ibid.*), although numerical figures for these factors are not always given. Thus, before considering agricutan-like textural pedofeatures as a primary result of present (or ancient) agriculture, it is at least necessary to consider that such features can vary, or may not even occur, depending on the factors mentioned above and summarized in Table 1.

Table 1.
Summary of factors affecting soil slaking and the formation of agricutans as defined by Jongerius (1970; 1983).

- Soil structural stability
- Soil texture
- Clay and organic matter content
- Water saturation; internal soil drainage
- Presence of obstacles to the downward movement of particles (e.g. ploughpans)
- Presence of suitable voids
- Presence of iron compounds
- pH-base saturation
- Rainfall
- Presence of melting snow or ice
- Time of the year (season)
- Kind of tillage

Geoarchaeology and ancient cultivated soils

It has been suggested that modern and past cultivated soils are comparable in respect to those features caused by the presence of an unvegetated or irregularly protected soil surface (Macphail, Courty and Gebhardt, 1990). Features similar to those described by Jongerius and USDA were also produced by prehistoric or historic cultivation (e.g. Macphail, 1986; 1992) and, on the basis of Jongerius' studies (1970; 83), such features have been considered to be a direct result of ancient agricultural practices (e.g. Gebhardt, 1989). It has also been suggested, however, that the presence and extent of agricutans as a result of past agriculture depends on soil pH and texture: the formation of agricutans would not be favoured in acid soils, as these would not encourage translocation, and soils with a pH which was neither too acid nor too alkaline would easily support biological activity which in turn would cause a loss of textural pedofeatures (Courty, Goldberg and Macphail, 1989).

Very few experimental studies have been carried out to investigate the formation of textural pedofeatures resulting from agriculture. Though the disturbance of archaeological material in plough soils as a result of cultivation has been investigated by Yorston, Gaffney and Reynolds (1990), such studies have not been concerned with the effect on pedological features of the soils. Courty, Goldberg and Macphail (1989) reported that from experimental studies it appeared that cultivation does not always lead to a surface *Ap* (ploughed top soil) horizon characterized by textural pedofeatures. The problem, however, may be more related to the question of whether agricutans occur below, rather than within, the Ap horizon – Jongerius' agricutans having been described in a horizon directly below ploughed layers (Jongerius, 1970; 1983).

Other types of studies have been concerned with the description of micromorphological features of soils in known archaeological contexts. For example, illuviated clay coatings have been found together with coarser (clay and silt) coatings in deposits within archaeological pits (Slager and van de Wetering, 1977). Whilst fine textured coatings were attributed to such agencies as the addition of woodash, coarser coatings were correlated with forest clearance which could cause the formation of a bare soil surface on which rain drops could exert an impact - this being seen as the indispensable condition for the formation of the coarser coatings (*ibid.*). Past truncation of soil profiles in northern Luxembourg was correlated with past cultivation practices inferred from the presence of agricutan-like features in mineral horizons of a buried soil underlying a present day plough soil (Kwaad and Mucher, 1979). Clay and silt textural pedofeatures from soils at West Howe, Orkney, Scotland, where past agricultural practices and field systems were recorded by historical documentation, have been interpreted as indicators of ancient cultivation practices, and greater frequency of textural pedofeatures in certain areas has been suggested as a possible reflection of more intense cultivation (Simpson, 1997). Other investigations of micromorphological features of soils in known archaeological contexts also included a study of soils near an Iron Age settlement in the present day Parish of Lodbjerg, in Jutland (Denmark), where dusty silty and/or sandy clay pedofeatures, organic residues, and a dusty fine mass, some of which resembled till material discovered in an underlying Iron Age floor, were found in ancient cultivated topsoils (Courty and Nornberg, 1985). In the same study, a few concentrations of fine soil material mixed with silt and fine sand were found in an A horizon above an Iron Age house floor and below the cultivated topsoil which, in places, was also mixed with till deposits. Such features, however, were not found in a podzolised soil in the same area. Pores lined with a material described as oriented silt and clay were found in deposits buried under the rampart of a Roman fort at Strageath Mains (Romans and Robertson, 1983). Mobilization of colloidal suspensions of clay and their deposition as linings of soil voids in contexts in a mount at North Mains of Strathallan was interpreted as indicating mechanical damage resulting from past ard cultivation both on the basis of the presence of other evidence for cultivation, and on the basis of the hypothesis that clay deposition was more likely to occur when clay was washed off recently cut surfaces than from undamaged structure faces (*ibid.*).

Later, it became clearer how easily a multitude of different types of clay coatings can be produced in a variety of circumstances and physico-chemical environments, and it was shown that clay coatings of different types could be easily produced in a short time, with a few cycles of leaching, their thickness, composition and morphology depending on the chemical and mineralogical composition of the clay suspension leached, and on the speed and number of leaching cycles (Akamigbo and Dalrymple, 1985; Theocharopulos and Dalrymple, 1987).

Other types of studies have been carried out in which micromorphological investigations of ancient cultivated soils did not highlight the presence of agricutans in certain soil horizons. For example, no evidence of agricutans is mentioned in a detailed micromorphological study of old cultivated soils from the Island of Papa Stour, Shetland (Bryant and Davidson, 1996). No micromorphological evidence for agricutans or other textural pedofeatures was found in topsoils which, through time, had gradually been deepened and mixed with manure, again in Papa Stour (Davidson and Carter, 1998). Here, past cultivation was well documented by historical and other evidence.

Thus, doubts remain as to whether past agricultural practices always resulted in micromorphologically diagnostic pedofeatures (e.g. Courty, Goldberg and Macphail (1989); Carter and Davidson, 1998) and, particularly, whether the absence of textural pedofeatures can be interpreted as evidence for absence of past agriculture (Carter and Davidson, 1998).

Other studies provided examples of causes for the formation of agricutans other than agriculture: mechanisms such as slaking on a floor, tree-throw, trampling or profile truncation have been suggested by Courty, Goldberg and Macphail. (1989). There have been subsequent studies in which agricutan-like micromorphological features were found in soils that could not have ever been cultivated: these features include many examples of different types of silty coatings, dusty clay, and impure clay coatings of various morphologies, layered or not, included within buried paleosols sealed by 2.27 million year-old basalt in Sardinia (Usai, 1996).

The issue of whether coarse, multi-texture or *dusty* pedofeatures – including the agricutans – are unequivocally diagnostic of past agriculture has now become the object of more doubt and debate. The view has been strongly emphasized that the presence of textural pedofeatures is not always diagnostic of past agricultural practices, and that Jongerius' conclusions concerning present-day agriculture are unlikely to provide an analogue which is applicable to the study of past soil conditions, or agricultural implements and activity (Davidson and Carter, 1998; Carter and Davidson, 1998).

To summarize: questions that need to be addressed concerning the significance of agricutan-like pedofeatures are: (a) are such pedofeatures diagnostic of past agriculture only in certain circumstances? (b) are they diagnostic only in certain parts of the profiles and, if so, which parts? (c) what other factors can cause them? And (d) does their absence indicate the absence of past agriculture?

Carter and Davidson (1998, 537) stressed that 'absence of evidence is not evidence for absence' (of past agriculture) and also emphasized that the impact of agriculture on soils can be better understood through the study of well-sealed buried agricultural soils which have a clearly explained archaeological context, and where the agricultural history can be determined from independent sources of evidence such as the presence of ard marks.

The second part of the present paper aims precisely at describing whether/where textural pedofeatures comparable to agricutans occur in ancient soils where unquestionable evidence for ancient cultivation is given by the extensive presence of ard marks in layers buried by archaeological Roman contexts near Hadrian's Wall and whether, really, 'absence of evidence is evidence for absence'.

Study sites

The study area is located to the NW of the Carlisle suburb of Stanwix, approximately 2 km north of Carlisle, in the vicinity of the Roman fort (stone fort of the *Ala Petriana* in Figure 1) at NGR NY 404573. The area is enclosed within two hills, Wall Howe to the west, and the hill where the Stanwix fort was located, to the east. Hadrian's Wall here runs in a NW-SE direction.

Several excavations in this area have been carried out by the English Heritage Central Excavation Unit (Smith, 1978) and, later, by the Carlisle Archaeology Unit (CAU), and all revealed evidence for extensive field systems pre-dating Hadrian's Wall. The excavations also showed a feature interpreted as the parade ground associated with the Stanwix fort (M. McCarthy and P. Flynn, personal communication). The parade ground deposit, of approximately three hectares in area and up to 0.7 m thick (Flynn and Zant, 1996) was probably material quarried locally, and redeposited into a depression to the NW of the fort, in the early second half of the 2nd century AD, possibly around AD 160 (*ibid.*). The parade ground deposit overlay layers of dark material whose lower surface appeared to follow the shape of extensive and clear plough grooves which cut into the underlying layers (CAU, personal communication). Similar stratigraphy (dark layers overlying a layer with plough marks along its upper boundary) was found under the counterscarp bank of Hadrian's Wall during other excavations by CAU (*ibid.*). The layers with plough marks pre-dated the counterscarp bank construction (AD 120) and post-dated a charcoal-filled feature the radiocarbon date for which fell in the range 8th-5th century BC (OxA-6181; Flynn and Zant, 1996).

Four trenches were excavated and sampled for the present micromorphological study (Figure 1). They included three profiles (L, T and D) through the parade ground deposit, south of Hadrian's Wall, Profile N through the counterscarp bank, and Profile K through and near the northern edge of the counterscarp bank. Profiles S and Z were sampled in another trench which had already been excavated in 1994 through the parade ground.

Sampling and methods

Most undisturbed samples for micromorphological analysis were collected using Kubiena boxes (Figure 2). Deposits from the sampled profiles were described employing mainly the methods of Hodgson (1976), with some additional observations. Thin sections were prepared by the Department of Plant and Soil Science, University of Aberdeen and the Department of Environmental Science, University of Stirling, and were described mainly using the method of Bullock *et al.* (1985). Micromorphological analysis was especially concerned with textural pedofeatures, but it also included analysis of microstructure, related distribution pattern of the coarse and fine material, the ratio between the quantity of coarse and fine material (c/f ratio), organic components, and voids.

Results

Field work and micromorphology

The stratigraphies of Profiles K, L, T, D, S and Z were all characterized by an organic-rich layer buried by Roman deposits (whether these consisted of the counterscarp bank or the parade ground). The lower boundary of this organic-rich layer followed the surface of the underlying buried deposits, this surface being characterized by linear or criss-cross grooves interpreted by the excavators as pre-Roman plough marks. The plough marks of Profiles L and K are shown in Plates 1 and 2. Profile N was selected as a natural control profile where no traces of past ploughing or other archaeological features were found. Full field descriptions of all profiles are presented in Usai (1999).

The stratigraphy of all the sampled profiles is shown in Figure 2. Horizon notations were obtained from both field and micromorphological descriptions. Summaries of the field analysis of two representative profiles, N and L, are also given in the text below.

The results of micromorphological analysis are described in Table 2. The micromorphological variables considered are those most relevant for the characterization of textural pedofeatures and their context, whilst more detailed micromorphological characteristics (such as the size of the coarse material, fine material, nodules and types of voids) are described by Usai (1999). Table 2 includes mainly information concerning pedofeatures, microstructure, some inclusions, the ratio between the quantity of coarse and fine material (c/f ratio), the related distribution pattern between coarse and fine material, and the boundary with plough marks.

Field description of Profile N

(0-9cm) *Present day pasture soil. A horizon.* Moderately strong dark brown (7.5YR 3/2) subordinately very dark greyish brown (10YR 3/2) silt loam; <5% rounded or angular gravels; up to 15% fine (1-2 mm) roots; strongly developed <10 mm subangular blocky peds. Diffuse irregular lower boundary.

(9-30cm) *Present day pasture soil. B horizon (cambic).* Moderately strong, dark brown (7.5YR 3/2) sandy silt loam; 5-15% rounded and angular gravels; <5% fine (1-2 mm) roots; moderately developed <10 mm subangular blocky peds; diffuse irregular boundary with deep pockets.

(30-140+ cm) *C horizon (weathered till deposits).* Very strong, massive reddish brown (5YR 4/4 to 4/3) sandy clay with 15-40% angular and rounded gravels and stones; no roots; thin patchy coatings apparently made of clay, located on fissures.

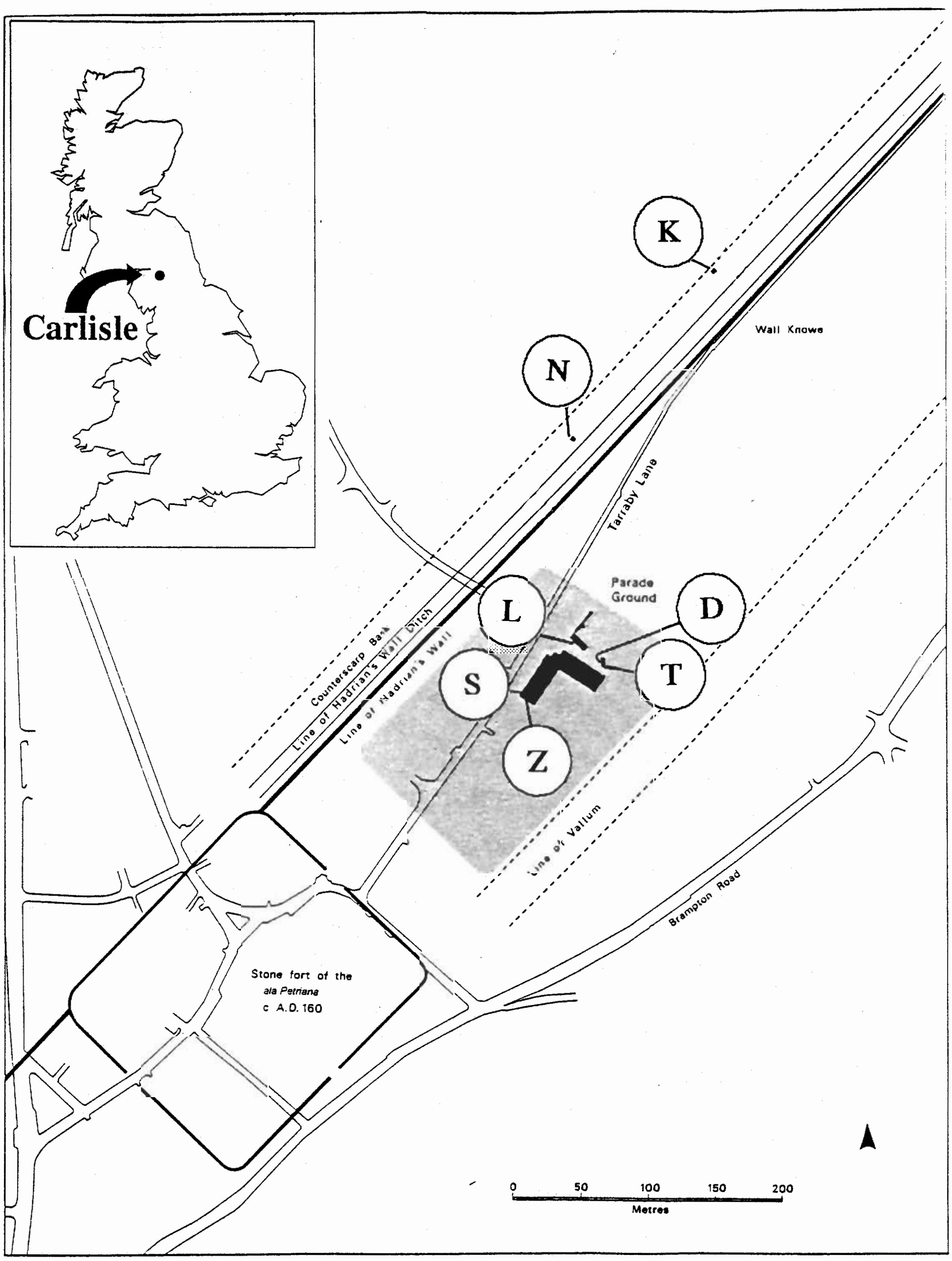

Figure 1. Location of Profiles N, K, L, T, D, S and Z in Carlisle. Modified from Flynn and Zant (1996).

Figure 2. Profiles and thin section sampling depth in centimetres.

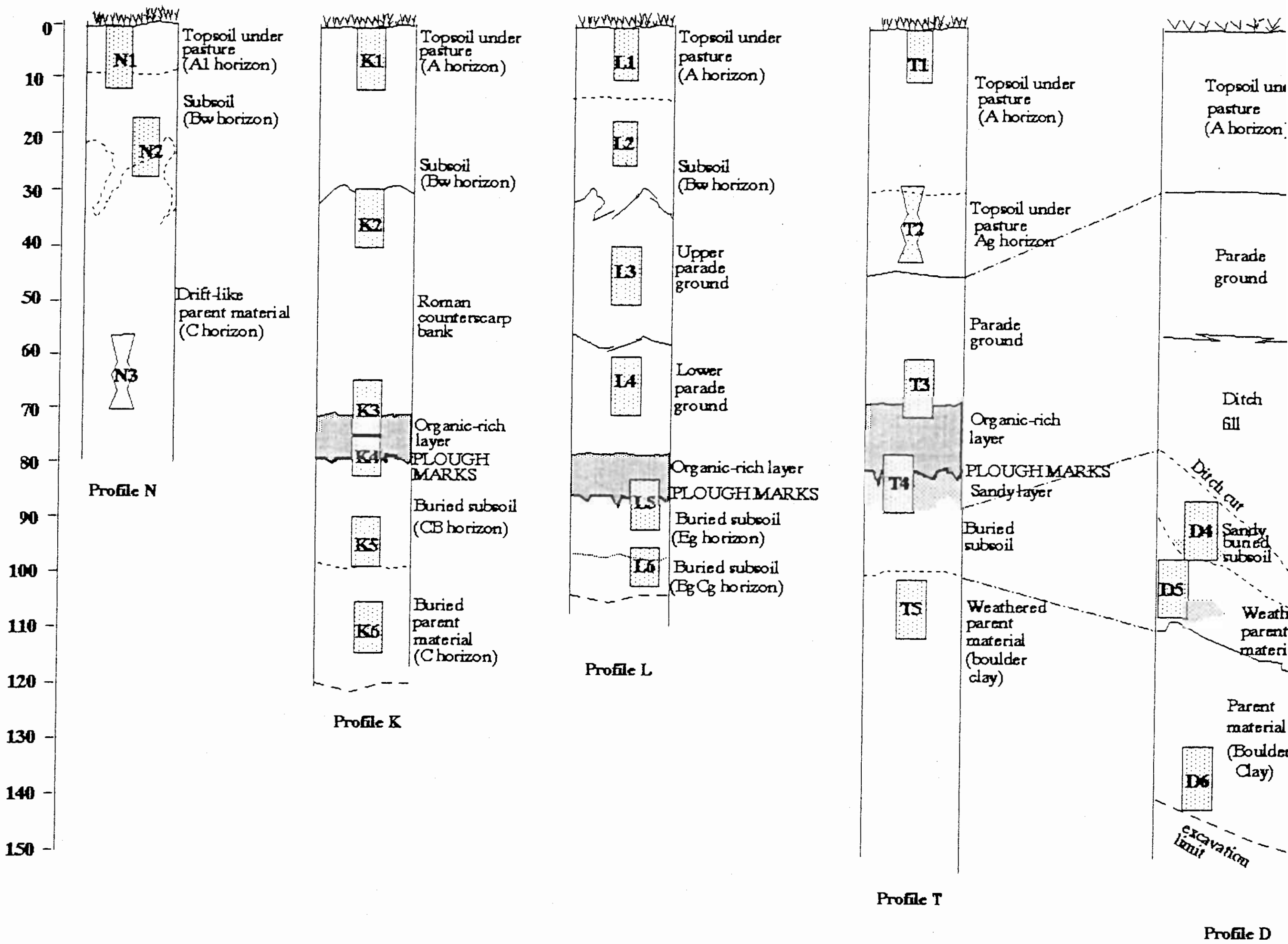

Figure 2

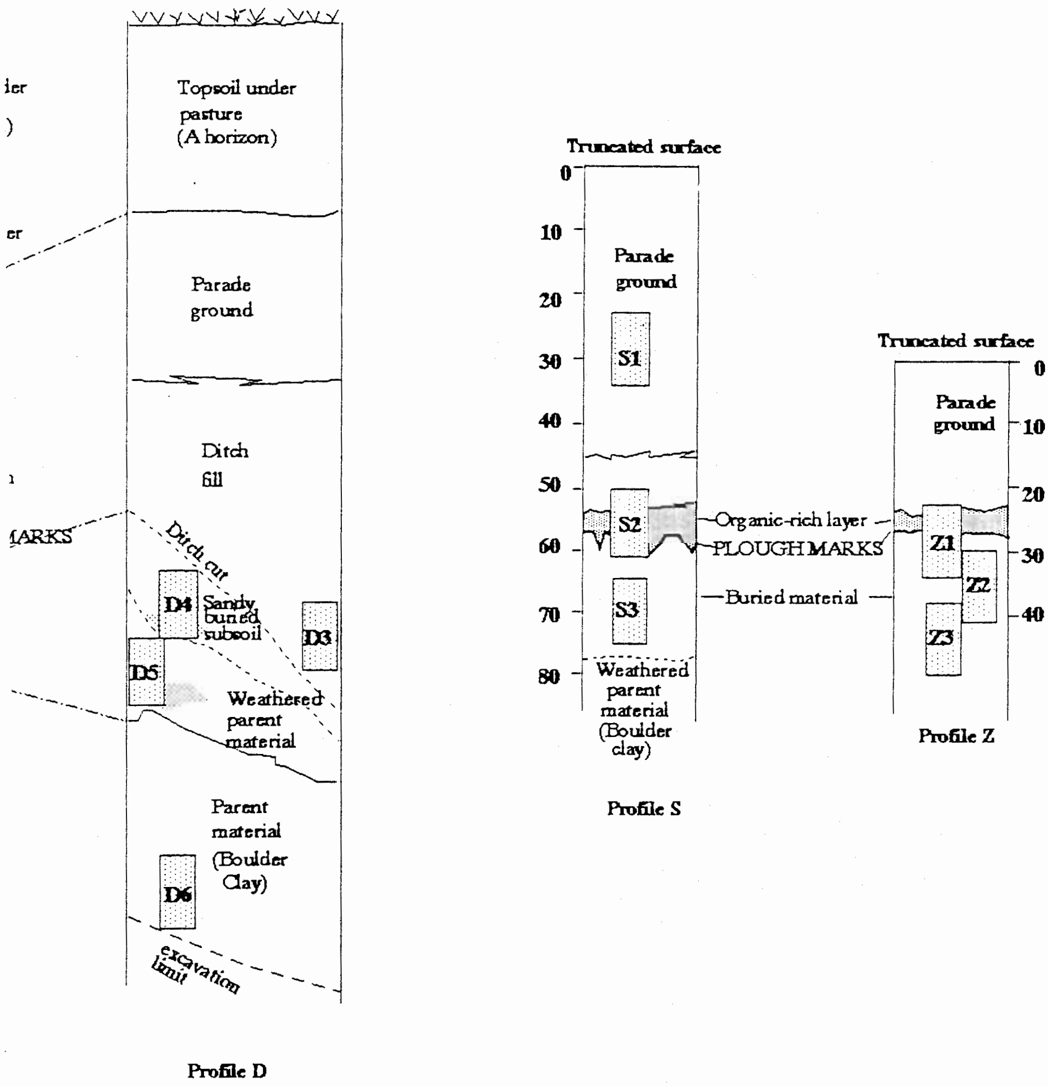
Topsoil under pasture (A horizon)
Parade ground
Ditch fill
Ditch cut
D4
Sandy buried subsoil
D3
D5
Weathered parent material
Parent material (Boulder Clay)
D6
excavation limit
Profile D
Truncated surface
0
10
20
30
40
50
60
70
80
Parade ground
S1
S2
S3
Weathered parent material (Boulder clay)
Profile S
Organic-rich layer
PLOUGH MARKS
Buried material
Truncated surface
Parade ground
Z1
Z2
Z3
0
10
20
30
40
Profile Z

Figure 2

Field description of Profile L

0-14 cm - *Present day pasture top-soil (A horizon)*. Friable, very dark brown (10YR 2/2) sandy silt loam, with roots, moderately developed subangular blocky peds. Gradual smooth lower boundary.
14-32cm - *Present day subsoil (cambic B horizon)*. Moderately strong, very dark greyish brown (10YR 3/2) sandy loam, no visible roots, strong subangular blocky peds. Irregular, abrupt lower boundary with wide pockets.
32-58cm - *Upper Roman parade ground.* Moderately weak, rigid when dry, reddish brown (5YR 4/4) massive sandy loam with 15-40 % unweathered or slightly weathered gravels and stones, similar to local boulder clay. <1mm roots. Clear broken lower boundary.

8-77cm - *Lower Roman parade ground*. Moderately strong, massive reddish brown (7.5 YR 4/4) sandy loam, with greyer or brownish variations, and dark reddish brown (7.5YR 3/2) subordinately mixing with discrete reddish grey (7.5 YR 5/2) parts with sharp boundaries. Frequent fresh gravels and stones; rare small charred inclusions. Clear smooth lower boundary.
77-89 cm - *Buried horizon with plough marks* and pockets in abrupt smooth lower boundary. Massive, moderately weak dark greyish brown (10YR 4/2) sandy silt loam with iron enrichment (15 to 40% iron-rich patches; mainly unweathered gravels; no roots.
89-96 cm - *Buried mineral sub-soil (Bg horizon)*. Massive, weak, loamy sand, mainly dark greyish brown (10YR 4/2 or 7.5 YR 4/2) with lighter brown patches (10YR5/3); < 5% unweathered or slightly weathered stones; <2% faint to distinct, clear to diffuse iron patches; no roots. Diffuse smooth lower boundary.
96-102+ cm - *Buried BgCg horizon (weathered till deposit)*. Very strong clay silt loam and sandy loam mixture of various components and colours, mainly reddish (7.5 YR 5/4 to 5/6) and grey (10YR 6/2).

Discussion

Whether or not boulder clay was employed for building the counterscarp bank, Profile N included a well-developed, non-truncated soil profile (acid brown earth) formed from parent material which was very similar to the local boulder clay. It showed no traces of cultivation, nor is there any known record of cultivation (M. McCarthy, personal communication). Table 2 shows that this profile is rich in dusty clay or silty/sandy clay coatings and hypocoatings in the non-buried horizon B and C (thin sections N2 and N3; see Figure 2).

All the profiles buried by the Roman deposits in Profiles K, L, T , D and Z were formed above a basal boulder clay layer. Studies on ancient ploughing suggest that ard marks were created when the point of the plough share penetrated the subsoil, making a groove into which the ploughsoil fell (e.g. Rees, 1981, 15). In this case study, the organic-rich layer (see Figure 2) is markedly different from all other layers in the profiles, and it is difficult to imagine that it could develop without input of material from an original natural soil of the type seen in Profile N. Thus, the organic-rich layer could have been deliberately put into place or, alternatively, formed as a result of adding manure and/or other materials during, before or after ploughing.

Field description of Profile L

0-14 cm - *Present day pasture top-soil (A horizon)*. Friable, very dark brown (10YR 2/2) sandy silt loam, with roots, moderately developed subangular blocky peds. Gradual smooth lower boundary.
14-32cm - *Present day subsoil (cambic B horizon)*. Moderately strong, very dark greyish brown (10YR 3/2) sandy loam, no visible roots, strong subangular blocky peds. Irregular, abrupt lower boundary with wide pockets.
32-58cm - *Upper Roman parade ground.* Moderately weak, rigid when dry, reddish brown (5YR 4/4) massive sandy loam with 15-40 % unweathered or slightly weathered gravels and stones, similar to local boulder clay. <1mm roots. Clear broken lower boundary.

8-77cm - *Lower Roman parade ground*. Moderately strong, massive reddish brown (7.5 YR 4/4) sandy loam, with greyer or brownish variations, and dark reddish brown (7.5YR 3/2) subordinately mixing with discrete reddish grey (7.5 YR 5/2) parts with sharp boundaries. Frequent fresh gravels and stones; rare small charred inclusions. Clear smooth lower boundary.
77-89 cm - *Buried horizon with plough marks* and pockets in abrupt smooth lower boundary. Massive, moderately weak dark greyish brown (10YR 4/2) sandy silt loam with iron enrichment (15 to 40% iron-rich patches; mainly unweathered gravels; no roots.
89-96 cm - *Buried mineral sub-soil (Bg horizon)*. Massive, weak, loamy sand, mainly dark greyish brown (10YR 4/2 or 7.5 YR 4/2) with lighter brown patches (10YR5/3); < 5% unweathered or slightly weathered stones; <2% faint to distinct, clear to diffuse iron patches; no roots. Diffuse smooth lower boundary.
96-102+ cm - *Buried BgCg horizon (weathered till deposit)*. Very strong clay silt loam and sandy loam mixture of various components and colours, mainly reddish (7.5 YR 5/4 to 5/6) and grey (10YR 6/2).

Discussion

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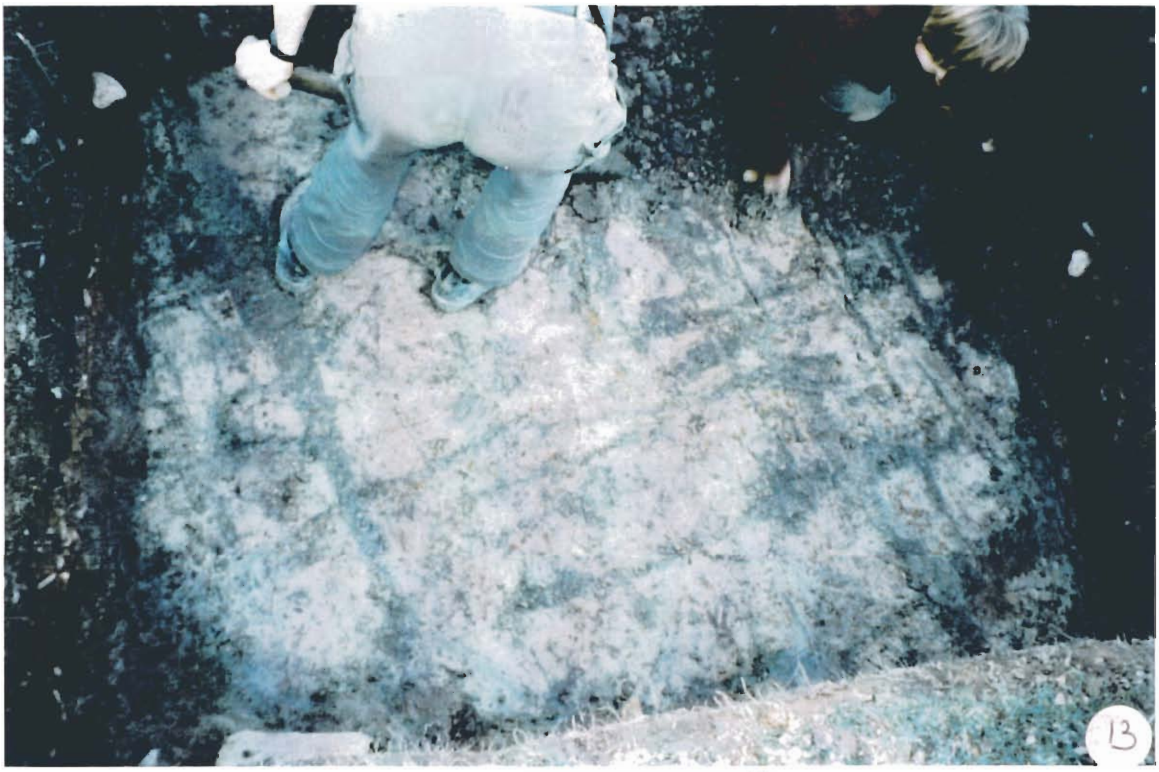

Plate 1. Criss-cross plough marks in Profile L.

Plate 2. Transverse section of plough marks in profile K.

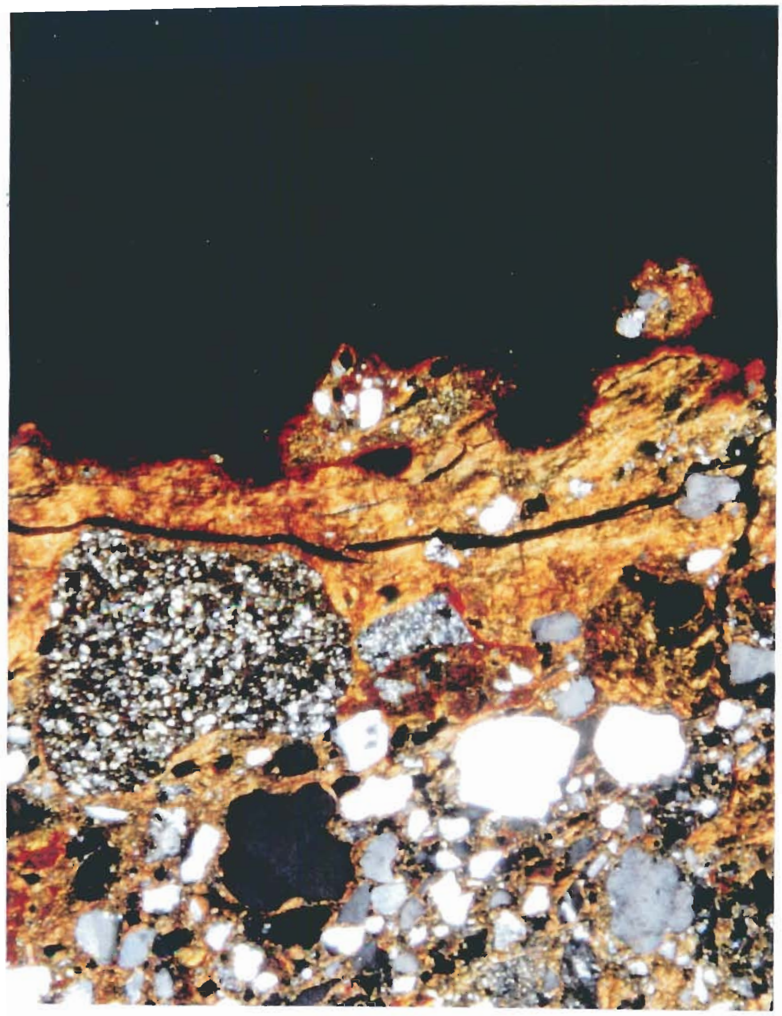

Plate 3. Layered silty clay coatings in the drift-like material of Profile N. Frame size: 230 x 310 µm.

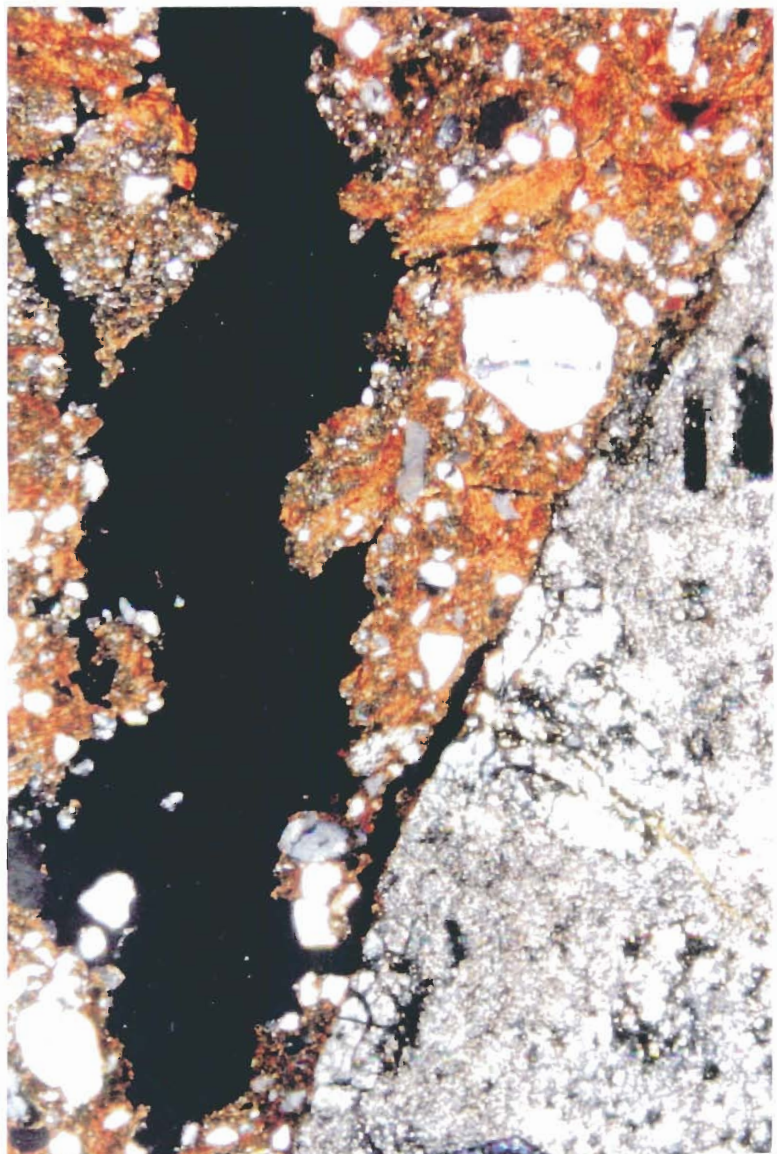

Plate 4 Clay, silt and sand coating in the drift-like material of Profile N. Frame size: 230 x 310 µm.

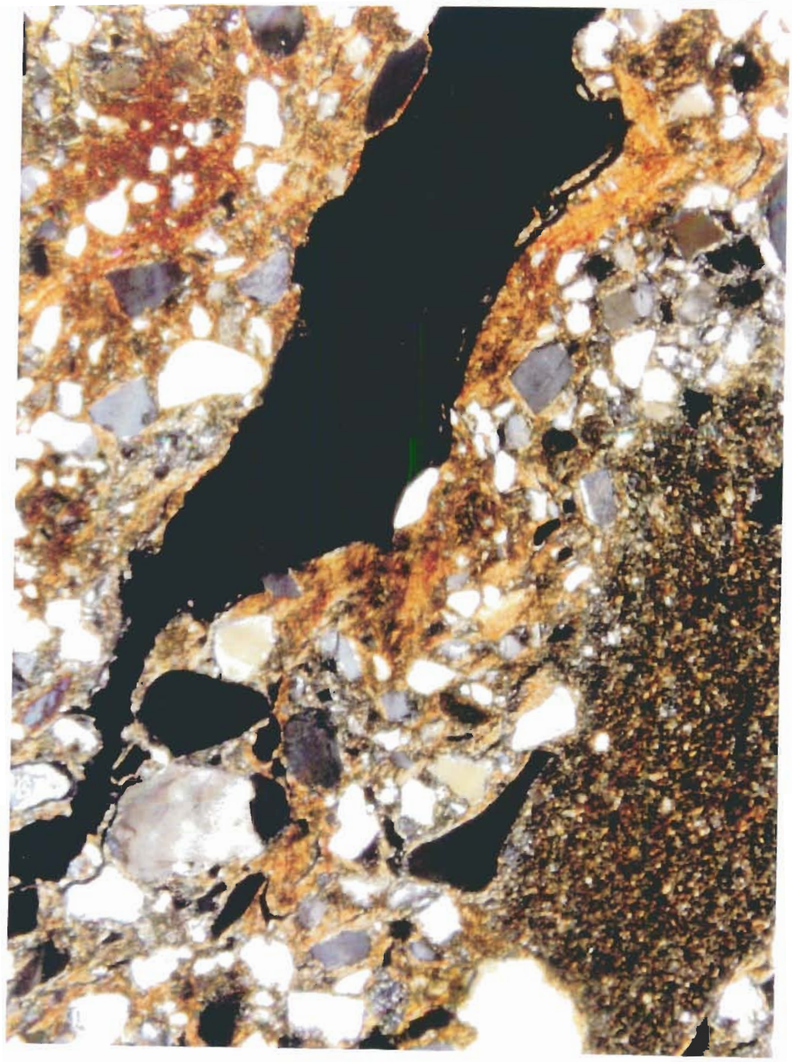

Plate 5. Silty clay coating in the buried materials under the horizon below the organic-rich layer of Profile Z (thin section Z3). Frame size: 230 x 310 µm.

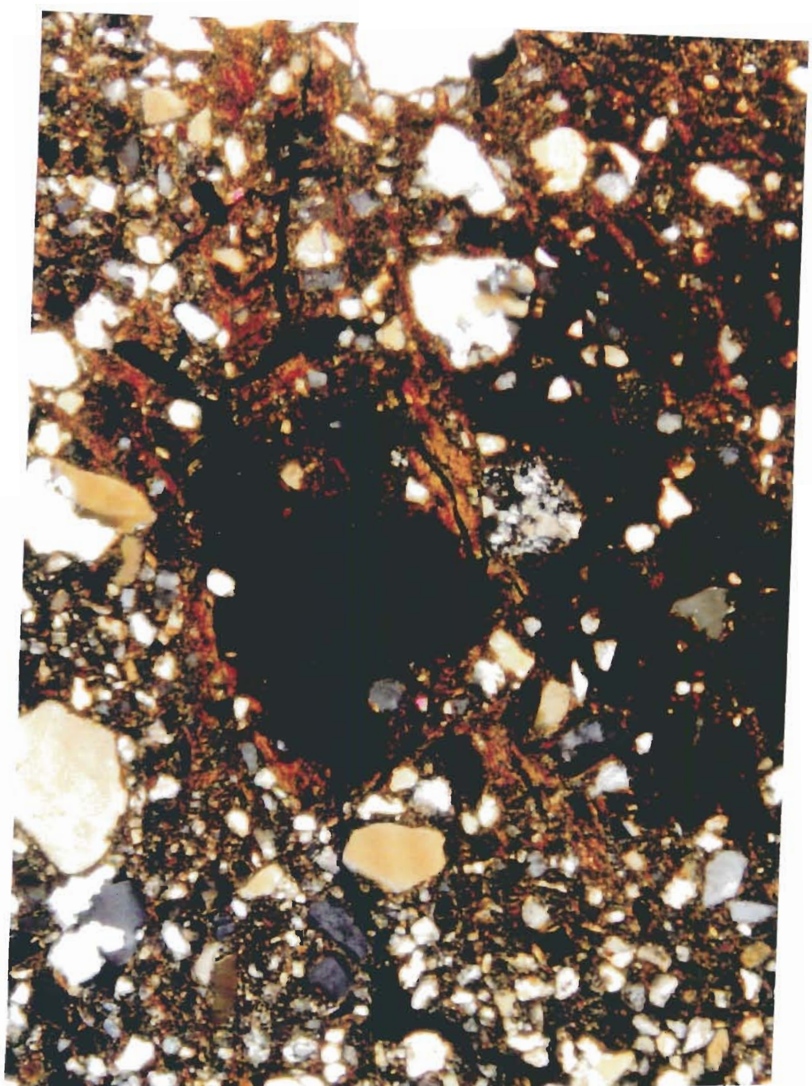

Plate 6. Impure, masked silty clay coating in the same material of Plate 5. Frame size: 230 x 310 µm.

The second alternative would be in agreement with observations of the upper part of thin section D3, containing plant remains parallel to the upper boundary of the organic-rich context, their appearance strongly suggesting that they had been artificially added to the upper part of the context. This was suggested in a preliminary report on the biological remains and sediments at the (Hall *et al.*, 1995). It is also possible that agriculture was not carried out on the organic-rich layer, and this could have been put into place at a later stage after the ploughed horizon was removed. What is most important for the present study, however, is that ploughing was carried out directly above the horizons marked with plough grooves. It is in these horizons that, if Jongerius' theory is applicable, agricutan-like features should be observable.

Profile K

In Profile K (see Figure 2), laminated dusty quasicoatings characterize the upper, non-buried, B horizon (thin section K2); occasional sandy or silty clay coatings are found in the organic-rich layer above the plough marks (thin sections K3 and K4), and the micromorphological examination suggested that such coatings could have resulted partly from translocation. If Jongerius thesis was applicable to ancient soils, such coatings could have originated from an overlying plough layer. In this profile, however, such translocation could rather have started from the overlying counterscarp bank deposits, which were rich in weakly weathered alumino-silicates – a ready possible source of colloidal clay particles. Also, some of the clay coatings in this layer appeared to be more like differentiations of fine material accompanied or followed by short distance movement *within* the context. It is not possible to establish here which one of these is the right interpretation or whether more than one of these three mechanisms could have occurred. Agricutan-like coatings, however, are not present in the thin sections representing the layer immediately below ploughing (thin section K5) or further down (thin section K6).

Profile L

No silty, sandy, or organic-rich coatings were found in any of the thin sections of Profile L, where criss-cross ploughing was documented (Plate 1) and T, where ploughing was also shown by ard marks.

Profile D

Masked to opaque and impure clay coatings were found in the thin section representing the ditch fill from Profile D. Such a ditch, which pre-dated the parade ground deposits, could either have been cut through the plough soils (thus being contemporaneous with or successive to ploughing), or could already have been open, but this relationship was not clear in the field (Flynn and Zant, 1996). If the second hypothesis is valid (ditch cut before ploughing in the adjacent profiles) the ditch could represent a field boundary (thus overlying layers not affected by cultivation) but, again, the evidence for this is not clear. Occasional sandy clay coatings were seen in the buried weathered till subsoil of Profile D (thin section D5), where a crack microstructure and a porphyric related distribution (signifying coarse particles separated from each other and situated into a matrix of fine material -

thus implying a relative abundance of fine material) could have allowed transportation and deposition of material. Dusty coatings were found on and between sand grains in sand lenses (thin section D5).

Profiles S and Z

The various types of pedofeatures in the mineral subsoil marked by plough grooves in Profiles S and Z (thin sections S-4 and Z-3) included some which were locally dusty.

Profile summary

To summarize: dusty, silty, sandy pedofeatures are found (a) in non-buried and most likely non-cultivated soils (present-day soils of Profile N and present-day non-buried layers in Profile K); (b) in the organic-rich layer of Profile K; (c) in a layer of weathered boulder clay, and within its sandy deposits, under the possible field boundary in Profile D (it is possible that this profile represents an area where agriculture had not been carried out and certainly in the field there is no evidence for plough marks - though it is also possible that marks were removed if truncation occurred after cultivation); (d) occasionally, in a buried subsoil marked by plough grooves in Profiles S and Z; (e) as impure clay coatings in the ditch fill.

Table 3. Relationship between microstructure, related distribution of coarse and fine material, and textural pedofeatures similar to agricutans.

Context	**Microstructure**	**Related distribution**	**Dominant sandy/silty or impure textural pedofeature**
Present day B horizon in Profile N	Subangular blocky	Gefuric and porphyric	Dusty clay; sandy/silty clay
Boulder clay (possible counterscarp bank) in Profile N	Subangular blocky, bridged grain	Porphyric	Dusty clay; sandy silty clay
Present day soil in Profile K	Intergrain	Porphyric and gefuric	Dusty
Organic-rich layer in Profile K	Intergrain	Porphyric and gefuric	Sandy clay; silty clay
Weathered boulder clay under ditch or field boundary	Chamber, crack	Porphyric	Impure clay
Ditch fill	Chamber, crack	Porphyric	Impure clay
Weathered boulder clay in Profile S	Chamber	Monic, porphyric	Sandy clay, impure
Buried sub-soil in Profile S and Z	Bridged grain, vughy	Porphyric	Locally dusty clay

Furthermore, dusty, sandy and silty pedofeatures were not found in the layers immediately below ploughing in Profile K or any layers under the criss-cross ploughing of Profile L or other ploughing of Profile T, nor within the organic-rich layers of Profiles S and Z. Thus, agricutan-like textural pedofeature were frequently found in layers where, and above which, there was no evidence or record of cultivation, and were only occasionally found in the layers beneath ploughing.

With regard to the type of layers where the pedofeatures were found and the relationship between microstructure (and thus voids) and related distribution pattern between coarse and fine material, Table 3 illustrates how almost always sandy and silty clay and dusty pedofeatures tend to be accompanied by a porphyric related distribution. This means that they tend to be more concentrated where there is a considerable fraction of fine material in the groundmass and, therefore, where planar and other voids were more easily formed. Such related distributions also match the type of microstructures, which tend to be of the chamber, subangular blocky, crack and, in fewer cases, vughy types and, again, include a significant quantity of voids where particles could be deposited. Thus, in this study, sandy, silty and dusty pedofeatures tend to be preferentially concentrated in certain types of microstructures and in layers with sufficient suitable voids.

Clearly, the spatial pattern of distribution of pedofeatures in this study does not reflect the spatial pattern of ploughing. It is also clear that the absence of evidence of sandy silty textural pedofeatures does not reflect absence of agriculture. This is even more significant in the light of considerations regarding soil variability. Since, normally, the distribution of soil micromorphological features is highly variable, one thin section may not be representative of its context and, therefore, some agricutan-like pedofeatures may have not been included within the selected thin sections.

More significantly, however, sandy, silty or dusty textural pedofeature are found in layers in which, or above which, there is no trace or record of agriculture. This indicates that such pedofeatures in this study have proved not to be diagnostic for past agricultural practices.

Conclusions

Sandy, silty and dusty textural pedofeature were mainly in layers where, and above which, there was no evidence or record of cultivation, and only occasionally in layers beneath ploughing. Thus, their spatial pattern of distribution did not reflect the spatial pattern of ploughing. Also, whether as a result of statistic variability in the pedofeatures distribution or as a result of a real absence of the pedofeature in question in the thin sections analysed, the absence of sandy silty textural pedofeatures did not reflect absence of agriculture. Such pedofeatures tended to concentrate in preferential microstructures and in layers with sufficient suitable voids rather than below cultivated layers. All this indicated that the sandy, silty and dusty pedofeatures in this study have proved not to be diagnostic for past agricultural practices. More studies are necessary of the

micromorphology of ancient soils with a known record of past agricultural practices.

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