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Soil report on West Heslerton, Near Malton, N Yorks
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R I Macphail, October 1983

West Heslerton is a multi-period site excavated in 1980, 1981 and 1982 (director Dominic Powesland), and comprised an area of blown sand over early post-glacial sands and gravels on the edge of the Vale of Pickering, at the base of the Yorkshire Wolds. The chequered soil-history of the site is exemplified by the now calcareous sands which were acidified in prehistory and re-calcified in Saxon times. The effect of this has been to hinder the preservation of both snails and pollen for environmental studies. Detailed micromorphological analysis was therefore undertaken to investigate the environmental history of the site (Macphail, 1982, 3706).

A wealth of archaeological (Mesolithic to Saxon) features are preserved in combination with a mosaic of dateable surfaces (Neolithic to post-Roman; Powesland, 1981). The archaeology is mainly preserved in medium and fine blown sand, which overlies early post-glacial alluvial sediments containing calcareous gravel and a higher proportion of medium-sized sand. The sands are mainly quartzose with up to 6% iron minerals, such as limonite (for details see Macphail, 1982, 3706). Soils investigated (Tables 1, 2) included pre and post-barrow ditch fills (Neolithic and Early Bronze Age respectively), a pre-barrow surface, barrow mound material, a Late Bronze Age/Early Iron Age surface and plough soil, and fills of Roman "haystack" and hollow-way ditches. These provide a sequence of soil formation from the Late Neolithic to post-Roman times each sealed by blown sand. (For methods see Macphail, 1982, 3706).

Results

The more recent blown sand activity (Simms and Radley, 1967), since the later Saxon period (circa 6th century; Powesland, 1981), produced the present surface cover of neutral to alkaline typical brown sands (Newport series; Steve King, Soil Survey of England and Wales, pers. comm.). Previous activity has buried successive archaeologically dated podzolic levels of which only illuvial (Bh and Bs) horizons apparently survive. Microfabrics of the archaeological features studied are therefore characterised by the effects of redeposition of soil plasma and cementation of horizons (i.e. podzol - B or spodic horizon formation). These properties have enabled the soil materials to resist periodic wind erosion, but not, for example, Iron Age ploughing.

The microfabric of the earliest of the Neolithic ditch-fills (1, Table 1) is similar to a weakly formed Bs horizon, containing a sparse amorphous sesquioxide (spodic) fabric and large amounts of limpid clay coatings and infills. It contains no fine charcoal. The later top two fills (3 and 4, Table 1) include less sand-sized rock fragments (lithorelicts), and have a strongly developed sesquioxidic fabric with fewer limpid clay coatings and infills, but increasing amounts of fine charcoal towards the surface.

The sequence through the Bronze Age barrows (5, 6 and 7) into the supposed "old ground surface" (2) is represented by well developed Bh and Bs horizon microfabrics with relatively large quantities of included fine charcoal. There is no obvious evidence of the original nature of either the buried soil or mound material.

The lower post-barrow (L) ditch fills (8 and 9) are also podzolic in character and occur near the unweathered, calcareous, parent material. These horizons contain limpid clay coatings and infills, and a small amount of fine charcoal and dusty clay void-coatings and infills.

At area K the Iron Age surface (10) is again of a Bs-horizon character with some limpid clay coatings and infills but very much fine charcoal and many, dusty clay coatings and infills. As the local Bs horizon is "reddenned" by the presence of a hearth, the Podzolic character probably predates Iron Age occupation. The Bs horizon fabric in the Iron Age ploughsoil (11) at area E has developed in soil layers formed during the Iron Age. These soils comprise a low porosity "plough-pan" containing fine charcoal, and are closely associated with possible ardmarks which gouged a Bs horizon developed during an earlier phase of podzolisation.

Later fills of Roman features (12, 13) with moderately well developed sesquioxidic microfabrics include both fine charcoal and limpid clay coatings and infills, especially in the hollow-way sample.

The chemical results (Table 2) substantiate the micromorphological findings in that horizons with amorphous (organic and sesquioxidic) microfabrics (5, 6 and 11) contain significant quantities of pyrophosphate extractable carbon, iron and aluminium as well as dithionite extractable iron, above the norms of the parent mateial (17). This is wholly in character with Bh and Bs horizons of humo-ferric podzols elsewhere (Macphail, 1983). Both the blown sand (14) and the Bs2 horizon (16) at L have rather low dithionite extractable iron contents, suggesting them as possible sources (at an earlier time) of illuvial iron, as no obvious Ea horizons were preserved on site.

Landuse and Soil History

The reconstruction of the pedological history of West Heslerton is hindered by a lack of corrolatory environmental data, and by microfabrics commonly dominated by amorphous organic and sesquioxidic coatings. Nevertheless, the pedological examination suggests the following reconstruction (Table 3).

At area L it is likely that the pre-narrow ditch (probably Neolithic) was cut in a brown earth. The soil, because of the close proximity of the calcareous sands and gravels below, may be regarded as base rich at this time. Relatively unweathered local soils (2), probably eroded from the ditch sides (Evans and Limbrey, 1974) produced the lowest ditch fills. Here (1) the lack of fine charcoal may be evidence of the primary fill occurring when activity, such as clearance and cultivation, had ceased, albeit temporarily. The character of the top two fills (3 and 4) suggest they derive from a more weathered soil horizon, perhaps resulting from blowing, rather than localised erosion.

The probable eroded soil surface and infilled ditch were buried by an Early Bronze Age barrow containing both cremations and inhumations. Studies of buried turf material from elsewhere suggest good preservation under acid conditions (Fisher and Macphail, in press), while little remains in a base-rich environment (Macphail in Clay, 1981). This implies that if the mound had been built of turves from an acid, podzolised soil, some diagnostic fabric would be preserved. None is present at either barrows L or M, however, and so a base-rich soil at the time of barrow construction may be suggested. If this is the case, it is likely that continued earthworm activity in this soil may have obliterated any firm evidence of an old ground surface. Further, as there is no indication of the soils behing acidified at this date, the possible continuation of earthworm activity in a base-rich oxidising environment may have destroyed the original character of the mound material.

In practical terms, the mounds would be resistant to wind erosion. At areas L and M the mounds are richer in organic matter than the surrounding soils (Table 2) and in the field they are obviously discrete from the blown sand and buried soils. In addition, an organic character is ideal for trapping organically mobilised sesqioxides in a podzol - Bh horizon (Anderson, Berrow, Farmer, Hepburn, Russell and Walker, 1982), which would explain the well developed illuvial fabrics in mound material at barrows L and M (5, 6 and 7). It can, therefore, be argued that the mound material comprised a "turf" or other organic-rich material, and that any relict fabric has been lost.

The post-barrow ditch fills most probably relate to an erosional phase soon after barrow construction, as described from the Experimental Earthwork at Wareham (Evans and Limbrey, 1974). Soil characteristics of both the pre-narrow and post-barrow ditch fills appear to follow the same sequence. An earliest phase of argillan deposition is preserved beneath the barrow perhaps due to its greater depth, while both series of fills have a primary coating of limpid clay coatings and infills. These are most likely to develop in a soil under a broad leaved woodland cover, and so this vegetation type may have become established after barrow construction. A successive phase identified in the microfabric of the buried soils of dusty coatings and infills, together with possible inclusions of fine charcoal, indicates a later period of woodland clearance, burning and possible agriculture (Slager and van der Wetering, 1977; Courty and Federoff, 1982). Soil disturbance probably encouraged wind erosion and sand transport, similar to that presently experienced at West Heslerton (Radley and Simms, 1967). This may have caused severe erosion to parts of barrows, but burial of the preserved parts would also have resulted. The sands themselves, which may have become decalcified and acidified under the woodland cover, were probably podzolised after subsequent abandonment. This may have been under a heath cover of the later Bronze Age, as was happening on sandy soils in southern England (Dimbleby, 1962). The presence of much fine charcoal in the amorphous organic and sesquioxidic coatings suggests podzolization occurred under a probable heathland that was regularly burned. The fine charcoal derives from coarse fragments, which disintergrate under biological activity and are subsequently washed down-profile (Courty and Federoff, 1982). As suggested above, the mounds preferentially absorbed illuvial material during podzolisation.

Podzolisation may have lasted until the Late Bronze Age/Early Iron Age when a new phase of soil disturbance commenced. Eluvial horizons, some upper Bh horizons, and in places all the illuvial horizons, were stripped off. The ardmarks (or drag-lines) at area E clearly show disturbance of the Bh horizon, while the hearth at area K rests on a truncated Bs horizon. Eroded eluvial horizons are difficult to trace and may have been mixed with more ferruginous illuvial material during blowing. The latter would account for the many sharp-edged nodules in the ditch fills.

Apparently, this Late Bronze Age/Early Iron Age period of cultivation and erosion was followed by at least two phases of podzolisation. These are identified by illuvial microfabrics in: a) the podzolised blown sand above and surrounding the barrow L; b) the cemented Early Iron Age/Late Bronze Age buried (probable) plough pans at area E; and c) Roman "haystack" ditch and hollow-way fills. The chemical data in the first case suggests relatively strong illuviation into a Bs2 horizon poor in dithionite extractable iron, indicating this may originally have been eroded eluvial material. At area E and in the Roman ditch fills anthropogenic activity is reflected in the fine charcoal content, while perhaps a shorter period of podzolisation, prior to Late saxon recalcification, has allowed the development of illuvial horizons less mature than those formed since the Early Bronze Age (Macphail, 1982, 3706).

Note on ploughsoil (or possible drag-line soil) formation.

The buried plough soil was characterised by both low porosity, (see micromorphological descriptions) and horizontal planar voids (planes), indicating compaction. Jongerius (1970, 1983) has suggested that such compaction is most commonly formed by pressure and shear forces at the bottom of the plough (ard) layer at moisture contents at which puddling occurs. Such a layer may reduce the downward flow of water, which in turn may encourage internal slaking. This also holds true for soils disturbed by drag-lines.

Note on podzolisation

At West Heslerton reconstruction of the history of podzolisation is complicated because no entire podzol profiles could be examined due to the nature of horizon survival. In addition, late podzolisation phases may have affected lower sequums, and late blown sand sequences may have contained material derived from eroded illuvial horizons. Nevertheless, it is possible to suggest that woodland clearance, and heathland development at West Heslerton allowed a mature humo-ferric podzol to form. This occurred in originally calcareous sands between the construction of a barrow cemetry in the Early Bronze Age and cultivation and occupation of the site in the Late Bronze Age/Early Iron Age. The microfabric and chemical characteristics are presented in Tables 1 and 2. Two undated phases of less well developed podzolisation are also recorded in the blown sand above the barrow at L. In these, greater amounts of pyrophosphate extractable Al and Fe were deposited the earlier phase, which could could correlate with illuvial deposition in the Iron Age plough soil at E. Lastly, the data from the Roman "haystack" ditch-fill may indicate a final short term phase of podzolisation prior to Saxon recalcification of the area (circa 6th Century).

Micromorphological Description (Nos 1-10 in Macphail, 1982, 3706)

Plough-soil Area E (11, Table 1): Homogeneous: Well developed coarse platy; intergrain channel structure within platy structure: 11% voids; compound packing voids, smooth walled fine channels; coarse horizontal planes:

coarse/fine (c. 0.02mm) 80/20; 71% coarse mineral; quartz; poorly sorted dominant medium - and fine-sized sand; frequent silt: 17% fine mineral; amorphous fine material; opaque; light reddish brown; sesquioxidic; may be speckled with black, probable fine charcoal: dominant sesquioxidic coatings and infills; few silt infills; few laminated clay coatings (reddish brown): undifferentiated, rarely birefringent (groundmass), generally opaque: chitonic to porhyric.

Hollow-way, area R (12, Table 1): Homogeneous: well developed massive structure; intergrain microaggregate structure: 26% voids; compound and simple packing voids, rough and smooth-walled: coarse/fine (c.0.02 mm) 60/40; 54% coarse mineral, moderately well sorted, dominant medium and fine-sized sand (Macphail, 1982, 3706): 19% fine mineral: amorphous fine sesquioxidic material; opaque; light reddish brown; may be speckled with black, probable fine charcoal: common dusty clay coatings, reddish brown; laminated: coarse charcoal present: undifferentiated, rarely birefringent (groundmass), generally opaque; chitonic to enaulic.

Haystack (ditch or gully infill), area S (13, Table 1). Homogeneous, poorly developed massive structure; intergrain micro aggregate structure: 22% voids (as above): coarse/fine (c. 0.02 mm) 80/20; 65% coarse mineral (as above): 13% fine mineral; amorphous fine sesquioxidic material (as above) with few associated amorphous fine organic material and fine charcoal (as above); opaque; light reddish brown and dark blackish brown: few limpid and dusty clay coatings; coarse charcoal present: undifferentiated, rarely birefringent (groundmass): mainly chitonic.

Terminology after Bullock etal (in press).

Table 1 Approximate % age micromorphological features at West Heslerton

Sample	Area	Description	Mineral	Void	Pedofeatures: Amorphous organic fine material	Pedofeatures: Amorphous sesquioxidic fine material	Clay coating	Charcoal	Count
1	L	Pre-barrow ditch fill, lowest sample	58.8	31.5	-	4.0	5.7	-	1100
2	L	Pre-barrow buried soil	62.7	25.2	+	10.1	+	*	1100
3	L	Pre-barrow ditch fill, middle sample	59.9	22.2	-	16.6	3.6	*	1100
4	L	Pre-barrow ditch fill, upper sample	56.0	34.3	+	10.5	+	***	1100
5	L	Barrow material, lower sample	59.4	22.0	18.0	0.7	0.2	**	1100
6	L	Barrow material, upper sample	52.8	25.7	20.3	0.4	0.3	**	1100
7	M	Barrow material	54.9	24.0	16.3	3.6	1.1	**	1100
8	L	Post-barrow ditch fill, lower sample	60.5	29.0	-	4.6	6.3	**	1100
9	L	Post-barrow ditch fill, upper sample	63.1	30.4	-	3.7	4.6	*	1100
10	K	"By hearth"	62.3	23.4	-	13.0	1.2	***	1100
11	E	Plough-soil	71.3	11.0	-	16.8	0.2	**	1100
12	R	Hollow-way	54.6	26.5	-	13.4	5.4	***	1100
13	S	"Haystack"	65.1	21.6	*	13.0	0.4	*	1100

+ -- present, but not counted
- -- absent
* -- quantitative estimate of presence

Table 2 Chemistry at West Heslerton

Description	Number	pH	%LOI	% Org. C	%Alk. Sol. humus	&Poryphosphate ext. C *	Al *	Fe *	%Fe res. *
Area L (Bronze Age Barrow									
Ap	-	6.8	2.26	-	-	-	-	-	-
Blown sand	-	7.0	1.70	-	-	0.3	0.0	0.01	1.2
bAp2	-	6.8	2.33	-	-	-	-	-	-
BB's	-	6.8	2.11	-	-	0.2	0.02	0.002	2.0
2bB's 2	-	6.9	2.06	-	-	0.2	0.1	0.1	0.6
"Mound"									
3bB'h	6	6.8	2.60	0.75	0.008	0.4	0.1	0.1	2.6
3bB'h2	5	6.8	2.08	0.59	-	0.3	0.1	0.3	2.6
"Old ground surface"	2	6.9	-	0.29	-	-	-	-	-
3bB'/c	-	6.7	1.05	-	-	0.1	0.01	0.1	2.5
Area M (Bronze Age Barrow)									
Ap	-	6.7	-	0.75	-	-	-	-	-
Blown sand	-	6.9	-	0.34	-	-	-	-	-
Blown sand	-	6.8	-	0.43	-	-	-	-	-
"Mound"									
2bB'h	7	6.8	2.31	0.96	0.01	-	-	-	-
Area E (Iron Age Ploughsoil)									
upper Ap	11	-	1.23	-	-	0.1	0.01	0.01	2.6
lower Ap	11	-	1.43	-	-	0.1	0.02	0.10	2.8
Area S (Roman "Haystack" Ditch)									
Ditch fill	13	-	-	-	-	0.1	0.04	0.0	2.8

-   - not determined or inapplicable
LOI - Loss on Ignition
Org. C - Organic Carbon
Alk. Sol. Humus - Alkali Soluble Humus
* - Analyses by Rothamsted Experimental Station

Table 3 An outline of soil and environmental history at West Heslerton, based on the pedological evidence

Period	Event	Soil Type	Soil Process
Modern		Calcareous	Recalcification
	-Burial by blown sand-	brown sand	(neutralisation)
Saxon	Settlement and Cemetry		
(Late Anglian)	(Wolds footslope)		
	Heath?	Podzols	Pozolisation 3
	-Burial by blown sand-		
Roman	Agriculture		
	Aeolian Erosion		
	Heath?	Podzols	Podzolisation 2
	-Burial by blown sand-		
Late Bronze Age	Agriculture		
-Early Iron Age			
	Aeolian Erosion		
	Heath?	Humo-ferric	Podzolisation 1
	Agriculture	podzols	
	Clearance?		
	Woodland regeneration?	Argillic brown	Acidification
	-Burial by blownsand-	earth	Decalcification
	Aeolian erosion		
Early Bronze Age	Barrow Construction		
	-Burial by blown sand-		
	Aeolian erosion		
Late Neolithic	Area already cleared?	Calcareous	
		brown sand	

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