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LOESSIC SOILS NEAR HOOK, SOUTH-EAST HAMPSHIRE

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SUMMARY

Soil profiles are described from an area east of the Hamble Estuary, near Hook, where a shallow (< 1.6 m) silty superficial deposit (brickearth) is common. The brickearth soils display variations in texture both vertically and laterally due to the effects of soil formation, and the depositional and erosional history of particular sites. Using field techniques, and laboratory determinations of texture, mineralogy, micromorphology and chemistry, the brickearth soils are shown to have been developed in an aeolian sediment comprised mainly of a far-travelled Late Devensian loess.

INTRODUCTION

Many soil profiles in south Hampshire are wholly or partially developed in the silty superficial sediment known as 'brickearth'. The Hampshire brickearth reaches considerable thickness at Barton-on-Sea and in the Itchen valley around Eastleigh, but generally it is less than 1.5m thick and overlies Pleistocene gravels (Fisher 1971; Keen 1980). Although all Hampshire brickearths are not of the same age most are Late Devensian deposits (Reynolds 1985). Wintle (1981) used thermoluminescence techniques to obtain respective dates of around 18800 B P and 14500 B P for deposition of brickearth at Barton-on-Sea and Sturt Pond, near Milford-on-Sea. Brickearth is known to be widespread in the Portsmouth district (Palmer and Cooke 1923), and the first modern mapping of soils developed in brickearth was by Kay (1939) in the area around the Hamble River. Subsequently the brickearth soil series described by Kay have been mapped by the Soil Survey in Kent, Sussex, Berkshire, Essex, East Devon, Dorset and on the Chiltern Hills (Catt 1978). The present study aims to examine in detail the character of the brickearth and its associated soils in a small part of south-east Hampshire (Fig 1) where the type soils were first described, but where extensive gravel working is now destroying many overlying brickearth deposits.

FIELD SITES AND SAMPLING

The study area (Fig 1) was a gravel terrace sloping gently south south-westward to sea cliffs about 10 m high. The gravel was underlain by sandy clay of the Bracklesham Beds and overlain by a continuous mantle of brickearth between 0.3m and 1.6m thick. An examination was made of the brickearth, and the soils developed in it, in the area south of Hook (SU510054). Detailed analyses were made of samples taken from pits excavated at Chilling Copse (profile A, SU515041) and Hook gravel pit (profile B, SU513053). A further four soil profiles (C–F) were examined in Chilling Copse (at SU514041, 515040, 516040, 515042) and two close to the current cliff line (G at SU513036, H at SU511038).

Chilling Copse was considered an important site since it was in the southern part of this small (*c* 8 ha) woodland that Kay (1939) described the uncultivated profile of the free draining, silty loam soil since known as Hamble Series. Chilling Copse is enclosed and subdivided into three by old banks and ditches. The vegetation of the southernmost section is largely coppiced hazel with some birch, and open areas dominated by bracken; the central section contains a plantation of young sweet chestnut whilst the northern area is largely of coppiced hazel with some birch, and open areas dominated by bracken; the central section contains a plantation of young sweet chestnut whilst the northern area is largely of coppiced hazel, birch and oak. Some elements of the woodland ground flora suggest soil drainage is sometimes impeded: wild garlic and ground ivy are frequent, and broad

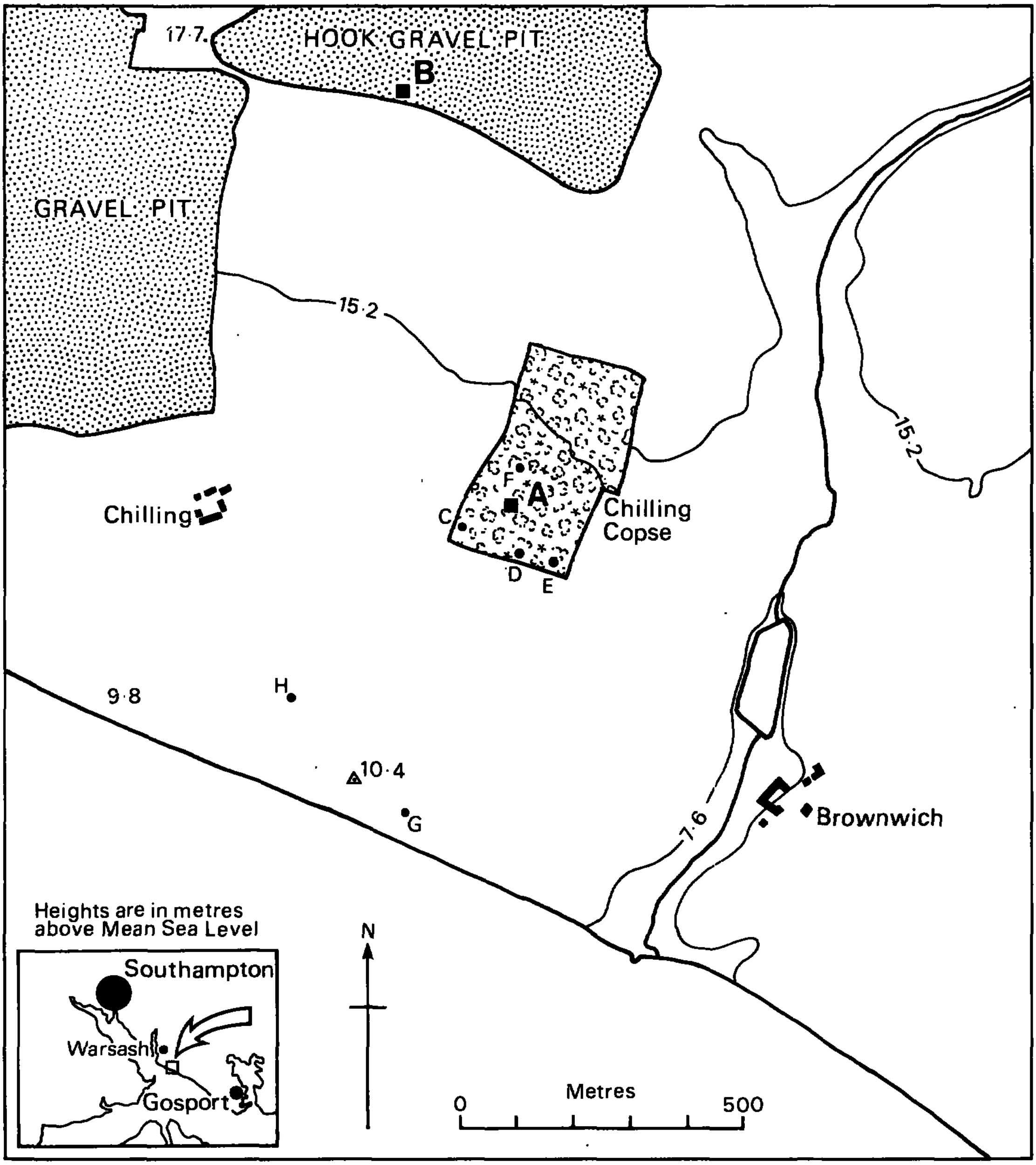

Fig 1. Location of the study area and main soil profiles.

buckler fern and rush common in places. Soil profiles A, C, D and E were in the southern part of the copse and profile F in the central part. The earliest map to show details of Chilling Copse is attached to 'Mr Webb's Survey of Titchfield, 1803' and indicates the copse was then two small woodlands separated by an arable field, but the first relevant sheet of the Ordnance Survey (surveyed 1810) shows a woodland with the present boundaries. Although it is likely all of Chilling Copse originated in plantings, no soils there have been cultivated since the early nineteenth century.

The field descriptions of the two soil profiles (A and B) selected for particularly detailed study are given below. The approach and terminology essentially follow that of the Soil Survey (Hodgson 1974) with colours for field moist soil compared to standards of the Munsell system.

Profile A (described 26.11.79, 19.5.80)
Location: Chilling Copse, near Hook, Hampshire (SU515041)
Elevation: 14 m; Slope: Level; Surface: Irregular; Vegetation: Bracken dominant in a clearing amongst birch and elder. Patchy ground cover of bluebell, ground ivy, wood anemone and ivy; occasional rush and foxglove.

Horizon notation and depth in cm	Horizon description
L	Plant litter, largely bracken fronds, variable in depth.
Ah 0–7	Light yellowish brown (10YR 6/4) to light brownish grey (10YR 6/2) silt loam, humose in places; weak structure; stoneless; abundant black bracken rhizomes; merging boundary.
A 7–16	Dark brown (10YR 3/3) becoming browner (7.5YR 5/4) silt loam, with a few very faint strong brown mottles (7.5YR 5/8); weak fine and medium sub-angular blocky structure; stoneless; frequent rhizomes and roots: merging boundary.
Eb 16–30	Brown (7.5YR 4/4) silt loam, occasional faint strong brown (7.5YR 5/8) mottles and black spots; weak fine structure; very porous; firm consistency; stoneless (apart from one flint at 30 cm); merging boundary.
Bt 30–59	Strong brown (7.5YR 5/6) silty clay loam, occasional flint mottles, yellowish red (5YR 5/8?) and strong brown (7.5YR 5/8?); weak fine and medium structure; extremely porous; firm consistency; stoneless: merging boundary.
2 Bt/C 59–160	Strong brown (7.5YR 5/6) clay loam, rare faint strong brown mottles (7.5YR 5/8); fine sand content greater than horizons above and increasing with depth; weak prismatic structure; extremely porous; firm; peds very hard when dry; stoneless.

Profile B (described 26.11.79)
Location: Margin of Hook gravel pit, Hampshire (SU513053)
Elevation: 17 m; Slope: Level; Surface: Irregular; Vegetation: Patchy cover of various grasses; soil surface often exposed.

Horizon notation and depth in cm	Horizon description
Ah 0–5	Pale brown (10YR 6/3) sandy silt loam; weak fine crumb structure; few small stones (flint); abundant roots; merging boundary.
Eb 5–19	Pale brown (10YR 6/3) sandy silt loam; less organic matter and roots than above; few stones; merging boundary.
Bt 29–60	Light brown (7.5YR 6/4) to reddish yellow (7.5YR 6/6) sandy clay loam; weakly developed structure; firm; peds brittle when dry; stoneless; merging boundary.
Bt /C 60–100	Reddish yellow (7.5YR 6/8) to yellowish red (5YR 5/8?) sandy clay loam, becoming a sandy loam at depth; structureless or very weak structure; firm; hard and brittle when dry; highly porous in places; few medium stones (flint).

In both cases flinty Plateau Gravel lay immediately beneath the described profiles. The most obvious field differences between the two profiles were that profile A (Chilling Copse) was far more silty throughout whilst fine sand was the dominant size fraction in profile B (Hook gravel pit), and profile A was stoneless and slightly mottled whereas profile B was slightly stony and mottles were largely absent. Profile A most strongly resembles soils of the Hamble Series which although essentially freely drained sometimes show mottles (Kay 1939; Hodgson 1967); profile B is a sandy variant of the Hamble Series.

Profiles C, D and E, which were examined under dense coppiced woodland at Chilling, also belonged to the Hamble Series and were almost stoneless and free of mottles. These profiles displayed thick (10 cm) litter and organic horizons, above 10–15 cm of humose greyish brown (10YR 5/2), friable, silty clay loam which became browner with depth and merged at about 40 cms into a firm, strong brown (7.5YR 5/6) Bt horizon of silty clay loam texture, which became sandier with increasing depth. Profile F in the central part of Chilling Copse appeared as an intergrade between the Hamble and, more poorly drained, Hook soil series (Kay 1939; Fordham and Green 1980). A thin litter was found above 5 cms of a light yellowish brown (10YR 6/4) silty loam merging into a light brown (7.5YR 5/4) silty clay loam, merging in turn at about 40 cms depth into a brown (7.5YR 4/4), silty clay loam, Bt horizon which became a slightly stony clay loam at about 1 m. Faint strong brown (7.5YR 5/6–5/8) mottles and black and purplish spots were common throughout the profile suggesting drainage impedence.

Profiles G and H represented cultivated shallow phases of the Hamble series found in the area south of Chilling. Profile G showed a 40 cm thick, uniform, ploughed horizon of sandy silt loam texture, brown (7.5YR 4/2), with stones common, immediately above angular flint gravel. Profile H displayed a great thickness (*c.* 1 m) of brickearth above gravel, with a very slightly stony uniform brown Ap/Eb horizon of sandy silt loam texture, above a denser, strong brown (7.5YR 5/6) clay loam Bt/C horizon. The considerable local variations in thickness and stoniness of brickearth were well seen in the cliff section between Meon Shore and Solent Breezes, with a minimum of 30 cm of stony silt loam over gravel.

LABORATORY ANALYTICAL METHODS

Samples from profiles A and B were subjected to detailed analyses of particle size, mineralogy and micromorphology. Some particle size and chemical data were also collected for profiles C to H.

Samples from A and B were air dried, coarse organic matter removed and then they were gently ground to pass a 2 mm-mesh sieve. Subsamples of 20g-30g were treated with hydrogen peroxide to remove humified organic matter and shaken overnight in a dilute suspension of sodium hexametaphosphate to aid dispersion. The particle size distribution was determined at 1 ϕ intervals ($\phi = -\log_2$ of grain size diamater in mm) by dry sieving and aqueous sedimentation with pipette sampling; the very detailed particle size distribution of selected samples at 1/4 ϕ intervals between 2–6 ϕ (250 μm–16μm) was by the same methods but on sepearate sub-samples. Particle size distributions of samples from C to H were determined by hydrometry and wet sieving.

For the purposes of mineralogical analysis fine sands (2 ϕ to 4 ϕ, 250 μm to 63 μm diameter) were collected by sieving and coarse silts (4 ϕ to 6 ϕ, 63 μ m to 16 μm) by repeated aqueous suspension and decantation. Fine sands and coarse silts were divided into light and heavy minerals by settling and centrifugation in bromoform (S G = 2.90) and examined in clove oil on glass slides. The mineralogical composition of the sands and silts was determined by counting at least 1000 grains of both the light and heavy mineral fractions under a polarizing microscope.

Thin sections of soil for microscopic study of morphology were prepared by a modified version of the technique of Bascomb and Bullock (1974) using a crystic resin to impregnate the soil. The reaction (pH) of soil samples was determined on a 1:2.5 suspension of soil in water using an electrometric pH meter.

RESULTS

The results of the particle size analyses of five samples from profile A (Chilling Copse) and three samples from B (Hook gravel pit) are in Table 1, with comparable data for other sediments from south Hampshire and similar soils from elsewhere in England; the source locations and origins of data are in the Appendix. The results of the detailed particle size analyses made at 1/4 ϕ intervals are in Fig 2. Samples one to three from profile A (Chilling

Table 1: Particle size distributions of fine earth (> 2 mm diameter), of brickearth soils and some related sediments (% by weight in each class, sample depths in cm)

Sample Size Class	Chilling Copse (Profile A) 1	2	3	4	5	Hook (Profile B) 1	2	3	Barton Sand	Headon Beds	B'sham Sands	Plateau Gravel	Loess Ford, Kent	Callis Wold, Yorks
	0–16	16–30	39–49	90–100	120–130	9–19	30–40	60–70						
Sands (–1–4ϕ)														
1000–2000μm	0.5	0.1	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	5.7	0.2	1.1	
500–1000μm	0.7	0.5	0.3	0.2	0.1	0.7	0.3	0.3	0.0	0.1	0.1	24.0	0.3	0.2
250– 500μm	1.5	1.2	0.9	1.6	1.6	2.5	3.3	4.6	0.1	0.2	3.2	45.1	1.0	0.2
125– 250μm	3.0	2.7	2.2	8.3	9.8	10.3	17.0	18.8	30.5	32.5	30.7	14.8	2.9	0.6
63– 125μm	6.6	6.7	5.8	21.8	24.4	17.5	31.2	34.8	61.3	36.8	31.4	2.1	7.1	10.8
SILTS (4–9ϕ)														
31– 63μm	22.8	21.5	22.2	22.1	21.5	17.5	13.1	11.1	1.7	4.0	1.8	0.9	26.5	25.2
16– 31μm	22.0	26.4	23.6	11.7	10.8	18.1	3.7	2.3	0.3	2.9	2.0	0.4	21.6	18.9
8– 16μm	13.8	13.5	13.1	5.5	5.3	8.3	3.9	2.9	1.3	3.0	1.5	0.3	10.0	10.2
4– 8μm	6.5	6.2	6.3	2.3	2.5	4.7	2.5	1.9	0.1	1.1	2.7	0.3	5.4	5.1
2– 4μm	6.1	4.6	3.9	3.2	3.2	3.5	1.9	1.6	0.4	1.9	2.5	0.7	2.6	3.9
CLAY (> 9ϕ)														
< 2μm	17.5	16.6	21.7	22.3	20.8	16.4	23.0	21.7	4.3	17.5	24.1	5.7	2.6	3.9

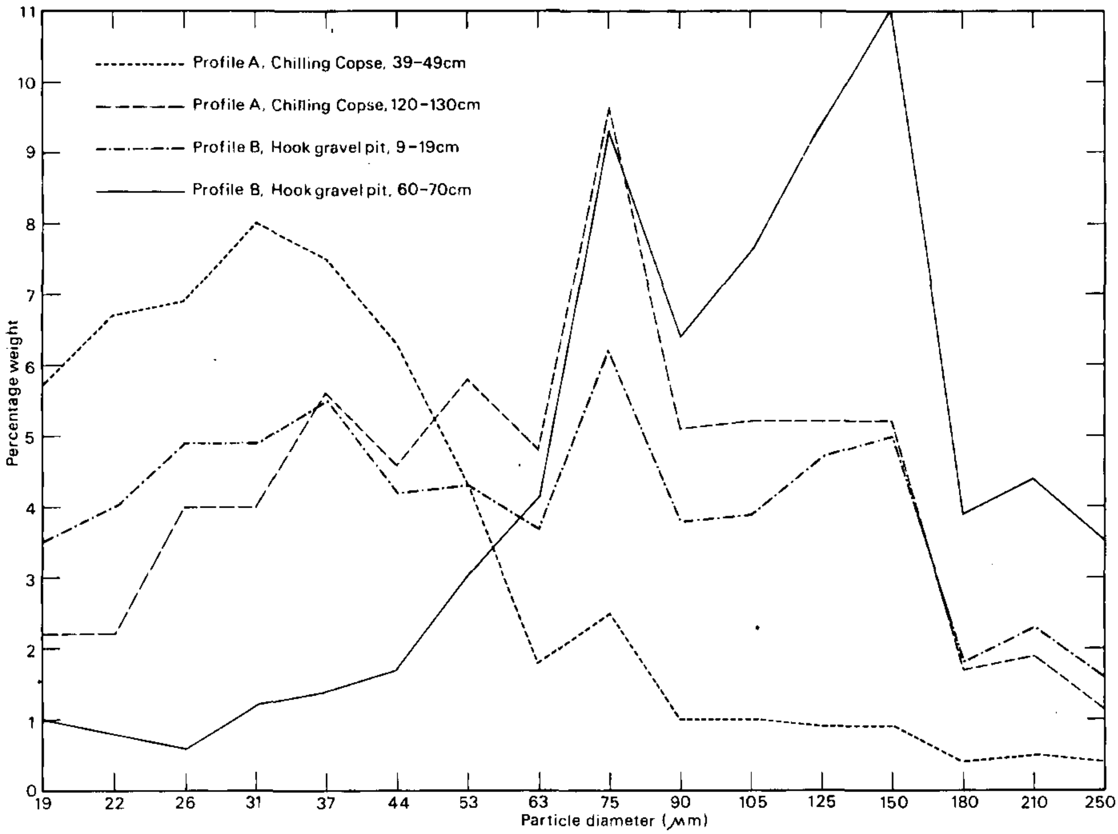

Fig 2. Particle size distribution of coarse silt and fine sand from brickearth soil samples.

Copse) were from the A, Eb and upper Bt horizons and showed almost identical particle size distributons with 69.1 – 72.2% of material of silt size (2–63 µm diameter), with a peak in the coarse silt fraction. Fine sand increases with depth in this profile so that samples 4 and 5 from Bt and C horizons have approximately four times as much as near surface samples, although retaining a moderately high silt content. The three samples from profile B (Hook gravel pit) are very sandy, with sample 1 similar to the deep samples from profile A and in samples 2 and 3 the fine sand content increases to about 50%. Sample 3 from profile A had a single, clear, coarse silt peak at 31 µm, but sample 5 had two smaller coarse silt peaks at 37 µm and 53 µm. These peaks were also found in sample 1 from profile B, however, sample 3 from profile B had such low quantities of coarse silt that no distinct peaks were visible (Fig 2).

The four samples subjected to detailed particle size analysis all showed three modes in the fine sand fraction at 75 µm, 150 µm and 210 µm with the 75 µm peak dominant, except in the deepest sample (3) from profile B (Hook gravel pit) where the 150 µm peak was the largest (Figure 2). Samples of Upper Barton Sand and Lower Headon Beds peaked strongly between 105 and 150 µm, with the latter showing a 75 µm peak also. The fines from the Plateau Gravel underlying the brickearth are dominated by sand in the particle size range 250–500µm.

The results of the particle size analyses of A horizon samples from soil profiles C to H are in Table 2. These results indicate that although the

Table 2: Particle size characteristics (percentage by weight) of A horizon samples (0–20 cm depth) from brickearth soils near Chilling. Gravel determined separately.

PROFILE	C	D	E	F	G	H
SIZE/CLASS						
GRAVEL (> 2mm)	–	–	–	0.9	12.0	2.6
SAND (63–2000µm)	16.0	12.0	11.0	15.5	39.1	33.4
SILT (2– 63µm)	63.5	68.5	70.5	67.5	46.5	50.5
CLAY (> 2µm)	10.5	19.5	18.0	17.3	14.3	16.0

upper horizon of brickearth soils around Hook and Chilling is always dominated by silt, there are considerable local variations in stoniness and texture; samples from profiles C, D and E are silty clay loams, profile F a silt loam, whilst shallower cultivated profiles G and H are sandy silt loams at the surface.

The fine sand mineralogy of two samples from the Bt horizons of profiles A and B was determined. These samples were unlikely to have been significantly affected by post-depositional weathering. The samples were alike in the type and quantity of minerals they contained (Table 3). Data are also provided on the fine sand mineralogy of

Table 3: Mineralogy of fine sand (63–250µm) samples. Grains per thousand (o/oo) in light and heavy mineral suites.

	PROFILE A SAMPLE 3	PROFILE B SAMPLE 3	MEAN OF 6 TERTIARY SANDS	MEAN OF 4 SANDY BRICKEARTHS	MEAN OF 4 PLATEAU GRAVELS
LIGHT MINERALS:					
Quartz	862	866	941	901	928
Alkali Feldspar	100	83	48	67	27
Flint	38	46	11	32	44
Muscovite	–	2	–	–	–
Glauconite	–	3	–	–	1
HEAVY MINERALS:					
Tourmaline	235	257	489	366	380
Zircon	182	172	139	218	455
Brown Rutile	21	19	19	25	24
Yellow Rutile	79	76	32	49	25
Red Rutile	3	12	2	4	5
Pink Garnet	2	1	–	1	–
Colourless Garnet	25	28	2	18	1
Hornblende, Green	6	–	–	–	–
Kyanite	70	102	47	47	22
Staurolite	56	61	52	63	21
Clinozoisite	29	38	11	16	3
Zoisite	11	36	9	24	3
Epidote	114	104	21	57	7
Anatase	6	1	4	6	2
Blue Tourmaline	4	10	17	10	7
Brookite	1	–	1	1	1
Andalusite	3	3	1	1	3
Chlorite	144	70	153	91	40
Tremolite/Actinolite	–	–	–	1	–
Biotite	9	3	–	1	1
Collophane	–	7	1	1	–

some sediments which are possible sources for the brickearth; mineralogically these are broadly similar to the brickearths, but quantitatively the Tertiary sands are most similar, and the Plateau Gravels show least resemblance. It is notable that all three groups of sediments compared with the two samples contain significantly less feldspar, garnet, epidote, zoisite and clinozoisite (Table 3 and Appendix). Examination of the coarse silt mineralogy of the same two samples of brickearth shows a lesser degree of similarity (Table 4). In essence the mineral suite is the same as that of the fine sand fraction dominated by quartz, feldspar and flint, with minor amounts of heavy minerals dominated by zircon, rutile, epidote and chlorite. The differences are mainly in the amounts of feldspar, flint, yellow rutile and hornblende the brickearths contain. Data on coarse silt mineralogy of West Sussex brickearths, other south Hampshire silty and sandy brickearths (Reynolds 1985), Plateau Gravels, and Tertiary sands are provided for comparison (Table 4).

The microscopic examination of the thin sections of soil from profiles A and B provided evidence of pedogenetical re-organization since the deposition of the brickearth. At a depth of 60 cm in both profiles, point counting revealed 4% of birefringent illuvial clay. In both cases about two-thirds of this clay occurred as undisturbed argillans lining voids, and one third as disturbed masses that have probably been redistributed by the activity of soil fauna. Profile B also contained 1.5–2.0% of birefringent illuvial clay at only 30 cm depth but in profile A at this depth there was none. In both profiles all the birefringent illuvial clay was of the yellowish brown variety typical of Flandrian soil formation (Bullock 1974). Sections from both profiles A and B showed some iron and ferri-manganiferous segregations (mottles) mainly below 30 cm depth, but amounts were greater in profile A.

The laboratory determination of soil reaction showed all the uncultivated profiles to be moderately acid, but the cultivated profiles G and H had A horizons limed up to pH 7.5 and 6.9

Table 4: Minerology of coarse silt (16–63m) samples. Grains per thousand (0/00) in light and heavy suites.

	PROFILE A Sample 3	PROFILE B Sample 3	mean of 4 Silty Hants Brickearths	mean of 4 Sussex Brickearths	mean of 4 Sandy Brickearths	mean of 3 Plateau Gravels	mean of 3 Tertiary Sands
LIGHT MINERALS:							
Quartz	791	788	798	834	803	702	776
Alkali Feldspa	179	100	139	135	138	60	143
Flint	21	92	44	13	36	231	50
Muscovite	9	6	18	12	17	7	6
Glauconite	–	14	1	6	6	–	25
HEAVY MINERALS:							
Tourmaline	41	54	66	38	89	197	113
Zircon	250	322	326	155	275	296	542
Brown Rutile	100	40	86	35	99	94	138
Yellow Rutile	100	40	86	35	99	94	138
Red Rutile	1	1	1	5	–	–	1
Pink Garnet	–	–	–	–	–	–	1
Garnet, Colourless	25	30	21	36	29	6	9
Hornblende, Green	60	19	34	82	38	17	2
Hornblende, Brown	3	–	–	7	1	1	–
Kyanite	9	3	6	4	5	3	6
Staurolite	6	4	4	6	4	4	8
Zoisite	20	11	13	18	11	17	7
Epidote	265	287	256	376	298	223	117
Anatase	19	11	17	28	24	25	17
Blue tourmaline	–	–	4	–	1	3	2
Brookite	3	4	5	4	3	8	7
Chlorite	173	184	130	151	95	90	12
Tremolite/Actinolite	20	24	23	27	17	10	3
Biotite	–	2	–	13	–	–	–
Collophane	–	–	1	–	–	–	–
Apatite	–	–	–	1	–	–	–

respectively. Acidity generally decreased with depth, profile A (Chilling Copse) giving the following series: A 1 pH 4.27, A 2 pH 4.03, Eb pH 4.28, Bt pH 4.41; whilst profile B which was under old grassland gave the series: A 1 pH 5.0, Eb pH 5.4, Bt pH 6.2, Bt/C pH 6.4. The greatest acidity was recorded in profile F (pH 3.97, Eb horizon). All uncultivated soil profiles were clearly decalcified.

DISCUSSION

The data in Table 1 show that the particle size distributions of samples taken down to a depth of 50 cm in profile A (Chilling Copse) closely resemble sediments from Kent and Yorkshire which have been called loess (Catt *et al* 1974). Loess is a silty, far-travelled aeolian deposit of Pleistocene age in Britain. The fine sand content of deeper samples from profile A is far higher than that of typical loess, although the moderately high silt content (43.3–44.8%) suggests there may be a considerable loess content. The near surface samples from profiles C–F all have silt contents greater than 60% and are clearly similar to samples 1–3 from profile A. The size and shape of the coarse silt distribution curve for sample 3 of profile A is similar to that of loess or loess dominated sediments elsewhere in England (Catt *et al* 1971, Weir *et al* 1971), and the 31 μm peak is consistent with the known westward decrease in the modal size for Late Devensian loess in England (Catt 1978). Sample 5 from profile A and sample 1 from the sandier profile B show two subsidiary coarse silt peaks at 37 μm and 53 μm. Polymodal coarse silt distributions in English loess have not been reported before using 1/4 ϕ resolution, although Eden (1980) using 1/9 ϕ resolution discovered up to five modes in loess of eastern England, which he claimed reflected the particle size distribution of the source sediment(s). The bimodal silt studied here may have originated at two sources or a single source with such a bimodal silt distribution.

The polymodal fine sand fractions from profiles A and B probably reflect the particle size modes of local source sediments such as Bracklesham Beds, Barton Sands and Headon Beds (Table 1, Fig 1). The secondary sand content of loess may arise through mixing with subjacent sandy deposits, or simultaneous aeolian deposition of local sand with far-travelled silt (Catt *et al* 1971). It seems probable that the fine sand of the brickearth studied was deposited with the silt since the underlying Plateau Gravel has a very different size distribution in the sand fraction.

The close similarity in the mineralogy of the fine sand fractions from samples of profiles A and B (Table 3) indicates the same sources for both. The local source sediments (the Tertiary sands and Plateau Gravels) are qualitatively similar to the brickearths, with the Plateau Gravels having the least quantitative resemblance. However, so great are the overall quantitative differences that it seems unlikely that all the fine sand of the brickearth has come from these sediments. The excess of feldspar, garnet, and the epidote group in the brickearth may represent the coarse tail of the aeolian silt, since these minerals are characteristically abundant in the coarse silt of the brickearth. A similar mineralogical enrichment of the fine sand fraction has been noted in the loess of Kent (Weir *et al* 1971) and Devon (Harrod *et al* 1973).

The obvious difference in coarse silt mineralogy between samples from profiles A and B (Table 4) may be linked to the major differences in particle size character at the sampling level. The sandier sample from profile B may relate to an early stage in the deposition of the brickearth involving a high fine sand content but very low silt content, whilst the sample from profile A relates to a later stage with higher levels of silt deposition. In support of this it might be noted that the mean mineralogical composition of four other south Hampshire brickearth samples shows intermediate levels of feldspar, flint, yellow rutile and hornblende coupled with intermediate levels of fine sand and silt (Table 4; Reynolds 1985). The mineralogical composition of the coarse silt of both samples is generally similar to that of the Late Devensian loess found nearby in West Sussex (J Catt pers com). Both samples have about

18% chlorite grains in the heavy mineral fraction, a level which conforms with the known westward increase in the content of this platy mineral in Late Devensian loess in southern England, which probably results from winnowing by easterly winds in the Pleistocene (Harrod *et al* 1973; Catt 1978).

It seems likely that the coarse silt in both the silt-rich and sand-rich brickearths around Hook and Chilling is largely Late Devensin loess. However, this brickearth does have a distinctive coarse silt mineralogy, for example, it contains more tourmaline, zircon and rutile, and less hornblende and epidote than the West Sussex loess, which seems in part to reflect the mineral concentrations in the silt fractions of south Hampshire Tertiary sediments. The evidence of the mineralogy of the coarse silt alone might lead to the conclusion that as much as half of the brickearth silt was locally derived, but this would be a gross overestimate for two reasons. Firstly, because of the effects of hydraulic equivalence (Folk 1974) heavy minerals originally deposited in association with the quartz dominated 75 µm peak in the fine sand would in fact be of silt size, so that local sands may have contributed considerable amounts of heavy minerals to the coarse silt fraction without contributing much coarse silt sized material. Secondly, only about 0.2% of the mineral grains in the coarse silt fraction of the brickearth are non-opaque heavy minerals, yet the Tertiary sands average about 0.6%. Thus even a small contribution of silt from local sediments would have a relatively large effect on the heavy mineral suite of the coarse silt of the brickearth. For these reasons the amount of locally derived silt in the brickearth is likely to be less than 20%.

The clay content of deep (> 1 m) brickearth soils rarely falls below 18% and the translocation of clay has occurred in the soils examined. The particle size analyses showed the maximum clay content (23%) was at 90–100 cm depth in profile A (Chilling Copse) but at only 30–40 cm depth in profile B (Hook gravel pit). The clay content of profile A was at a minimum at 16–30 cm indicating an eluviated horizon. Kay (1939) noted a clay maximum of 31.6% at 70 cm in a Hamble Series soil south of Hook, and Hodgson (1967) found the average depth of maximum clay content was 75 cm for Hamble and Hook Series soils in West Sussex. Clay content was found to increase markedly from 40 cm depth in profiles C–F but the maximum associated with a clay loam texture was much deeper. Thus the unusually shallow depth of the Bt horizon in profile B is unlikely to be the depth at which the clay originally accumulated, and may be explained by the partial erosion of A and Eb horizons at some time after the main development of the Bt horizon. The iron and ferri-manganiferous mottles noted from field and laboratory studies of all the deeper brickearth soils indicate drainage impedence probably due to the development of the Bt horizon and the weak structure of the soils.

CONCLUSIONS

The silt fraction which dominates the brickearth deposit around Chilling and Hook is most probably far travelled Late Devensian loess. Elsewhere in Britain such loess has been shown to be derived from Late Devensian glacial deposits in eastern England and the North Sea Basin, with which it has strong mineralogical affinities. The silt from the upper part of profile A (Chilling Copse) probably has this source since the coarse silt peak at 31 µm and the chlorite content of 17–18% are values to be expected on the basis of a model involving winnowing of outwash by easterly winds in the Late Devensian (Catt 1978). However, the bimodal silt also found in profiles A and B probably belongs to an earlier phase of loess deposition in the Late Devensian; the 37 µm peak may relate to far travelled material from the North Sea Basin, but the coarser 53 µm peak could have been derived from local sources within the Hampshire Basin, or possibly more westerly sources (Catt and Staines 1982). The sand of the brickearth is mainly locally derived from a common source, and decreases up the profiles, probably reflecting the blanketing out of local sources of sand by far-travelled loess in Late Devensian times. The south Hampshire brickearths have been interpreted as flood loams incorporating fluvially reworked loess (Fisher 1971; Keen 1980), but there seems little reason to regard the brickearths on level, uneroded sites in this study area as anything other than a sequence of undisturbed aeolian sandy silts and silts (loess). The brickearth is clearly not derived from the underlying Plateau Gravel, although locally Plateau Gravel may be mixed with the brickearth by cultivation, mass movement on slopes or cryoturbation where the brickearth is thin.

Aeolian sediments are generally deposited over the landscape with little preference for site so that where the brickearth is shallow or its depositional sequence incomplete this may be attributed to post-depositional erosion. Thus the absence in profile B (Hook gravel pit) of the very silty brickearth apparent at the surface in most other profiles is probably due to erosion that occurred after the main development of the Bt horizon. In Kent, Weir *et al* (1971) demonstrated that the bulk of clay illuviation in a loessic soil had been completed by about 5000 BP, and if the same is true for profile B its erosion has taken place largely in the last 5000 years. The micromorphological evidence suggests erosion of 60 cm of material, the particle size analysis suggests some 100 cm has been lost at profile B; erosion of this profile has probably been due partly to its closeness to a small valley of the Hook Lake system.

Soil formation in the deep brickearth has resulted in a moderately acid soil, with a clear Bt horizon, which may be described as a typical argillic brown earth, although at several sites there are signs in the soil and vegetation of drainage impedence. However, the profiles are little weathered and still clearly display the characteristics of the stone free, structureless, aeolian sands and silts in which they formed. The earlier description by Kay (1939) of the majority of these soils as fine sandy loams, rather than silt loams, was because she employed a different definition of silt (2–20 µm diameter) from the British Standard employed here (2–63 µm).

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APPENDIX

The sources of sediments analysed or data cited in tables.

Table 1: Barton Sand, Barton Cliff (SZ238929); Headon Beds, Hordle Cliff (SZ238929); Bracklesham Sand, cliff south of Chilling (SU515035); Plateau Gravels, mean of four samples from Barton Cliff (SZ238929), Holbury Pit (SU425045), Passford House Farm Pit (SZ297975), Rockford Gravel Pit (SU173084); Loess, data from Catt, Weir and Madgett (1974).

Table 3: The mean of six Tertiary sands derived from samples from Barton Cliff (Barton Sand); Hordle Cliff (Headon Beds); Longslade Bottom (Barton Sand, SU264005); Park Pale, Lyndhurst (Barton Sand, SU308081); Mudeford Cliff (Bracklesham Beds, SZ196918); Rockford Gravel Pit (Bracklesham Sands, SU164083).
The mean of four sandy brickearths derived from samples from Rockford Gravel Pit (SU173084), Calveslease Copse (SU323002), Beaulieu Heath (SU339015), Thorns Farm (SZ389964).
The mean of four Plateau Gravels samples as for Table 1.

Table 4: The mean of five Tertiary sands, as for fine sand less Rockford Gravel Pit; the mean of three Plateau Gravels as fine sand less Rockford Gravel Pit; the mean of four sandy brickearths as fine sand; the mean of four other Hampshire brickearths from Barton Cliff, Ashley Manor Farm (SZ256940), Hollybush Farm (SZ275955), Sturt Pond (SZ298910); the mean of four Sussex brickearths (J A Catt, pers com).

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