The Soil at Rothamsted

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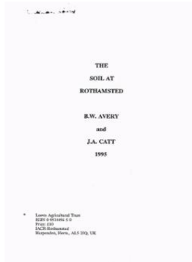
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Soil Classification and Mapping

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been derived from the same deposit, though mineralogical analyses (Moffat 1980) have failed to confirm this and suggest that the sand could equally well have come from a former cover of sandy Reading Beds.

Everywhere on the dipslope plateau, the topsoils and often the immediate subsurface horizons contain more silt (2-60 μm) than the deeper subsoil. Mineralogical analyses (Avery *et al.* 1959; Catt 1969; Avery *et al.* 1972) support the conclusion that the upper silty horizons are composed of Late Devensian loess (windblown dust deposited about 14,000-18,000 years B.P.) intimately mixed by cryoturbation with clay and frost-shattered flints from the Plateau Drift. On parts of Whittlocks, Park Grass (Fig. 1) and other fields, the layer rich in Devensian loess exceeds 80 cm in thickness and contains few stones below the topsoil.

In many localities on the Chiltern Plateau, thicker and often almost stone-free silty deposits known as brickearths occur as inclusions within or below the more stony Plateau Drift and have been exploited at various times for brickmaking. They occupy funnel- or basin-shaped depressions in the underlying Chalk surface, which appear to have originated as solution hollows or dolines when the Reading Beds cover had only been partly removed. Investigations during the 1970s revealed the existence of such a doline beneath Little Knott Field (Fig. 1) (Avery *et al.* 1982) and there may well be others elsewhere on the farm, as they are normally completely infilled and hence have little or no surface expression. Mineralogical analyses of silt fractions from within the infill at Little Knott, where the Chalk surface locally descends to a depth of at least 11 m, suggest that the uppermost layer of Devensian loess is underlain by inwashed deposits consisting partly of older (Wolstonian and Anglian) loesses. No artefacts have been found there, but similar infilled dolines elsewhere on the Chilterns (Caddington, Gaddesden Row) have yielded rich assemblages of Paleolithic flint implements, and at Round Green (Luton) there is an intriguing record of a human skeleton found about a century ago. It is likely that the dolines were often water-filled and attracted human interest at various times in the later Quaternary.

The various deposits underlying sideslopes of the Ver valley and in minor valleys heading on the plateau also consist partly of loess, which was mixed with locally derived materials under periglacial conditions and moved downslope by gelifluction or by more recent rainwash since the land was first cultivated. In Flint, Scout and Osier Fields (Fig. 1) the drift includes more or less re-arranged flint gravel originally laid down by precursors of the Ver in Devensian or earlier cold periods. Flint gravel with a sparse loamy matrix also underlies the floor of the valley and is covered in the lowest places by thin spreads of silty alluvium. On construction of the A5183 Redbourn bypass, however, the stream course in Ver field was diverted and the naturally occurring superficial deposits and soils there were incorporated in loamy and gravelly 'made ground'.

Soil Classification and Mapping

Soil surveys based on field examination of topsoil and subsoil horizons, together constituting the soil profile, were initiated in Britain during the 1920s. Following contemporary American usage, soil series were adopted as the basic units of classification and mapping and named according to the localities where they were first identified or were most extensive. By 1939, when the Soil Survey of England and Wales received formal recognition, soil-series maps had been made in a number of widely scattered localities, each series being conceived as a set of soils with similar profiles developed

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under similar conditions from the same type of parent material. To systematize their differentiation and show their relationships, they were grouped into broader classes termed genetic or major soil groups (brown earths, podzols, calcareous soils, gley soils and organic soils) and subgroups, and characterized by field-determined properties supplemented by particle-size and chemical analyses of horizon-samples from representative profiles (e.g. Kay 1939).

A soil-series map of the Rothamsted Farm was first compiled by Professor Linwood L. Lee of Rutgers University, New Jersey, in 1931 (Rothamsted Report for 1931, p. 40). He identified and mapped 14 series, four of which were further divided into soil types on a textural basis, but a later (1945) survey by B.W. Avery failed to substantiate his findings. They were therefore disregarded in subsequent surveys of similar terrain by the Soil Survey of England and Wales, including those of the neighbouring Aylesbury and Hemel Hempstead district (Avery 1964), the West Sussex Coastal Plain (Hodgson 1967) and the Reading district (Jarvis 1968). In these the classification adopted featured a number of series, including Batcombe, Charity, Hamble, Hook, Icknield, Wallop and Winchester, originally named and mapped in earlier surveys in Berkshire, now Oxfordshire (Kay 1934), Hampshire (Kay 1939; Green 1940) and Dorset (Robinson 1948).

This classification, summarized in Table 1, was used in accounts of the soil published in successive issues of the Station Guide from the mid-1950s onwards, together with a soil map based on closely spaced screw-auger borings along traverses 50-100 m apart. In accordance with contemporary Soil Survey practice, soil textures were described using U.S.D.A. classes (Fig. 2a) as determined in the field by comparison with analysed samples. In 1966, following the purchase of the greater part of Scout Farm, Redbourn, including Black Horse, Bylands, Meadow, Scout, Flint, Osier, Ver, Drapers, Webbs, Stubbings, White Horse and Summerdells fields (Fig. 1), the newly acquired land was surveyed in the same fashion and the soil map extended accordingly. By this time particle-size and chemical data had been obtained on samples from 18 representative profiles described in detail, but most of these were in Knott Wood and on Scout Farm, and only three in classical experimental sites (Park Grass and Broadbalk Wilderness). In 1968 and 1971 respectively, the soils of Broadbalk and Barnfield were examined more intensively (Avery and Bullock 1969; Weir *et al.* 1969; Catt 1969; Avery *et al.* 1972); six profiles in Broadbalk and 13 in Barnfield were sampled for analysis, which included mineralogical and micromorphological studies as well as particle-size and chemical measurements.

The decade beginning in 1973 saw the adoption by the Soil Survey of a revised hierarchical soil classification scheme (Avery 1973, 1980; Clayden and Hollis 1984) in which major soil groups, soil groups, soil subgroups and soil series are defined by progressive division, using selected observable or measurable profile characteristics as differentiating criteria. In particular, soil series were redefined as divisions of subgroups with limited ranges in lithology, including texture, stoniness, depth to specified substrata and mineralogical or mineralogically related characteristics. At the same time the U.S.D.A. textural classes (Fig. 2a) previously used were replaced by a smaller number of newly defined particle-size classes (Fig. 2b) based on the particle-size grades of the British Standards Institution (1975). For differentiating soil series, the classes were grouped as in Fig. 2c. These classes accord closely with those used to differentiate family groupings in the US Soil Taxonomy (Soil Survey Staff, 1975). The system was first fully utilized in compiling the national 1:250,000 soil-association maps (Mackney *et al.* 1983;

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Jarvis *et al.* 1984) in which associations are identified by the names of the dominant or most distinctive soil series each contains. As a consequence of the newly systematized soil-series definitions, the total number of series recognized nationally was considerably reduced, although the number represented within a limited area such as the Rothamsted estate is generally larger, particularly in situations where differentiating criteria not previously used have been introduced. Thus the Winchester, Charity, Coombe and Icknield series as previously conceived (Table 1) have each been divided into two or more series.

Table 1. Soil series on Chalk, Clay-with-flints and associated deposits (after Avery, 1964 and Hodgson, 1967)

Major soil group	Subgroup	Parent material or substratum	Soil series
Calcareous soils	Rendzinas	Chalk	Icknield
	Brown calcareous soils	Silty chalky drift (Head) Thin Clay-with-flints over Chalk	Coombe Wallop
Brown earths	Brown soils (*sols lessivés*)[1] (leached brown soils)	Silty drift (brickearth) Flinty silty drift (Head) Clay-with-flints	Hamble Charity[2] Winchester
	Brown earths (*sols lessivés*)[1] with gleying	Silty drift (brickearth) Clay-with-flints (Plateau Drift)	Hook Batcombe

[1] With clay-enriched (argillic) subsurface B horizons.
[2] Mapped with associated soils as Charity complex at Rothamsted.

Twenty soil series as currently defined have been positively identified at Rothamsted, including three that have yet to be named by the Soil Survey. They are listed in Table 2, along with their differentiating characteristics. Batcombe and Carstens soils on Clay-with-flints are together estimated to cover nearly three-quarters of the area, and several of the others are only sporadically represented. The table also relates each series to classes in the internationally utilized U.S.D.A. (Soil Survey Staff 1990) and F.A.O. (1990) systems, and lists recorded profiles with morphological and analytical data conforming or nearly conforming to the prescribed definitions. As classes of the England and Wales Soil Classification do not correspond precisely with those of the other systems, in which different differentiating criteria are used (cf. Avery 1980), the correlations are inexact and in some cases tentative. Abridged descriptions of the 42 profiles listed and related analytical data (Avery and Bascomb, 1982) are given as Appendices A and B, respectively. The colour, texture and stoniness of the horizons distinguished are described in accordance with the Soil Survey Field Handbook (Hodgson 1974). For profiles 1-33 described and sampled before 1974, this entailed modifying the original descriptions. Similarly, the particle-size data were recalculated where necessary to accord with the currently used size grades (Fig. 2b) in order to attain uniformity.

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Table 2. Classification of Rothamsted soils according to the Soil Survey of England and Wales (Avery 1980; Clayden & Hollis, 1984), the U.S.D.A. Soil Taxonomy (Soil Survey Staff 1975, 1992) and F.A.O. (1990)

Soil Subgroup (Avery 1980)	Soil Series (Clayden & Hollis 1984)	Soil Subgroup (Soil Survey Staff 1992)	Soil Unit F.A.O. (1990)	Recorded Profile(s)
3.42 Grey rendzinas	UPTON loamy, lithoskeletal chalk	Typic Udorthent	Eutric (or Rendzic) Leptosol	
3.43 Brown rendzinas	WALLOP clayey, lithoskeletal chalk	Typic Udorthent or Rendollic Eutrochrept	Eutric Leptosol or Calcaric Cambisol	6
5.11 Typical brown calcareous earths	PANHOLES fine silty over lithoskeletal chalk	Rendollic Eutrochrept	Calcaric Cambisol	8
	COOMBE fine silty, chalky drift	Rendollic Eutrochrept	Calcaric Cambisol	18
5.47 Colluvial brown earths	NOTLEY fine silty, non-calcareous colluvium	(no definite correlative)	(no definite correlative)	4, 23*, 27
5.71 Typical argillic brown earths	CHARITY fine silty drift with siliceous stones	Typic Hapludalf	Haplic (or Chromic) Luvisol or Alisol	12*, 28*, 36
	HAMBLE silty, stoneless drift	Typic Hapludalf	Haplic Luvisol or Alisol	15*, 31
	ROWTON silty over non-calcareous gravel	Typic (or Glossic) Hapludalf	Haplic (or Chromic) Luvisol or Alisol	14*
	WOLD fine silty over clayey, over lithoskeletal chalk	Typic Hapludalf	Haplic (or Chromic) Luvisol	9
	________ fine silty over clayey, chalky drift	Typic Hapludalf	Haplic (or Chromic) Luvisol	7, 29

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Soil Subgroup (Avery 1980)	Soil Series (Clayden & Hollis 1984)	Soil Subgroup (Soil Survey Staff 1992)	Soil Unit F.A.O. (1990)	Recorded profile(s)
5.71 Typical argillic brown earths	MAPLESTEAD coarse loamy, drift with siliceous stones	Typic Paleudalf (or Glossudalf)?	Chromic Luvisol (or Eutric Podzoluvisol)	16
5.72 Gleyic argillic brown earths	HOOK silty, stoneless drift	Typic (or Aquic) Hapludalf or Paleudalf	Haplic (or Chromic) Luvisol	32, 33*, 41*
	TIDMARSH loamy-gravelly with very hard siliceous stones	Mollic Hapludalf (or Glossudalf)	Chromic Luvisol?	38
5.81 Typical paleo-argillic brown earths	CARSTENS fine silty over clayey, drift with siliceous stones	Typic Paleudalf (or Hapludalf)	Chromic Luvisol (or Alisol)	25*, 35*, 40
	PORTON fine silty over clayey, over lithoskeletal chalk	Typic Hapludalf	Chromic Luvisol (or Alisol)	
	WINCHESTER clayey over lithoskeletal chalk	Typic (or Vertic) Hapludalf	Chromic (or Vertic) Luvisol	5, 30
5.82 Stagnogleyic paleo-argillic brown earths	BATCOMBE fine silty over clayey, drift with siliceous stones	Aquic (or Typic) Paleudalf	Chromic Luvisol (or Alisol)	1*, 2, 10, 11, 13, 19, 20, 21, 22*, 24, 26*, 34, 42
	HORNBEAM fine loamy over clayey, drift with siliceous stones	Aquic (or Typic) Paleudalf	Chromic Luvisol (or Alisol)	3
8.41 Typical argillic gley soils	BINSTEAD loamy-gravelly with very hard siliceous stones	Typic (or Aeric) Endoaqualf	Gleyic Luvisol?	39
8.73 Argillic humic gley soils	_________ fine silty over non-calcareous gravel	Typic Argiaquoll or Mollic Endoaqualf	Gleyic Phaeozem?	17, 37

* Marginal in respect of one or more differentiating characteristics at series level.

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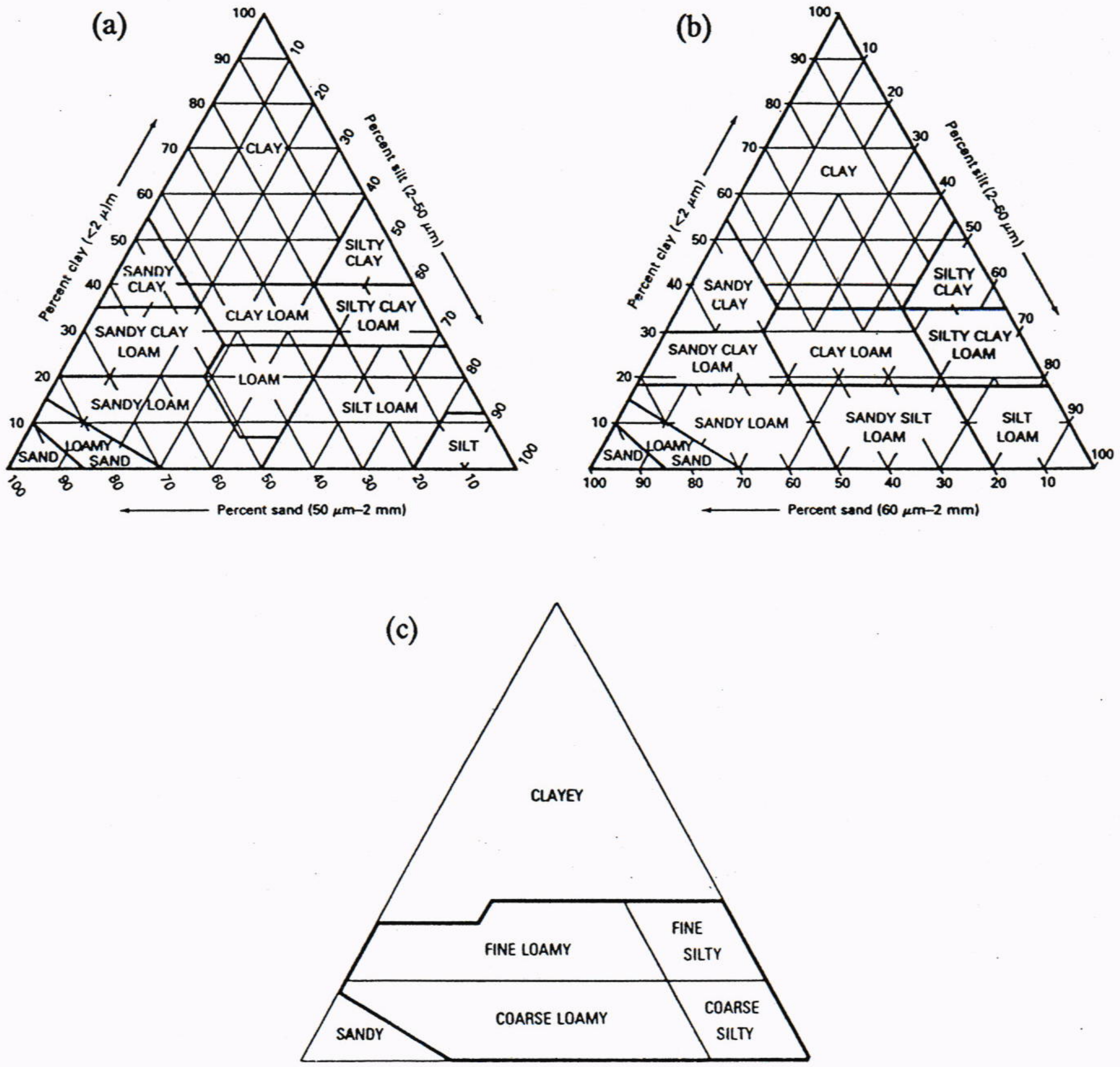

Fig. 2. Textural (particle size) classes according to (a) United States Department of Agriculture; (b) Soil Survey of England and Wales (now Soil Survey and Land Research Centre); and (c) groupings from (b) used to differentiate soil series in England and Wales.

Locations of the numbered profiles are shown on the accompanying 1:10,000 soil map (Fig. 3). This was derived from an improved auger survey made in 1977 by C.G.G. Van Beek and L.G. De Klerk of the University of Utrecht, with due reference to earlier work. Borings were made at 1,225 pre-determined points 50 m apart (grid survey), using a 6 cm diameter Edelman auger which permits examination of soil colour, texture, structure and consistence to a depth of one metre except where stopped by very stony material. Details of each boring were recorded on cards designed for the purpose: 16 topsoil samples were submitted to particle-size analysis to aid field determinations of texture, and three further profiles (nos. 40-42) fully described and sampled.

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The map legend (Table 3) includes 13 units identified in all but one case by names of the dominant soil series as now defined. 'Typical' and 'heavy' phases of the Batcombe series are set apart on a textural basis and the locally variable soils on the Ver valley floor are grouped as the Ver complex. A further unit comprises unsurveyed and/or disturbed (made) ground, including pits and 'dell-holes'.

It is now generally recognized that soil-series mapping based on field examination of the soil profile at sampling sites is subject to errors arising firstly from short-range lateral variability and secondly from the limited precision of field estimates of differentiating properties defined in quantitative terms. Thus the bodies of soil represented by mapping delineations normally include profiles conforming to more than one soil series. A map unit is conventionally identified by a single series name when it is predicted that most of the soil in every delineation conforms to it and that unconforming inclusions are similar for practical purposes or occupy negligible proportionate areas. Undifferentiated units, estimated to include substantial but variable proportions of two or more closely related series, are identified by the names of the two most extensive (e.g. Batcombe-Carstens); units comprising significant proportions of contrasting series in each delineation are distinguished as complexes.

Salient Soil Properties

General profile characteristics

As indicated in earlier accounts, the undisturbed soils are readily divisible into three broad classes as follows:

1. Well drained calcareous soils (rendzinas and brown calcareous earths) on Chalk or chalky drift.
2. Well drained to moderately well drained, originally acid soils (nearly all paleo-argillic or argillic brown earths) on Clay-with-flints and in other non-calcareous or superficially decalcified drift over Chalk.
3. Low lying soils (groundwater gley soils, including argillic, humic and humic-alluvial gley soils) over river gravel, that show signs of periodic saturation by groundwater in the recent past.

Soils of the first class, confined to sloping land on the eastern side of the Ver valley, have relatively simple profiles in which the topsoil rests more or less directly on fragmented chalk (rendzinas) or overlies a brown subsurface (B) horizon of similar texture (brown calcareous earths).

Soils of the second class, which are by far the most extensive, nearly all have brown to yellowish-red subsoil horizons of noticeably finer texture (argillic Bt horizons), either directly below the topsoil or at greater depths beneath a less strongly coloured and more friable subsurface (Eb) horizon. In both cases the increase in clay content with depth is at least partly attributable to downward translocation of clay-size particles, though on the Clay-with-flints, as mentioned above, it is accentuated by the presence of a more silty superficial layer rich in loess-derived material. Soils in the thicker loess-containing deposits of Devensian age (argillic brown earths) have B horizons that are less brightly coloured than the Clay-with-flint subsoils, which are normally strong brown

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