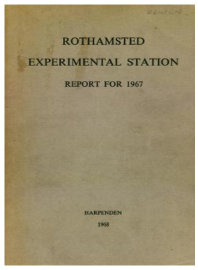
Rothamsted Report for 1967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Soil Survey of England and Wales

K. E. Clare

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SOIL SURVEY OF ENGLAND AND WALES

K. E. CLARE

The aims of the Soil Surveys of England and Wales and of Scotland are to describe, classify and map the distribution of the soils of Great Britain mainly on the basis of observations of the properties of the soil profile as found in the field. Observations are also made of the parent material from which the soil is thought to come, the environment and the use made of the land. Samples are analysed in the laboratory to confirm and give precision to field observations, to characterise the soils further and to study soil-forming processes. The properties of the soils shown on maps are described in accompanying memoirs or bulletins, as are the geography, geology, climate, vegetation and land use of the district surveyed. A soil map and text together are a permanent record of the distribution and properties of the various kinds of soils. Descriptions take into account the whole depth of the soil profile (i.e. surface and subsoil to a depth of 3 ft) and, with the additional information provided, are of use in agriculture, forestry, land-use planning, land drainage, geography and ecology.

The Headquarters Office, the Analytical Laboratories and the Cartographic Section of the Soil Survey of England and Wales are at Rothamsted Experimental Station, Harpenden, Herts., and surveyors are stationed at 13 centres.

A new principle has been adopted for mapping. Selected 38 sq mile areas in each county of England and Wales will be surveyed at a scale of 1:25 000 and maps published at the same scale. The areas correspond to the Ordnance Survey 10 km × 10 km Outline Edition 1:25 000 map series, and are chosen for their geomorphological and agricultural interest, and as a basis for later county, regional and national maps. Survey has now started in nine areas; Yorkshire, Huntingdonshire, Norfolk, Derbyshire, Nottinghamshire, Buckinghamshire, Essex, Kent and Pembrokeshire.

Northern England

Yorkshire

Sheet SE 60 (Armthorpe). The new county mapping programme in the West Riding started in the district immediately east of Doncaster. After a study of profiles in 18 sand and gravel quarries, 12 sq miles were mapped.

The land is slightly undulating and mainly sandy or stony. A Pleistocene riverine or deltaic formation extends in a crescent from Armthorpe via Barnby Dun to Hatfield. The adjacent lower-lying, flatter areas are 1, alluvial clays of the Don, 2, clays, sands and reed-swamp peat in West Moor and between Holme Wood Lane and the Torne and 3, mixed reed-swamp and woody peat along the Torne. Bunter sandstone underlies the district, but nowhere forms the soil material, although Pleistocene sands may merge into weathered sandstone at as little as 2 ft below the surface.

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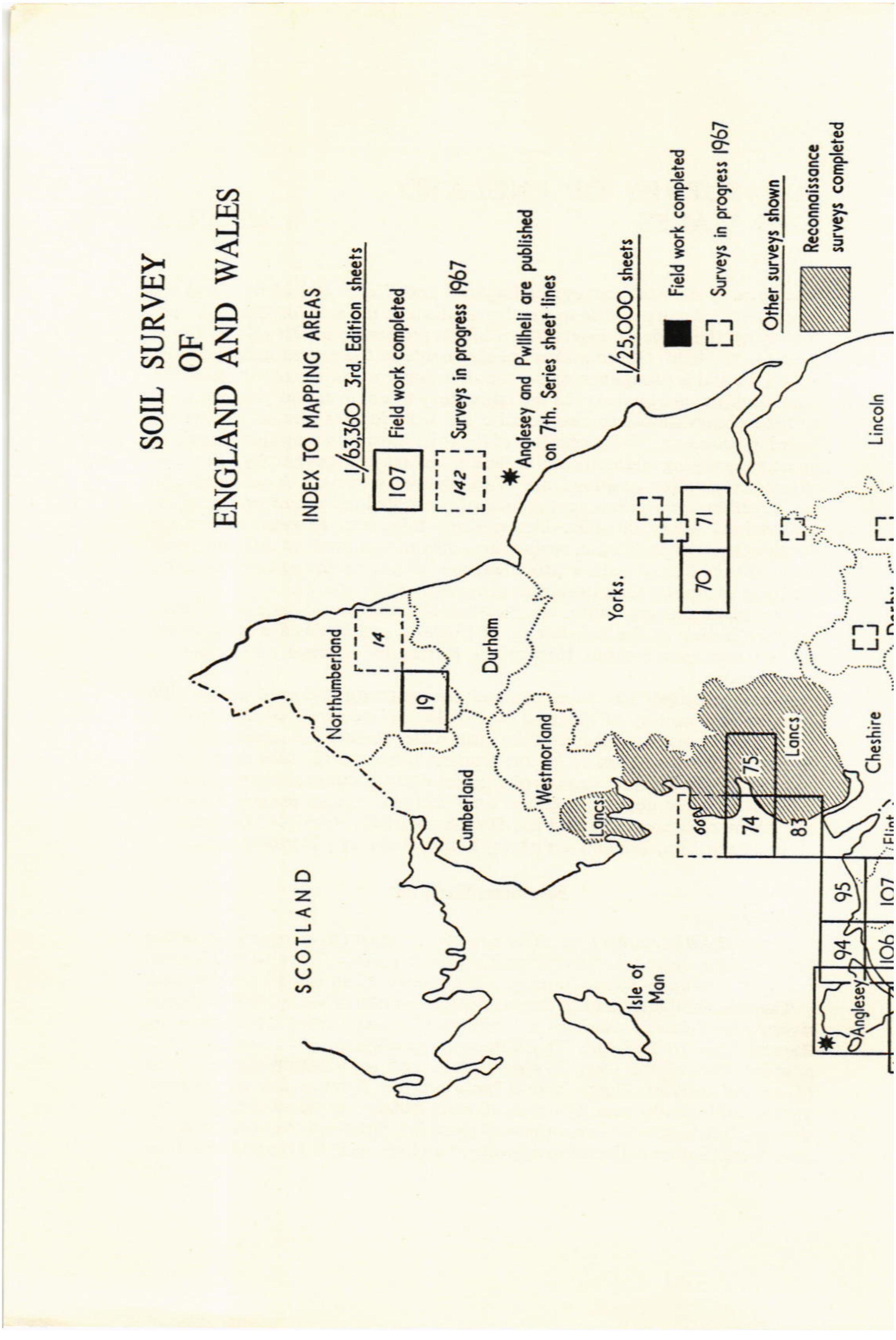
SOIL SURVEY
OF
ENGLAND AND WALES
INDEX TO MAPPING AREAS
1/63,360 3rd. Edition sheets
107 Field work completed
142 Surveys in progress 1967
Anglesey and Pwllheli are published on 7th. Series sheet lines
1/25,000 sheets
Field work completed
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Other surveys shown
Reconnaissance surveys completed
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14
19
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Lancs
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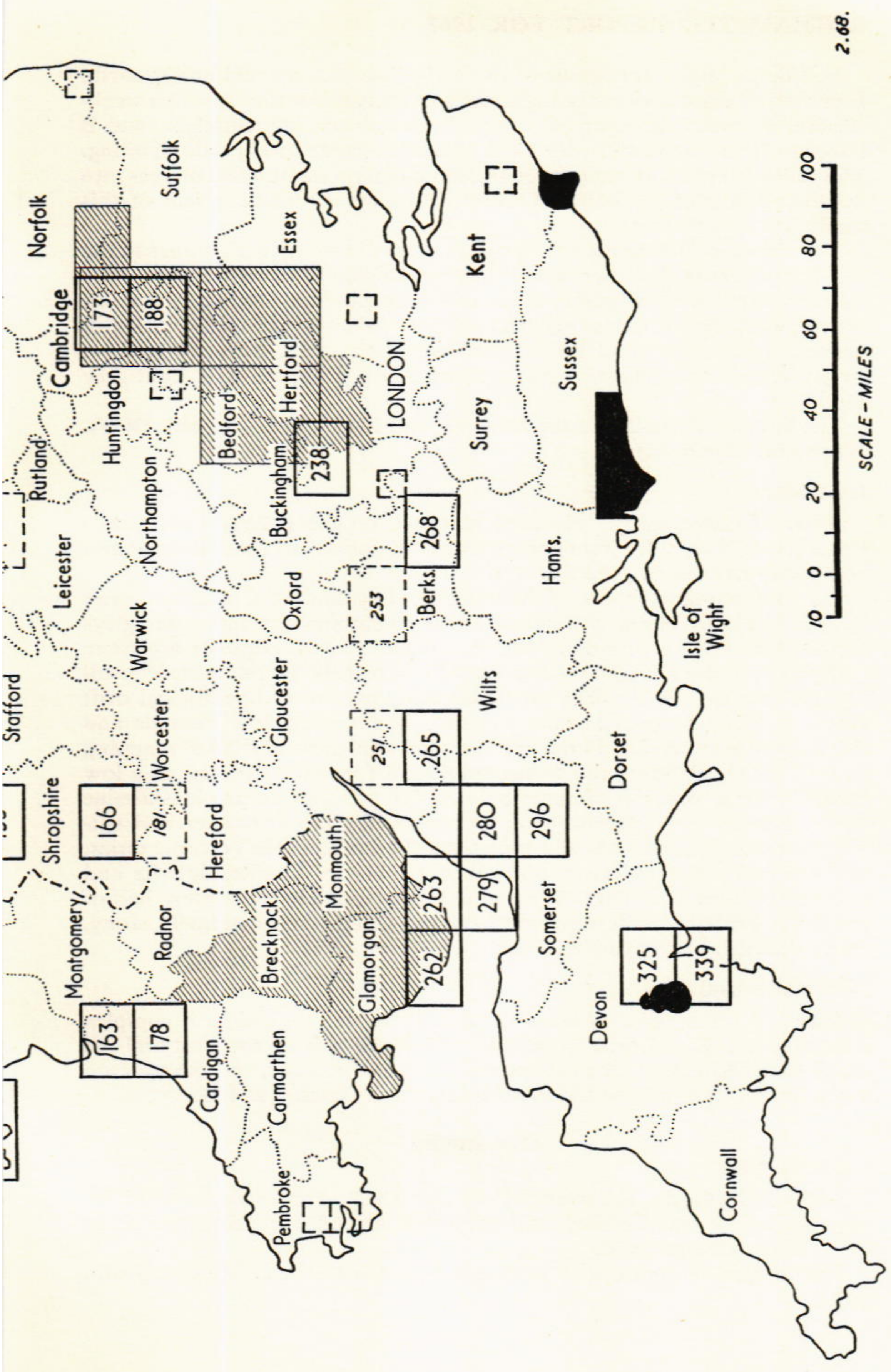
Anglesey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Norfolk
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LONDON
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Northampton
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178
10 0 20 40 60 80 100
SCALE - MILES

Full descriptions were made of two soils. The first, an acid brown earth, is on well drained sites in the higher area of Pleistocene sands, with a weak-structured loamy sand topsoil over a brown, loose, structureless sand B horizon. It can be stony, with Coal Measures sandstones predominating. The yellowish red C horizon at 36 in., has a platy structure and merges into weathered Bunter sandstone. Olive-yellow clay lamellae, typical of this sandstone, are present.

The second soil, a ground-water gley, occurs in sandy drift, either in the low-lying areas of Armthorpe and Cantley parishes or in depressions in the elevated area of Pleistocene sands. The topsoil is a very dark greyish brown, weak-structured loamy sand or sandy loam, above a light yellowish brown structureless sand Bg horizon with many grey, brownish yellow, strong brown and yellowish red mottles. The Cg horizon is a light grey sand.

The first soil is similar to the Newport and Ellerbeck [1] series. (R. A. Jarvis and Matthews)

Lancashire

Sheet 66 (*Blackpool*). Detailed mapping on the 1:25 000 scale continued, and 29 sq miles were completed. Descriptions of the soil series and complexes have been published [2].

On the southern shores of Morecambe Bay and at Cockerham and Pilling, the soils of the salt marshes are calcareous ground-water gleys formed on active estuarine alluvium. Inland, alluvial deposits are more complex and often overlie peat or Downholland Silt. To the west, Preesall Shingle occurs over a wider area than is shown on old geological drift maps, and is best seen around Preesall, where many low mounds and ridges have been worked in the past for sand and gravel. Detailed mapping shows that the deposits run to the south-east for about 2 miles, as a low esker-like ridge or series of hummocks 50–100 yds wide ending in Stalmine Moss. Pebbles from several samples are of Silurian gritstones and siltstones, rhyolites, andesites and tuffs from the Borrowdale Volcanic series, and red and yellow Triassic sandstones. Pebbles of granite, dolerite and gabbro also occur, similar to some of the types found in the western half of the Lake District. Soils developed on the shingle are extremely stony, freely drained, brown earths. (Hall)

Northumberland

Sheet 14 (*Morpeth*). About 12 sq miles were mapped in a complex area of fluvio-glacial drift associated with ice-flow from the west and the north-east. Drift from the north-east is the richer in bases, and the soils are more fertile. Several new series were described. (Ashley and George)

East Anglia

Cambridgeshire

Sheet 173 (*Ely*). The resurvey of this sheet, previously covered by reconnaissance was finished and map and legend are being prepared; 26 sq miles were mapped.

The pattern of roddons in Benson's Fen, Chatteris, at Welches Dam,

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Coveney Byall Fen, and east of the River Lark, all occurring in the Downholland [3] complex, was confirmed. In Burnt Fen roddon patterns were traced and Prickwillow [4] series separated from the Downholland complex.

In areas of deep peat of the Adventurers [4] series the edges of the Fen Clay were traced in Padnal and Middle Fens near Ely, and near the Cross Bank north of Mildenhall Fen. In the Methwold Fens both the edge of the Fen Clay was traced and the depth of peat recorded.

In Mildenhall Fen the uneven microrelief of land at the edge of the Fens gives a complex pattern of soils mapped as several complexes containing Adventurers, Bottisham, Padney, Isleham, Wilbraham, Willingham, Reach, Block, Swaffham Prior and Newmarket [4] soils.

The soils of the "islands" of raised ground at Littleport and to the north-west, mainly on Boulder Clay, were resurveyed. On high ground at Southery a new brown earth formed in the Sandringham Sands was mapped. (Seale)

Huntingdonshire

***Sheet TL 26* (*Papworth*).** This 1 :25 000 sheet area is typical of south Huntingdonshire, which was briefly surveyed during reconnaissance of 3rd edition Sheet 187 (Huntingdon) last year. It is a low, undulating Boulder Clay plateau, but with lower ground shown as Oxford Clay on geological maps, and parts of the extensive terraces and alluvium of the Ouse. 13 sq miles of higher ground in the south were surveyed. The soils are formed in Boulder Clay and associated deposits, and two mapping units were used.

The plateau surface and upper valley slopes carry Hanslope [4] soils, mapped as a series. On the plateau, surface texture is clay loam, and most soils have an unmottled B horizon beneath the plough layer. Many valleys are asymmetric, with steeper west- and south-facing slopes. Where slopes exceed 3–5°, eroded Hanslope soils have slightly finer textured topsoils, mottling just below the plough layer and chalk stones brought to the surface by ploughing.

The bottoms of the main valleys on the plateau and their re-entrants have soils derived either from Boulder Clay detritus, possibly by solifluction, or from a brown non-calcareous silty deposit of unknown origin, and were mapped as a Valley Bottom Complex. This includes Stretham [4] soils on Head at the foot of steeper slopes, with many profiles resembling the Dullingham [4] series, although often non-calcareous. Further downstream, profiles like those of the Takeley [5] series occur, possibly from more complete sorting, whereas in shallower valleys, deposits, set askew, can resemble Milton [4] soils. In re-entrants there is a brown earth soil on silty deposits. (Hodge)

Norfolk

***Sheet TM 49* (*Beccles*).** A centre was set up at Norwich and mapping started in the Beccles area, on one of five 1 :25 000 sheets selected to represent Norfolk. A reconnaissance was made, some 30 profiles sampled, a taxonomic legend prepared and some 20 sq miles mapped.

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A low plateau projects eastwards into an acute band of the Waveney, where the floodplain is up to a mile wide. It contains two sheets of Chalky Boulder Clay separated by glacial sand and gravel. The upper forms the central portion of the spur, and is in places covered by thin sands, or gravelly sands. The lower, outcropping along the edge of the river marshes, is masked in some places by gravelly terrace material.

Soil on the upper Boulder Clay has a mainly sandy clay loam surface texture and is related to the Ashley [4] series, although poorly drained. On small areas of sand Highlodge or Row [6] soils were mapped, and towards the edge of the plateau there are Hanslope [4] soils. At the fringe of the upper Boulder Clay and on some spurs at a height of between 50 and 100 ft Ashley soils and an associated soil of similar surface texture on Boulder Clay Head occur. They are well drained or moderately well drained, as they lie over sands and gravels.

In the western part of the sheet these spurs form a surface at a height of 25–40 ft O.D., and Glacial Sands and Gravels crop out on the lower parts, giving well drained soils of the Freckenham [4] series of loamy sand texture, often with a gravelly phase on small knolls. Sandy loams occur adjoining Boulder Clay and on the spurs, where the sands and gravels are mixed with Head.

The lower Boulder Clay is close to the river floodplain. Slopes carry shallow Hanslope soils, and on flatter, slightly higher, ground the soils have a surface texture of sandy loam or sandy clay loam, and are imperfectly drained.

The extensive river marshes are mainly of estuarine alluvium. Narrow creek ridges carry imperfectly drained soils of silty clay loam or clay loam texture, with poorly drained silty clays in between. Adventurers and Prickwillow soils on eutrophic fen peat fringe the upland. (Corbett and Tatler)

East Midlands

Leicestershire

Sheet 142 (Melton Mowbray). The remaining 33 sq miles of this Sheet were completed, and a memoir is being prepared. The area contains much

TABLE 1

Major mapping units

Soil group	Parent material	Soil series
Gleyed Calcareous	Lower Lias Clay	Evesham
	Chalky-Jurassic Boulder Clay	Hanslope
Non-calcareous surface-water Gley	Lower Lias Clay	Charlton Bank
	Chalky-Jurassic Boulder Clay	Ragdale
Undifferentiated Gley	Head over Lias Clay	Unnamed
Brown Earth	Keuper Marl	Worcester
Ferritic Brown Earth	Ironstone	Banbury
Gleyed Brown Earth	Head over Keuper Marl	Brockhurst

of the clayey terrain of Leicestershire, Northamptonshire and parts of Warwickshire, associated mainly with Jurassic clays and "Chalky-Jurassic" boulder clay. Eight major mapping units (Table 1) occupy 80% of the sheet area, although the legend includes over 25 units because of the complexity of the remainder. Only 15% is occupied by naturally well drained soils

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including the Banbury [2], Newport [1] and Sherborne [7] series. The remainder suffer from varying degrees of waterlogging, mainly as a result of impermeable subsoils, but locally aggravated by high ground-water and flooding near major watercourses. Drainage in Worcester soils, which are easily modified by land use and cultivations, is discussed elsewhere [8]. In most of the imperfectly and poorly drained fine-textured soils (Evesham [7], Ragdale [9], Hanslope [4] and Charlton Bank [7] series) the water regimes differ with the structural properties, which need accurate assessment to improve drainage. The soil series concept helps here, and account must be taken of the effect of land use on structural properties of A and B horizons.

Although traditionally grassland, the proportion of permanent pasture has diminished during the past 30 years. There are extensive areas of permanent pasture in only limited areas of very heavy soils, such as the Vale of Belvoir. Much of the area carries arable crops, mainly cereals and short leys, with few root crops, which are commoner on better-drained or more easily worked land.

Horticulture is practised along the Soar valley on Newport [1] or Brockhurst [10] soils. Around Ruddington some holdings, also mainly on Brockhurst soils, grow roses. (Thomasson, Robson and Johnson)

Derbyshire

***Sheet SK 17* (*Tideswell*).** The new programme of mapping selected 1:25 000 sheets began in the Carboniferous Limestone areas (900–1100 ft O.D.) represented by this North Derbyshire sheet. The terrain is typical of the main limestone outcrop with a gently undulating plateau, locally deeply dissected by steep-sided valleys. Superficial silty drift of aeolian origin [11] covers most of the area, giving soils of the Nordrach [10] series. The friable silt loam with few stones, ranges from 15 in. to more than 36 in. in depth, because of the irregular surface of the hard, fissured limestone. The profile has a Bt horizon. The Lulsgate [10] series occurs where limestone rock is at less than 15 in. Very thin, humose A/C soils are uncommon over the hard limestone, and usually base-unsaturated.

Peaty gleyed podzols of the Priddy [7] series occur on cherty, silty drift on the eastern margin of the limestone, especially under acid heath vegetation. Management influences the distribution of these soils, and traces of thin iron pan persist in recently reclaimed heathland, whereas older soils resemble the stony phase of the Nordrach series. Soil boundaries often run with field boundaries in such areas. (Robson and Johnson)

Nottinghamshire

***Sheet SK 67* (*Ollerton*).** Soils on outcrops of the Bunter Pebble Beds and Keuper Waterstones were mapped. The former are reddish, coarse-grained sandstone with pebbles thinly distributed. Soils of the Bridgnorth [12] series, with sandstone rock in the upper 3 ft, occur on some steep slopes in the mostly gently undulating country. The remaining extensive acid, coarse-textured, freely drained soils are mapped as Newport [1] series. Parent materials are *in situ* sandstone at depths greater than 3 ft, and sandy drift and Head from Bunter Sandstone. Phases were mapped to show

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stoniness and coarseness of texture of the upper soil horizons, which influence the moisture regime, here particularly interesting because rainfall is small. An imperfectly drained coarse-textured soil, which holds ground-water, occurs in valley bottoms; it consists of a slightly pebbly loamy sand over distinctly and coarsely mottled sand. These soils, tentatively named the Ollerton series, are often associated with peaty and humose sands. Podzol–acid brown soil intergrades occur under coniferous vegetation in Clipstone Forest with, occasionally, humus–iron podzols of the Crannymoor [12] series. Podzol morphology is poorly defined in them, but bleached sand grains in the Ea horizon and the brittle consistence of the B horizons show that some sesquioxides have moved.

Soils on greenish clayey basement beds were mapped on the Keuper Waterstones; unlike those on the Tea Green Marl, they are non-calcareous. Surface textures are loam or fine sandy clay loam, possibly from drift or Head derived from Bunter Sandstone. The distinctly mottled pale brown, greyish brown and strong brown loamy B(g) horizon is succeeded by greenish grey clay containing thin red marl bands. On eroded facets of the landscape, soils are clayey throughout and prominently mottled in the subsoil, but such mottling may be geological and not caused by the present moisture regime. (Robson and Johnson)

West Midlands

Shropshire, Herefordshire and Worcestershire

***Sheet 181* (*Ludlow*).** 53 sq miles were surveyed in the parishes of Kimbolton, Laysters, Bockleton, Wolferlow, Tedstone Wafer, Kyre, Rochford, Eastham, Boraston and Neen Sollars.

Most soils are of the Bromyard [13] series, with smaller areas of the Eardiston [13] and Hayton [13] series on the *Psammosteus* Limestone outcrop. Middleton [13] series also occurs on the flat broader interfluves around Sallings Common and at Wolferlow on more clayey marls over the Limestone. A dissected train of sandy gravel runs along the Kyre brook somewhat above the present stream, probably of Wye glacier provenance. It includes material of Welsh and local Silurian origin with some fragments of basic igneous rocks, and is probably related to the outwash gravels at Grendon Green [14]. Most stones are fine and well rounded, but there are some large boulders. Most of the outcrop is calcareous with abundant cornstone pebbles, and gives soils of the Peaton [9] series, but these are intimately mixed with non-calcareous soils and will be mapped as a complex.

The Peaton series extends eastward along the Teme valley as far as Newnham Bridge and the fine calcareous gravels up the Rea brook. According to Dwerryhouse and Miller [14], drainage of the Teme has reversed, and it is interesting that there are no gravels east of the confluence with the Rea. Reversal may have occurred since the terraces were laid down, and further work is needed to establish whether they are related to a former stream flowing westward along the line of the present valley.

Soils of the Haymore [13] complex are extensive in the parishes of Nash and Coreley, and on the Clee Hill footslope. The Head in which these soils

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are developed becomes progressively finer in texture away from the Clee and limited to the crests of narrow interfluves. Freely drained soils dominate the complex, although some along the footslope are moderately well or imperfectly drained.

Excavations in the Orleton–Woofferton area exposed a sequence of deposits below the recent alluvium. These were deposited in front of the Wye glacier, and consist of a calcareous gravelly outwash and fine well-laminated reddish silt loams and silty clays, similar to those in the Wigmore basin [2]. They have remains of mosses between laminations in places, are almost certainly lacustrine in origin and were probably deposited in a pro-glacial lake over a long period. The relationship between the Teme terraces at Woofferton, known from stones to be of northern origin, and these deposits from the south needs clarifying.

Aerial photographs proved useful in mapping ground at Titterstone Clee disturbed by extensive coal, dolerite and limestone mining. Small limestone outcrops have been worked out, and all the soils on the Carboniferous Limestone are disturbed. Gley soils of the Melville complex dominate the Coal Measures outcrop, resembling in range those near Church Stretton [13]. The Melville complex will probably have to be extended to include very stony soils, over and around the Clee dolerite outcrop, where many large dolerite stones occur in Coal Measures sediments.

Soils formed *in situ* on dolerite occur at the top of Titterstone Clee Hill, along Hoar Edge, in smaller areas elsewhere on Clee Hill and on adjacent areas of dolerite Head and scree. A thin turf mat commonly lies on a thin humose A horizon over a brown bouldery silt loam with a fine crumb structure. Sheep prefer the vegetation associated with these soils, and the closely grazed grasses with interspersed gorse bushes contrast greatly with the coarse mat-grass, purple moor-grass, wavy hair-grass and rushes on Melville complex soils. The vegetation and soil pattern is distinct on aerial photographs. (Hodgson)

South-east England

Buckinghamshire. Some $2\frac{1}{2}$ sq miles were surveyed in detail around Great Horwood for the soil association map, and traverses were made where boundaries needed confirmation. Observations were made along 8 miles of gas pipeline trench between Newton Longville and Wavendon.

A detailed survey was also made of 2 sq miles south of Beaconsfield, on the part of the Thames terrace sequence described by Hare [15] including the Winter Hill and Harefield Terraces around and north of Burnham Beeches. Most of the deposits are very stony coarse loamy material up to 15 ft thick over Reading Beds. Even on steep slopes, solid formations are rarely reached by auger because the surfaces are covered with fine- to medium-textured Head. The frequency of silty topsoils also suggests that loess may have been added.

There is no consistent soil pattern; in Burnham Beeches, on the Winter Hill Terrace, humus–iron podzols predominate in association with less podzolized soils; on the lower Harefield Terrace (probably the Rassler Terrace of Sealy [16]) acid brown soils are associated with rather more

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podzolized analogues, and the upper Harefield Terrace carries gleyed *sols lessivés* and surface-water gley soils.

Gleyed *sols lessivés* and surface-water gley soils, usually with textural B horizons, are developed on valley slopes and bluffs in a mixture of stony, sandy or silty materials and clayey deposits derived from Reading Beds.

Peaty and humose surface-water gley soils occur round springs, near the junction of terrace deposits and Reading Beds clay and in the bottoms of some valleys.

Where terrace deposits are deeply dissected, Chalk lies under the valley floor giving dry valleys, many occupied by well drained, brown earths developed in stony loams, and often more silty in lower horizons. (Mackney and Sanesi)

Sheet SU 88 (Marlow). The district includes lower slopes of the Chiltern plateau, through which the Thames (and its antecedents) has carved a deep west–east channel in Chalk, leaving a steep cliff to the south and a broad flight of terraces, dissected by deep, dry valleys to the north. Only the Taplow and the Floodplain Terraces are extensive, because the older terraces are fragmented and their limits blurred by gravitational wastage. The Taplow Terrace is modified by gravels from the dry valleys, piled up in fan-shaped zones giving it an undulating surface.

Chalk underlies the whole region. The gentle slopes of ridges are extensively mantled by Plateau Drift, and on steeper slopes Chalk or Chalk Head is near the surface. Outliers of clayey Eocene strata appear in places, capped by pebbly fluvial deposits. Most terraces older than Taplow are of pebbly loamy sands and sandy loams, but some are of sandy clay loams and sandy clays; the pebbles include far-travelled stones and rounded and subangular flints. On and below the Taplow Terrace, rounded and irregular flints predominate and silt loam or loam topsoils are common. Chalky gravels occur on the Floodplain Terrace, often at 2–5 ft. The Thames floodplain contains clay loams, silty clay loams and clays; calcareous materials often occupy narrow belts next to the river.

Patches of silty, slightly stony material are thought to be loess; they occur on both major Terraces, in dry valleys and on adjoining ridges, banked up against south-facing bluffs.

All surfaces older than the Floodplain Terrace have been disturbed and reorganised by cryoturbation to some extent.

21 sq miles were mapped; most of the soils had been recognised in earlier surveys of Chalkland. (Mackney and Hunting Technical Services Staff)

Essex

Sheet TQ 59 (Brentwood). Detailed surveying began on this map, the first of the four chosen to represent Essex.

Solid formations present are the London Clay, loams of the Claygate Beds and sands of the Bagshot Beds, but round Navestock and the north-east, south of Doddinghurst there is Chalky Boulder Clay with associated gravels. Pebble gravel caps the higher ground of the Bagshot outliers. The River Roding flows across the north-west corner of the sheet, with a

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broad valley floored by clayey and gravelly alluvium, and with terrace gravel remnants of reputed Taplow age.

Reconnaissance was made of 31 sq miles; the remaining 20% of the area is building land and will not be mapped. The provisional legend has 20 series described earlier in Hampshire, Hertfordshire and Essex. About 3 sq miles around Doddinghurst and Kelveden Hatch were mapped in detail, and observations from 210 sites recorded on pro-forma cards. (Sturdy)

Kent

Sheet TR 04 (Ashford). This is one of six chosen to represent Kent. A segment of the North Downs occupies the northern part, and the prominent escarpment facing south to south-west rises to between 500 and 600 ft O.D. The drift mantled, and deeply trenched, plateau rises to 612 ft near Hastingleigh. Here it is about 300 ft above the highest land south of the Chalk, where older formations—Gault, Lower Greensand and Weald Clay—give belts of undulating country running north-west to south-east. North of Wye the Chalk is cut by the Great Stour into a trumpet-shaped valley, narrowing towards Godmersham. This river rises 4 miles to the west near Lenham and is joined by two major tributaries on the low Weald Clay plain south of Ashford, one fed by springs at the Lower Chalk–Gault junction between Brabourne and Brook and by streams rising within the Gault vale. These streams converge within the outcrop of the Lower Greensand, where valleys are well marked, with the main one cutting another south-west facing escarpment overlooking the Weald.

The segment of North Downs plateau east of the Stour gap is trenched by the heads of many dry valleys cutting down to the Lower Chalk. They are floored by flinty and chalky drifts, with Middle Chalk cropping out on the side slopes. The Upper Chalk is obscured by plateau drift, mainly clay-with-flints, but there are patches of silt loam (Head Brickearth) and sands, with subordinate bands of ferruginous sandstone. Parts of the escarpment are much indented, especially near Brook, where several steep-sided coombes cut into the Lower Chalk. The village is on a chalky outwash deposit. The Gault is partly buried by drift, especially bordering the Great Stour, and chalky to gravelly layers or flints within 4 ft of the surface show that the formation has been widely reworked.

The Lower Greensand consists, in ascending order, of Atherfield Clay, Hythe Beds, Sandgate Beds and Folkestone Beds. The first is thin and relatively unimportant, but the grey, mottled clay is exposed towards the base of the largely drift-covered escarpment overlooking the Weald Clay. This feature is poorly developed near Ashford, but rises to 212 ft O.D. in the south-east near Sevington, nearly 100 ft above the clay plain and alluvium. The Hythe Beds, of alternate Rag (sandy limestone) and Hassock (calcareous sand), crop out locally on upper slopes and along valley sides farther north, but shallow, loamy drift with flints or limestone fragments is common on the gently inclined backslope. Sandgate Beds have a very narrow outcrop except where built over at Ashford, but the characteristic yellowish red and grey mottled sandy clay formed by weathering is free from drift in several places, e.g. near Willesborough and Smeeth. The

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Folkestone Beds outcrop is more than a mile wide, but the ferruginous to pale sands seldom come to the surface except in scattered hillocks and ridges. Most drift is sandy and occasionally stony, with texture ranging from loamy sand to sandy clay. Some hill summits at 200 ft O.D. here and elsewhere south of the Chalk are capped by gravels laid down early in the Pleistocene when rivers were graded to a sea-level below 200 ft. The stones differ in shape and constitution; angular or rounded flints are most common, but pebbles and fragments from miscellaneous Wealden rocks also occur, and one bed contains chalk pebbles. The texture of the matrix ranges from sand to clay.

In an extensive drift-covered area around Kennington between Ashford and Wye the clay alluvium of the Great Stour is bordered by variably stony silt loam (Head Brickearth) with river gravels in between. Brickearth also occurs on shallow valley footslopes downstream, on the Lower and Middle Chalk. Stoniness increases upslope west of the Stour changing to clay-with-flints drift. (Head)

A general reconnaissance was made, and 24 sq miles mapped in detail during the year, south of the North Downs. The soils can be mostly assigned to series recognised between 1930 and 1935 in other parts of the county, when nearly 100 soils were named, but only briefly described. Many resemble those mapped under other names elsewhere, and need to be correlated. (Green and Fordham)

Berkshire

Sheet 253 (*Abingdon*). 24 sq miles were mapped along the western margin of the sheet, plus some areas of the Berkshire Downs.

The landscape of the Vale of the White Horse between Faringdon and Uffington is traversed by a ridge of Lower Greensand. The lithology is variable with sandy clays and very coarse sands and sandstones, often iron-cemented, and near Faringdon there is an unusual calcareous sponge gravel. Except for a brown calcareous soil developed on this, mapping units reflect drainage and texture. Freely draining sandy brown earths are on higher ground, and imperfectly and poorly drained leached brown soils and gleys lower down.

A thin band of Kimmeridge Clay underlying the Lower Greensand seldom comes to the surface. Where it does, on moderate slopes, colluvium from the Lower Greensand above forms the upper part of the profile. The complex pattern of resulting soils reflects the thickness of the colluvium and the influence of ground-water held over the clay below. On gentle slopes thin bright-coloured, heavy textured soils of the Shippon [2] series occur.

Soils on the Corallian beds were described previously [2]; these rocks are thin between Faringdon and Shrivenham and the outcrop small. The Oxford Clay below them, underlying the whole of the north-west part of the sheet, is a grey calcareous clay, often shaley, seldom evident in soil profiles. Two areas of Oxford Clay can be distinguished lying to the north and south of the Faringdon–Lechlade road. The southern area has mainly non-calcareous surface water gley soils of the Denchworth [17] series, differing from those developed on Gault Clay by having a calcareous C

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horizon. The northern area has olive or brown calcareous surface-water gley soils of the Evesham [7] series, with subdued mottling. Other features include a series of flat-topped interfluves and shallow valleys in the northern area. The interfluves have accordant surfaces at 25 ft above river level, the height of the Summertow–Radley terrace of the Thames. They carry thin and discontinuous loamy soils, with brown chert, quartz and quartzite stones, like those at a higher level in Buscot Park, described by Sandford [18]. They are often easier to work and better drained than the surrounding soils on the Oxford Clay. The landscape of the southern area is much more undulating, with drift in valley bottoms of Corallian and Lower Greensand origin, giving gley soils similar to the Rowsham [17] series. Small areas of high-level drift, like that at Buscot Park, occur in Eaton Wood and on Taylor's Hill.

Soils on Oxford Clay extend as far north as the Thames at Eaton Hastings. North of Faringdon, however, the drift material in the valleys running northward from the Corallian scarp merges gradually with river-terrace gravel below colluvial fine-textured material in upper horizons of soil profiles. Round Thrupp there is a large area of this clay-over-gravel soil, which was mapped farther east and elsewhere in the Thames valley.

Across the river, with its narrow zone of clayey ground-water gley soils of the Thames [19] series, is an area of brown calcareous soils on limestone river-terrace gravels. These differ from the Sutton [20] series in being more loamy and calcareous to the surface. There are also topographically similar areas where drainage is impeded, probably because the gravel over the Oxford Clay is shallow. (M. G. Jarvis)

South-west England

Gloucestershire

Sheet 251 (Malmesbury). 100 sq miles were surveyed or resurveyed in previous reconnaissance areas, leaving only a strip of scarpland south of Wotton-under-Edge and the lower Carboniferous outcrop around Cromhall to complete the combined Bath and Malmesbury sheets.

On the Cotswold dipslope resurvey of soils on the Forest Marble outcrop was finished in the Tetbury–Shipton Moyne district. Sections in a pipeline trench confirmed the variability of soil over this formation and showed some superficial layers of limestone rubble or stoneless silty material over clay on gentle slopes and in depressions. After separating Sherborne [7] soils on the most prominent of the Forest Marble limestones and of loamy soils on Hinton Sands, there remains a large area of imperfectly drained soils developed *in situ* on the grey calcareous clay but containing many small inclusions of other soils; these are all included in the Chickerell complex.

North of Tetbury lies the largest of several tracts of soil on the fine sandy facies of the Hinton Sand. These fine sandy loams may overlie limestone or finer-textured substrata or may continue downwards into sand, and are included in the Tetbury complex of well-drained soils. Another complex, Neston, includes fine sandy loams of imperfect drainage over thick clay at various depths.

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In deeply incised valleys around Nailsworth, and on the dissected scarp between Uley and Wotton-under-Edge, mapping units were related to those used in the valleys around Bath. Where valleys cut into the Great Oolite, upper slopes, and in places whole valley sides, are of slumped Fuller's Earth, mapped as Landslip complex, mainly with Trip [21] series, but containing flush gleys. The Inferior Oolite forms small spurs on valley sides with Sherborne soils, often carrying farms and villages. More often it forms steep slopes, where Sherborne soils give way to very shallow rendzinas. A similar situation exists around Dursley, where headwaters of the Cam and Little Avon have dissected the scarp into long narrow spurs capped by Inferior Oolite and fringed by steep wooded slopes. Sherborne soils are still predominant, although the limestone rubble is rarely *in situ* and usually overlies Cotteswold Sand 2–5 ft below. As slope is a major factor, a steepland unit was mapped, mainly of this limestone brash soil, but including small areas, both of Atrim [21] series on the sharpest spurs, where there is little stone in the sands, and of Badsey [21] soils on fine oolite gravel.

Cotteswold Sand outcrops mainly on moderately steep, often terraced, slopes passing uphill into the steepland unit; some of the steepest banks are covered with bracken where mowing and hard grazing are impossible. The Marlstone Rock Band forms a discontinuous shelf below the sands and usually gives dark brown, rubbly clay loams of the Pennard [21] series. These pass locally into deeper loamy soils on ferruginous sandstone or into calcareous clays like the Haselor or Evesham [7] series on the Upper Lias component of the Junction Bed. Below this bench Dyrham Silts, the local representative of the Middle Lias, comprise interbedded mottled silty clays and siltstones giving soils of the Martock [21] series. These may vary more in subsoil texture than elsewhere.

Poorly drained soils of the Long Load [7] series are extensive below the scarp around Cam, but less so southwards; coarser-textured soils in flush sites on the sides of coombes in the scarp have also been grouped with them. The Rhaetic and Lower Lias Clay plain between Stinchcombe and Chipping Sodbury is dominated by poorly drained Charlton Bank [7] soils; those on Rhaetic have coarser-textured surface horizons, as in the Wedmore district south of the Mendips [7]. Imperfectly drained Evesham soils and their rocky phase (Haselor series) cover a much smaller area, usually on higher or gently sloping sites. A few patches of Cotswold-derived drift also occur.

The Rhaetic scarp is insignificant at Berkeley Road, but is more prominent south of Upper Wick and much indented in places like the uneven slopes mapped as Hurcot [7] complex in Somerset, although the Tea Green Marls from which these soils come are here very thin. Low spurs of Keuper Marl from the scarp have slopes of Worcester [7] series, and crests are often capped with limestone gravel, giving soils of the Badsey series, and around Coldwick there are clay loams about 2 ft thick over gravel, equated with Podimore [21] series. Soils over marl are dull grey brown mottled clay loams to about 18 in. and were mapped as the poorly drained Spetchley [7] series; finer-textured soils on thin Head were also included where marl is within 2 ft. West of Wickwar and around Itchington soils

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over Marl are more loamy, partly because of lateral changes in the parent rock, but mainly because of drift, presumably from Cromhall Sandstone.

Recent clay alluvium in minor valleys and depressions extending from the Rhaetic scarp is of very mixed origin, and was mostly mapped as Fladbury [7] series; the Lias Clay element predominates. (Findlay and Tomlinson)

Devonshire

***Sheet 339* (*Teignmouth*).** The remaining 60 sq miles were surveyed, and representative profiles described and sampled. The area is mainly to the west of the Teign and includes the Bovey Basin and adjoining country around Chudleigh, Bovey Tracey, Ilsington and Bickington. A reconnaissance survey was described earlier [22, 23].

The complicated soil pattern of the Bovey Basin reflects both facies variation in the Tertiary deposits and the distribution and thickness of widespread drift. At the centre are surface-water gley soils of the Teigngrace series with characteristic subsoil horizons of mottled, light grey clay from kaolinitic Ball Clays. On Bovey and Knighton Heaths a variant has a thick peaty surface horizon, and on the higher ground of Bovey Heath a gleyed podzol occurs on coarse-textured head over clay. Thick head deposits overlie clays on low terrace features projecting from the flanks of the Basin; the associated loamy, gleyed brown earths have well-developed fragipans and are mapped as Stover series. Sands and gravels of the basal Bovey Beds crop out at the edges of the Basin at Milber, Staplehill and north of Kingsteignton, giving sandy, humus–iron podzols of the Milber series and loamy brown earths of the Gappah series.

To the south the Basin is flanked by Devonian slates, with many small dolerite intrusions outcropping on ridge crests. Shallow, well-drained brown earths of the Highweek series predominate with small areas of a surface-water gley soil, the Pulsford series, in depressions. The Trusham [24] series is distinguished on the larger outcrops of dolerite and the Highweek–Trusham complex in areas of small intrusions.

The Devonian limestone between Bickington and Ashburton have significant contents of manganese carbonate in black, "umber" deposits that were formerly worked. The soil on the limestone often has a black, silty layer above the rock or the clayey subsoil horizon has many black inclusions. Similar soils occur on the limestone plateau north-east of Kingsteignton and have sandy material from outliers of the Bovey Beds.

The Devonian and Lower Culm Measure rocks of the high ground to the west of the Basin around Ilsington include slates, cherts and mudstones. Brown earths on the slates include Highweek soils and others with strongly ochreous B horizons more typical of soils in the area. The Lower Culm cherts form bold hills and ridges, and two series of soils are mapped. The Ramshorn series are stony, ochreous brown earths with some rankers, and the Rora series includes the humus–iron podzols of Rora Down and Penn Hill with very thick, stony bleached horizons. A distinctive group of black mudstones and slate outcrops on the western edge of the sheet; the soils have dark A horizons and ochreous sub-surface horizons and are distinguished from the Bridford [23] complex. Near Bovey Tracey the

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unusual podzols in Yarner Wood described earlier [25] extend to the south-east across Lower Down.

Around Bovey Tracey and Chudleigh soils developed on Culm shales and granite were mapped with units described earlier. A new soil was found near Lustleigh, where small patches of moderately well-drained loam have *in situ* granite 24 in. below in which all the feldspar phenocrysts have a cheesy consistency. (Clayden and Harrod)

Wales

Pembrokeshire. On sheets SM 90 (Pembroke) and SM 91 (Haverfordwest) 219 soil profiles were described and related numerically to landscape units and geological formations, using punched feature cards (Table 2).

TABLE 2

Areas of landscape units over geological formations (sq km)

	Geological Formation				
Landscape Unit	Carboniferous	Devonian	Lower Palaeozoic	Igneous	Total
1. Valley flat	2	—	3	—	5
2. Valley complex	—	2	2	—	4
3. Smooth slopes	28	58	42	11	139
4. Rough slopes	7	1	5	—	13
5. Drier complex	5	1	2	—	8
6. Wetter complex	5	—	4	—	9
7. Built-up	—	4	—	—	4
Total	47	66	58	11	182

TABLE 3

Proportions of soil groups related to selected landscape units and rock types

		% of observations					
Geology and landscape unit	Number of observations	Gley soil*	Partially gleyed soil	Ungleyed soil	Ranker or brown rendzina+	Brown earth	Ungleyed surface horizon
Carboniferous rocks	56	30	18	52	30	25	73
Shales	32	37	16	47	28	28	62
Sandstone	25	38	14	48	24	32	72
Limestone	13	8	8	84	54+	15	100
Landscape unit 3	32	14	21	65	38	41	94
Shales	20	20	15	65	40	40	90
Sandstone	15	13	13	74	40	47	100
Limestone	(6)	(0)	(17)	(83)	(50)+	(33)	(100)
Landscape unit 4	(7)	(100)	(0)	(0)	(0)	(0)	(0)
Devonian rocks	77	4	8	88	64	21	90
Landscape unit 3	65	0	9	91	72	20	100
Red marl	42	0	12	88	76	17	100
Sandstone	17	0	6	94	53	41	100
Lower Palaeozoic rocks	80	22	15	63	40	29	83
Landscape unit 3	52	8	7	85	50	37	96
Landscape unit 4	(6)	(83)	(17)	(0)	(0)	(0)	(33)
Igneous rocks	11	0	18	82	0	100	100
Extrusive	(4)	(0)	(50)	(50)	(0)	(100)	(100)
Intrusive	(7)	(0)	(0)	(100)	(0)	(100)	(100)

* A soil with a gley horizon within 50 cm of the surface.

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Landscape units are derived from aerial photographs independently of the profile. Unit 3 covers three-quarters of the area and nine-tenths of the Devonian rocks. Carboniferous rocks carry the most varied landscapes.

The occurrence of soil parameters such as "ungleyed surface horizon" was studied in relation to rock type and landscape (Table 3). 73% of soils on Carboniferous rocks have ungleyed surface horizons, compared with 94% in Unit 3 over the same rocks, confirming that gleying is as much influenced by site as by parent rock. Ungleyed topsoils are especially associated with Unit 3 over Devonian rocks, and occur in all 65 profiles.

The proportions of soil groups were also estimated within each landscape and geological unit. Gley soils are insignificant over Devonian rocks, confirming visual estimates previously reported [2]. Of ungleyed soils, rankers are more extensive than brown earths, especially where underlain by the Red Marls. Brown earths are commoner on Carboniferous sandstones, and dominate the soils on igneous formations.

TABLE 4

Depths of freely draining soil over geological formations

Geological formations	Number of observations	>40 cm%	>80 cm%
Carboniferous	56	50	12
Shales	32	37	0
Sandstone	25	40	4
Limestone	13	76	46
Devonian	77	58	19
Red Marls	48	60	17
Sandstone	23	70	30
Conglomerate	(7)	(14)	(0)
Lower Palaeozoic	80	45	10

Depth of freely draining soil is an important parameter affecting the growth of many crops. The Devonian Formation carries the deepest freely draining soils and Lower Palaeozoic rocks the shallowest (Table 4). Over the Carboniferous Limestone, soils are deeper than over shales and sandstones. (Rudeforth)

Laboratory investigations

Analyses were made on 1200 samples of soil, 40% for the Directorate of Overseas Surveys and other departments. Thin sections were prepared from 230 samples for micromorphological studies.

To improve identification of soil horizons in which amorphous sesquioxides have accumulated, iron and aluminium extractable by pyrophosphate and acid ammonium oxalate [26] were determined in samples from 39 types of profile. More iron + aluminium was extracted by both reagents from the B horizons of "ochreous brown soils" (*sols ocres podzoliques*) than from less well defined B horizons of brown earths (*sols bruns acides*) on similar material. A rapid test for allophanic material proposed by Fieldes and Perrott [27] was applied to these and other soils. With few exceptions, the "ochreous" B horizons and the B horizons of humus–iron podzols gave a positive reaction, whereas other sub-surface horizons did not.

The development of Wiegner's method of obtaining particle-size accumulation curves, with automatic recording, has produced a new apparatus for recording particle-size distribution. A paper has been prepared. (Bascomb)

Work on the mineralogy of Anglesey drift-derived soils was concluded, and a paper written for the *Journal of Soil Science*. (Pettersson)

Rapid and reliable methods are needed to characterize soil classes by the nature of their clay-size fractions. X-ray and chemical methods for quantitative mineralogical analysis were applied to 40 samples from 17 profiles.

Major differences in mineralogy and chemical constitution were found, but mineralogical analysis sufficiently accurate for soil classification cannot be obtained by a routine procedure. However, it may be possible to improve classification by a few chemical measurements supplemented by some X-ray diffraction data. Such measurements are of cation exchange capacity, specific surface area, non-exchangeable K_2O content and the proportions of dithionite-extractable iron and aluminium. This approach is being further examined, using replicated samples from clayey soil series from Leicestershire. (Pettersson, Pritchard, Avery, with Brown, Pedology Department)

Special Surveys

In connection with the National Wheat Survey, information was obtained on the physical environment in which the 1964 wheat crop was grown. Of 182 sites examined: 1, wheat was grown in only 4 fields with slopes of $>7°$; 2, only 15 fields lay at elevations >400 ft; 3, parent materials of 103 fields were classed as fine loamy or clayey, and 4, 112 fields were classed as imperfectly and poorly drained.

Yield was influenced by drainage class (Table 5), being largest for ground-water gley soils and warp soils (Table 6). Yields were smallest on

TABLE 5

Grain yields and drainage class

Drainage class	Number of fields	Mean grain yield (cwt/acre)
Excessive	17	31·4
Free	26	36·4
Moderate	28	38·5
Imperfect	84	36·2
Poor	28	30·7

TABLE 6

Mean yields and soil classes

Soil class	Number of fields	Mean yield (cwt/acre)
Brown calcareous	7	35·6
Gleyed calcareous	21	33·8
Peaty, humose calcareous and non-calcareous gleys	31	36·7
Gleyed non-calcareous	57	34·5
Peat	3	33·3
Warp	10	39·9
Rendzinas and brown calcareous	11	32·9
Brown earths (excluding sandy brown earths)	29	36·8
Sandy brown earths	6	28·7

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shallow calcareous soils, and sandy soils, probably from water shortage in this dry summer. Mean yields were larger with silty (zl, zcl), calcareous clayey (zc, sc, c) and fine loamy (zcl, cl) textures than with sandy (s, ls), coarse loamy (sl, l) and non-calcareous clayey textures. In fields homogeneous enough to be so classified, coarse loamy, fine loamy and silty textures predominated in the plough layer; mean grain yields were larger with fine loamy surface textures (36·1) than with coarse loamy and silty textures (34·7). (Mackney)

100 sq miles of East Oxfordshire and Hampshire were surveyed for the Agricultural Land Service of the Ministry of Agriculture, Fisheries and Food. (M. G. Jarvis)

Other work

Assistance was given to the Agricultural Land Service of the Ministry of Agriculture, Fisheries and Food in Shropshire, Warwickshire, Worcestershire, Herefordshire, Gloucestershire, Northamptonshire, Leicestershire and Lincolnshire.

Information and advice was given to the National Agricultural Advisory Service, Worcestershire County Council Planning Department, University of Newcastle-upon-Tyne, Birmingham University Extra-mural Department, the Morecambe Bay Barrage Project, Mersey and Weaver River Authority, Liverpool Museum, Broom's Barn Experimental Station and Ashford New City Study Area.

Many lectures and demonstrations were given, and several field excursions were arranged and conducted. In a five-day tour, organised for a party of 18 students and staff of the Pedology Institute, University of Utrecht, soils and associated landscapes and land use in the East Anglian, South-eastern, West Midland and Northern regions were studied.

A Memoir "Soils of the South-west Lancashire Coastal Plain" and Bulletin No. 3 "Soils of the West Sussex Coastal Plain" were published, both with accompanying maps.

In the Cartographic Section work continued on five 3rd Edition Sheets at a scale of 1 : 63 360, and on four maps at other scales.

Staff and visiting workers

Dr. G. Sanesi of the University of Florence spent five months working with surveyors and studying soil-survey techniques.

Mr. K. Z. Hamdoukh, of the Ministry of Agriculture in Jordan spent three months at headquarters studying the scientific work of the Survey.

Members of the Staff of Hunting Technical Services Ltd. (Messrs. R. D. Law, D. A. Holmes, K. J. Virgo, J. H. de Vos, S. Western and L. P. White) took part in the mapping of south Buckinghamshire. The Survey is very grateful for this assistance.

C. B. Crampton, A. H. Maclean and P. R. Tomlinson accepted appointments with the Canadian Department of Forestry, the Kafue Irrigation Research Station, Zambia, and the New Zealand Soil Bureau, respectively.

M. J. Pettersson resigned to enter private industry.

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D. W. Cope, R. R. Furness, W. A. D. Whitfield, S. J. Fordham and W. Tatler were appointed.

A. J. Thomasson was awarded an M.Sc. degree by the University of Nottingham.

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