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Report for 1969 - Part 1

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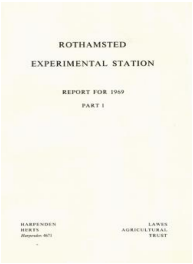
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Soil Survey of England and Wales

K. E. Clare

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SOIL SURVEY OF ENGLAND AND WALES

K. E. CLARE

The aims of the Soil Survey of England and Wales and of Scotland are to describe, classify and map the different types of soils in Great Britain. Classification is mainly on the basis of properties of the soil profile as observed in the field, but also on observations 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 1 m) 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 are at Rothamsted Experimental Station, Harpenden, Herts, and surveyors are stationed at 15 centres.

The new mapping programme described in 1967, in which selected areas of 38 sq miles in each county of England and Wales will be surveyed and maps published at a scale of 1 : 25 000, is continuing. The areas, which correspond to the Ordnance Survey 10 km × 10 km Outline Edition 1 : 25 000 map series, are chosen for their geomorphological and agricultural interest, and as a basis for later county, regional and national maps.

Northern England

Yorkshire

Sheet SE 60 (Armthorpe). The map was completed by survey of the remaining 42 km² in Auckley, Blaxton and Hatfield parishes. The terrain includes the eastern extremities of glacio-lacustrine deltaic sands and gravels, whose distribution in the sheet area resembles a capital E, and which rise above 6 m O.D. Free draining, sandy soils of the Newport (1) series are characteristic and include a phase with rounded Bunter quartzite stones and an unmapped wind eroded phase on knolls from which much top soil has been blown on to lower land nearby, exposing the red subsoil.

Soils on land below 6 m O.D. are on postglacial sands and estuarine clays, till and peat. The sands give the moderately gleyed Stockbridge (2) series and the strongly gleyed Blackwood (3) and Gilberdyke series, the latter with a black humose topsoil. Some depressions in the sand land contain a gley podzol, with podzolized upper horizons above a 7 cm compact, brittle dark reddish brown humus-iron pan over gleyed sand.

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The Foggathorpe (2) series occurs on the clays and includes a phase with prominent reddish brown mottling below 25 cm. Small areas of the Portington (3) series occur at the sand/clay transition, where a sandy deposit overlies clay. A peaty topped soil, with silty clay below 30 cm, occupies small areas.

The till forms slight hills at Lindholme and is a sandy clay with Bunter and Carboniferous stones. It supports a surface-water gley soil with loamy surface textures, and a thin strongly gleyed subsurface horizon, over a yellowish prismatic-structured clay with thick sand washes on ped faces.

Two types of peat occur, the raised peat of Hatfield Moss, occupied by bracken, heather and birch, and waterlogged carr peat in scattered depressions elsewhere.

The wet spring made it impossible in places to prepare ground for sowing in soils of the Foggathorpe series, and tractors and machinery were bogged in peaty topped soils. (R. A. Jarvis)

Sheet SE 76 (Westow). The remaining 52 km² were surveyed, mainly east of the Derwent, and 13 km² of early work revised.

Much landslipping occurs on steep valley sides of the glacial spillway of Kirkham Abbey gorge between Howsham and Menethorpe, giving a complex of soils, including the poorly drained non-calcareous clayey Denchworth (4) series, micaceous gleyed brown earths of the Martock (5) series and freely drained sandy acid brown earths. This complex also occurs on strongly accidented relief of the Jurassic outcrop in Leavening and Acklam.

The alluvium of the Derwent and its tributaries is very variable and includes patches of very poorly drained silty clay loams with *Juncus* spp. and bushgrass (*Calamagrostis epigejos*). Near Welham and Crambe patches of well drained and imperfectly drained flinty calcareous loamy sands and sandy loams over chalky gravel, with charcoal fragments, carry soils of the Harswell series. Peaty gley soils and soils derived from algal marl with peaty layers also occur, especially in a large depression south of Langton Beck, where the calcareous layers have a honeycomb-like structure cemented with iron and containing many gasteropod shells. There are also small patches of Foggathorpe (2) soils developed in lacustrine clay. Reddish brown clays of the Worcester (5) series are the most extensive soils on the gently undulating outcrop of Triassic rocks near Leppington and Scrayingham. The surface soil usually contains a few angular flints, remnants of former drift. Small patches of the calcareous greenish grey clayey soils of the Hurcot (5) series also occur near Scrayingham, but are more extensive west of the Derwent. There are poorly drained Spetchley (5) soils in the valleys of the Whitecarr and Leppington Becks and in nearby depressions.

The more gently undulating area of Jurassic rocks in Firby, Burythorpe and Langton have mainly well drained soils. Acid brown earths of the Fyfield (6) series predominate on sandstones, with a few small patches of slightly podzolized soils under conifers near Firby. Brown calcareous soils of the Marcham (6) series occur on Coralline Oolite near Langton.

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The chalk of the Wolds in the south-east has mainly rendzinas of the Icknield (4) series. (Matthews)

Cheshire

Sheet SJ 65 (Crewe West). Detailed mapping of 86 km² completed the sheet which is now being prepared for publication with an explanatory text.

Fine textured soils of the Cottam and Crewe series are widespread in the north. The Crewe series, a surface-water gley soil, occurs on level or enclosed sites on a stoneless lacustrine clay, probably associated with post-glacial 'Lake Lapworth', which covered much of Lancashire and Cheshire at the end of the Pleistocene. The Cottam (7) series, which is developed from till rather than lacustrine clay, is on the surrounding gentle slopes and slightly undulating land.

Around Nantwich the Middle Sands, with associated sandy washes over adjacent areas of till, give an extremely complex soil pattern. The Crannymoor, Newport and deep and shallow phases of the Astley Hall and Rufford series (7) were mapped. There are also fine sands and silts, probably of a new series, especially around Willaston and Stapeley on lower slopes of the Middle Sands ridges. These are outwash deposits and in places show a transition through to clays of the Crewe series.

Alluvial and terrace deposits, resembling those of the Douglas (7) complex, occur along the Weaver valley and its tributaries.

Wybunbury Moss in the south-east is a small *schwingmoor* in an enclosed hollow. The margins are of fen-carr peat, with Sphagnum moss in the centre. (Furness)

Northumberland

Sheet 19 (Hexham). Further profiles were described to illustrate themes developed in the Memoir. Soils on drift from Carboniferous sources were compared with similar soils in Scotland, where the parent material contains material from Ordovician and Silurian deposits in addition to some igneous rocks. In England, the climate is different, the drift older and the soil profiles more developed. (Ashley)

East Anglia

Cambridgeshire and the Isle of Ely

Sheet 173 (Ely). Areas totalling 25 km² were re-surveyed in detail near Welney, Mildenhall and Earith and at Ely and Brandon Creek. There are four new soil series among the 43 identified. These are the Chatteris, Ely, Manea and Ireton series, all peaty and humic gley soils, respectively on fine silty creek ridges in estuarine alluvium, on calcareous clay till with chalk, on non-calcareous Jurassic clays and on coarse loamy to coarse silty terrace drift. (Seale)

Sheet TL 38 (Chatteris). A partial reconnaissance was made of this map, which is mainly fenland with large areas of soils of the Adventurer's series on shallow peat over fen clay, and Downholland series where the

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peat has been eroded from the clay. Areas of both soils are broken up by a network of small roddons carrying Chatteris soils. Some exploratory bores were made to depths of up to 5 m. (Seale)

Huntingdonshire

Sheet TL 26 (Papworth Everard). 10 km² were mapped both on the Boulder Clay plateau previously described and in the Jurassic clay lowland round Hilton. Wicken (8) soils were separated on the steeper slopes, but most of the area is flat with thin surface drift 50 cm or more thick over Oxford Clay. Soils of the Aldreth and the St. Lawrence series (8) with a reworked phase of the Wicken were here grouped into a compound mapping unit. (Hodge)

Norfolk

Sheet TM 49 (Beccles). The soil map, land capability map and soil drainage map are being published, with an accompanying text.

Sheet TG 13 (Barningham) and TG 14 (Sheringham). The combined sheets were surveyed.

The two major landscapes are the Cromer Ridge, largely coarse textured Pleistocene sands and gravels, and the Southern Boulder Clay Lowlands where deeply weathered boulder clay of sandy loam to sandy clay texture is locally capped by shallow outliers of Cromer Ridge gravels. Flat surfaces of these materials are covered by about 50 cm of fine sandy loam or silt loam, thought to be wind deposited. The soil pattern is determined by the variation in depth and texture of this material with slope and aspect. On flat raised surfaces a silt loam type of the Hall series occurs and similar soils on the boulder clay are provisionally classed as Wickmere series. Freely drained Freckenham (8) or Hall series are on steeper slopes, usually with southern or westerly aspects, where there is no fine sandy or silty cover.

In both landscapes, dry valleys and associated valley side re-entrants and plateau concavities have the silt loam type of the Hall series, with a few profiles of the Hook (9) series. Lower in the boulder clay landscape such sites are affected by the regional water table and have imperfectly drained soils of similar texture. These are often in a catenary sequence with poorly drained Parkgate (9) series and very poorly drained Hanworth soils, both on deep silty parent materials. On terraces the fine textured material covers coarse alluvial gravels on boulder clay. The catena is completed by the Adventurers (8) series on peat next to the stream. The sequence of fine textured soil in many ways resembles that of the Hamble, Hook and Parkgate series in Sussex (9), but they are slightly coarser in texture and there is less clay enrichment of lower horizons. (Corbett and Tatler)

East Midlands

Derbyshire

Sheet SK 17 (Tideswell). Mapping was completed. A land capability classification map and accompanying text are being prepared jointly with the N.A.A.S. (Johnson)

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Nottinghamshire

Sheet SK 66 (Ollerton). Mapping was completed and a publication is being prepared. (Robson and George)

Sheet SK 85 (Newark-on-Trent East). Reconnaissance mapping to establish the soil series and mapping units is in progress.

The solid geology is of Keuper Marl, and Lower Lias clays and limestones. The Lias clays give soils of the Evesham and Charlton Bank series (5).

Fluvio-glacial gravels, representing the Beeston terrace of the Trent (10), are extensive and support soils of variable drainage. Freely drained soils of the Newport (1) series and a gley podzol were distinguished. Alluvium in the upper Witham valley gives both non-calcareous and calcareous poorly drained soils. (Johnson)

Lincolnshire

Sheet TF 16 (Woodhall Spa). Reconnaissance survey started on this, the first 1 : 25 000 sheet in Lincolnshire. Parent materials include Kimmeridge Clay, Chalky Boulder Clay, Plateau and Old River Gravels, and mixed riverine and marine alluvium. Soils of the Denchworth (4) and Ragdale (11) series occur on Kimmeridge and Chalky Boulder Clay respectively, although incorporation of coarse textured Head from plateau deposits was often noted.

The Trent flowed through the Lincoln Gap during the late stages of the last (Weichsel) glaciation and the Old River Gravels are thought to be equivalent to the lower (Beeston) Trent terrace (10). Soils on these gravels are probably closely correlated with those of the Sutton (12) complex.

Alluvium in the broad Witham Fen is a mixture of riverine and tidal marine deposits. Recent aerial photographs show an intricate pattern of silt roddon and peaty or clayey fen soils resembling the Downholland (13) complex. Loss of peat by oxidation after drainage, and intensive cultivation, brings the silty clay below progressively into the plough layer, increasing cultivation and harvesting difficulties in wet years. (Robson and George)

West Midlands

Herefordshire

Sheet SO 52 (Ross-on-Wye West). The remaining 63 km^2 were surveyed and checked. The map and text are being prepared for publication.

Sandy loam soils of the Ross (14) series are widespread. Deep, shallow and steep phases were separated where possible. Small areas of the Eardiston and Bromyard series (15) were identified. The Newnham series on stony terrace deposits along the river Wye were correlated with soils on similar deposits in the Hereford and Ludlow area, as were alluvial silty soils on the Wye floodplain.

Freely drained alluvial soils of sandy loam texture mainly from local rocks, were named Walford series. Similar imperfectly drained soils are now called Elvastone series. Brown earth soils in sandy loam material on

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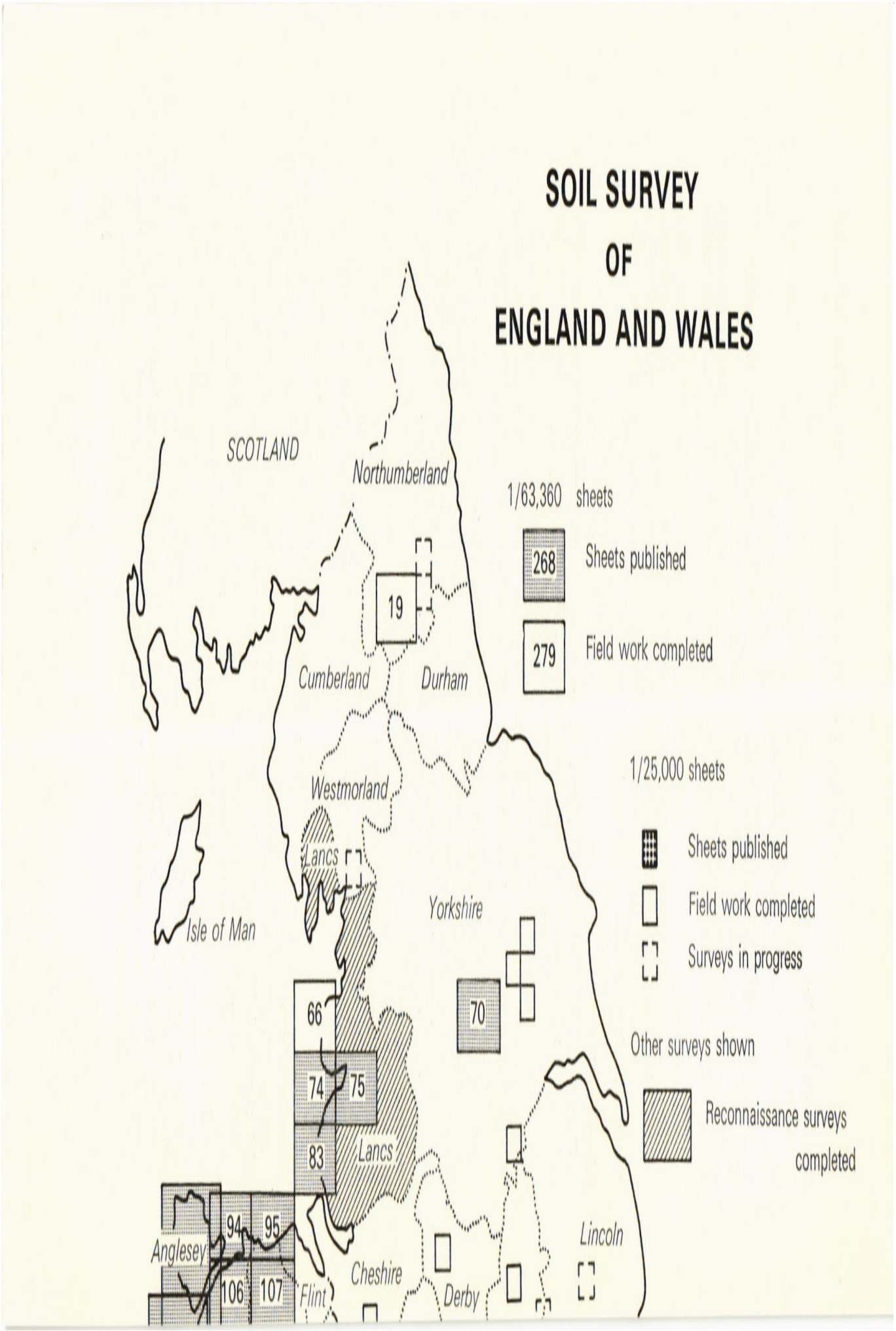

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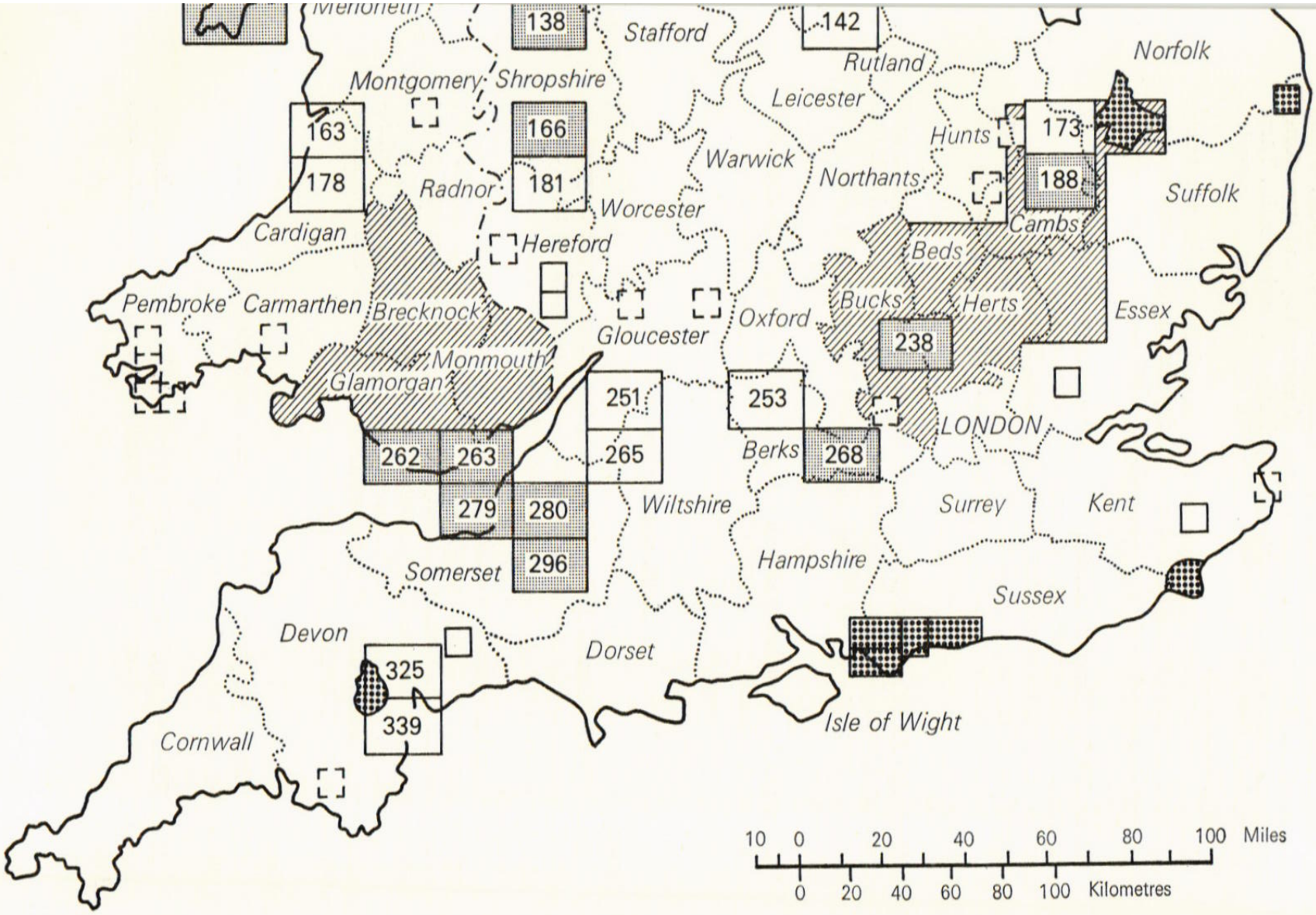

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marl or alternating thinly bedded sandstone and marl were included with the Sellack series and mapped with Ross series as the Ross complex. Within the area of the Ross series, narrow strips of moderately and imperfectly drained soils occur in valley bottoms associated with spring heads. These soils are included with the Biddlestone series and mapped as a complex with deep Ross soils.

The available water capacities of samples of Ross soils are being measured. A map of available water capacity for the Ross area will be produced from these measurements and field observations. (Whitfield)

Sheet SO 53 (Hereford South). 90 km² were mapped and field work completed. The range of soils resembles that near Ludlow and Church Stretton (15), with the addition of the Ross and Sellack series. The map and text are being prepared. Detailed records of over 2800 small pits were made with a small portable tape recorder. (Hodgson, Palmer and Pepper)

Sheet SO 33 (Vowchurch). A reconnaissance survey was made and several profile pits described. The sheet is not now included in the 1 : 25 000 mapping programme and Sheet SO 34 (Staunton-on-Wye) has been substituted.

Sheet SO 34 (Staunton-on-Wye). A preliminary survey was made and representative profile pits described. 3 km² were mapped mainly on soils of the Wootton (16) series. (Palmer and Hodgson)

South-east England

Essex

Sheet TQ 59 (Harold Hill). The remaining 42 km² were mapped in detail, completing field work. 533 borings were recorded on field cards, and the acre-boring ratio increased slightly above last year to speed up mapping.

The Essendon series was established. It is a surface-water gley soil in pebbly loam over clay or sandy clay, and differentiated from the Oak series, to which it had been tentatively ascribed, by coarser textured stonier upper layers and the vivid red, strong brown, and grey mottling of the clayey subsoil. The Oak series is reserved for less brightly mottled surface-water gley soils on boulder clays known or thought to be leached of calcium carbonate to depths greater than 75 cm. (Sturdy)

Kent

Sheet TR 04 (Ashford). Surveying was completed and the map and publication are being prepared.

Sheet TR 35 (Deal). The 70 km² of land in this area stretches from the east Kent coast between Sandwich Bay and Walmer, inland as far as Ash

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and Tilmanstone. After reconnaissance, 21 mapping units were established and 22 km² mapped in detail.

There are three physical regions. The southern half is a segment of the North Downs backslope, gently inclined from 60 m O.D. in the south, to 8 m in the north. Mature dry valleys in this exhumed sub-Eocene surface give it a gently rolling appearance. Brickearth often covers hill tops and east to south-east facing slopes, and coombe deposits floor all valleys. On some plateau relics, as around Telegraph Farm, cohesive clay-with-flints underlies brickearth.

The Eocene outcrop to the north-west is mainly of marine Thanet Beds, rising in low hills, just exceeding 30 m O.D. near Woodnesborough, where they are capped by the sandier, but mineralogically similar Woolwich Beds. Brickearth again occurs widely on hill slopes and in valleys, the middle slopes often with a thin cover of drift from Woolwich Beds.

To the east and north-east is a region of clayey alluvium near the Stour and its many small tributaries. Thick peat occurs in a narrow chalk valley near Hacklinge. North of Deal, this district is cut off from the sea by sand dunes and a system of storm gravel beaches, the latter interdigitating with alluvium to the north.

A traverse across a typical dry valley on the chalklands shows Hamble (9) fringed by Rewell (9) soils on plateau brickearth, Icknield (9) soils on upper and Coombe (9) soils on lower chalk slopes with a deep phase of the Coombe series along valley bottoms.

On the Eocene outcrop imperfectly drained clay loams or silty clay loams from the Thanet Beds are co-dominant with Hamble soils. Well drained sandy loams or loams in Woolwich Beds drift (Woodnesborough series) also occur on gentle upper slopes. Clayey calcareous gley soils of the Arundel (9) series are dominant on the alluvium.

In the south, soils over Chalk are mainly in arable cultivation, but land use is more varied on and near the Eocene outcrop where fruit growing and market gardening is widespread. Pastures predominate on land along the Stour and its major tributaries, and on peatlands near Hacklinge. (Fordham)

Berkshire

Sheet 253 (Abingdon). Mapping was completed and the field sheets are being revised and edited. The accompanying memoir is being prepared.

The area surveyed completes the section of the map on the Berkshire Downs. Shallow soils of the Icknield (4) and Ilsley series occupy most of the Downs with deeper Coombe (4) soils in valleys and on concave slopes. A variant of the Coombe series, in the broad Churn Gap and Seven Barrows valley, is formed in up to 40 cm of brown non-calcareous silty drift over Chalky drift, but has no argillic horizon. In the large Ilsley dry valley, very flinty Coombe profiles are common. In most valleys, the Chalk soils are typically asymmetrically disposed, with shallow soils on steeper west and south facing slopes and deeper soils in drift on gentle slopes opposite. (M. G. Jarvis)

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South-west England

Gloucestershire and Wiltshire

Sheets 251 and 265 (Malmesbury and Bath). A legend of soil mapping units was prepared for these combined sheets and the memoir is in preparation. (Findlay)

Sheet SO 82 (Norton). This area north of Gloucester City is typical of the Severn Vale. It is over Keuper Marl and Lower Lias clays and limestones. In the south-east there are thin superficial deposits from the Cotswolds, and river terrace deposits cap the low hills and slopes near the floodplain of the Severn. Alluvium is extensive along the river and its tributaries, and most of the lowlying land is flooded during winter. After a reconnaissance and the preparation of a mapping legend, 44 km^2 were mapped in detail.

Liassic strata cap the low hills to the west of the Severn and also form isolated hills to the east rising above the gently undulating Cotswold sub-edge plain. The Evesham (5) series is the main soil on Lias clay, although upper horizons are often contaminated by Triassic pebbles and coarse sand and their colours influenced by Head. The depth of the B horizon varies and there is often no grey Liassic clay within auger depth. The Haselor series (i.e. the rocky phase of the Evesham series) is also common both on gentle and moderately steep slopes. The poorly drained Charlton Bank (5) series is less extensive.

Stratified clayey, gravelly and coarse loamy deposits derived in part from the Cotswolds occur in interfluves of rivers flowing west to the Severn, and are attenuated extensions of thicker deposits around Cheltenham. The imperfectly drained Podimore (16) series, with fine loamy to clayey A and B horizons, occurs on lower slopes of interfluves. Subsoils contain coarser layers overlying the substratum of grey calcareous clay which may occur below 60 cm. Moderately well drained soils are common in the centres of the interfluves, including soils with loamy non-calcareous A and B horizons over limestone gravel.

Red Keuper Marl forms undulating country in the north where the imperfectly drained Worcester (5) series occurs in drift-free sites. A phase was recognised on grey non-calcareous marl. Much of the Keuper outcrop is covered by Head, however. The Spetchley (5) series is mapped where poorly drained clayey Head overlies Keuper Marl below 40 cm. An imperfectly drained soil occurs on gentle slopes down to the alluvium, with a brownish eluvial horizon in fine loamy Head and with Keuper Marl at 45–55 cm.

Fluvio-glacial terraces, mainly of Triassic material, cap many hills and slopes near the Severn. Brown earths and gleyed brown earths occur on the lowest terraces with coarse loamy to fine loamy B horizons of variable stone content. The older, higher, terraces have more strongly differentiated profiles in imperfectly to poorly drained soils.

Most of the Severn floodplain is occupied by a poorly drained soil on reddish clayey alluvium. Textures become coarser in imperfectly to moderately well drained soils on slightly elevated and levee-like sites.

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Low-lying areas at the edge of the floodplain, which are under water most of the winter, are occupied by grey poorly drained clayey alluvium. Gypsum usually occurs below 60 cm in this soil; and also in adjacent areas of the reddish alluvium. Tributaries entering the Severn from the east flow in narrow valleys and there is an imperfectly to poorly drained soil, resembling the Butleigh (5) series, in the greyish brown to light olive-brown clayey alluvium, which is slightly calcareous in places. (Cope)

Sheet SP 12 (Stow-on-the-Wold). This is typical of the northern tracts of the Cotswold Hills where the Inferior Oolite limestones are best developed. With the Fullers Earth and Great Oolite formations, limestones occupy two-thirds of the sheet, forming a gently sloping dipslope between 240 and 180 m O.D. The rest, in the Bourton and Moreton vales, is low lying and soils are in Liassic silts or clays, thin overlying drift, or alluvium. After reconnaissance of sample blocks over the whole area, 10 km^2 were mapped in detail, mostly on Lower and Middle Lias near Bourton-on-the-Water. Soils identified included Long Load, Charlton Bank, Martock, Evesham and Podimore series (5, 16). Alluvial soils were mapped near the river Dickler. (Findlay and Courteney)

Devonshire

Sheet ST 10 (Honiton). The remaining 31 km^2 were mapped and a publication prepared including a section on Land Use Capability. Two further mapping units were established, both in the extreme south-west; one, the Bridgnorth (1) series, is associated with the Trias sandstone outcrop, the other is a gleyed brown earth of silt loam to silty clay loam texture in basal Keuper Marl with a low clay content.

Sheet SX 65 (Ivybridge). This is typical of the South Hams district and is on Lower, Middle and Upper Devonian slates and volcanic rocks, with the southern flank of the Dartmoor granite impinging on the northern edge of the area. The Geological Survey separated several formations in this area including Dartmouth Slates, The Meadfoot Group (slates and grits) and the Staddon Grits (with slates) in the Lower Devonian, Middle Devonian Slates and Limestones, Upper Devonian Slates and the Ashprington Volcanic Series of tuffs and larvas.

Preliminary identification of soils before constructing legends showed many brown earths of silt loam to silty clay loam texture, resembling those weathered from Devonian slates near Newton Abbot (17), with surface-water gley soils on a few footslope sites. Most of the soils of the Ashprington Volcanic Series are brown earths. Coarser textured soils are rare, and the Meadfoot Group and Staddon Grits produce soils similar to those on the slate formations. (Harrod and Staines)

Wales

Carmarthenshire

Sheet SN 41 (Llangendeirne). Previous work in the county was confined to a survey of Llangunnor parish (18) and an unpublished recon-

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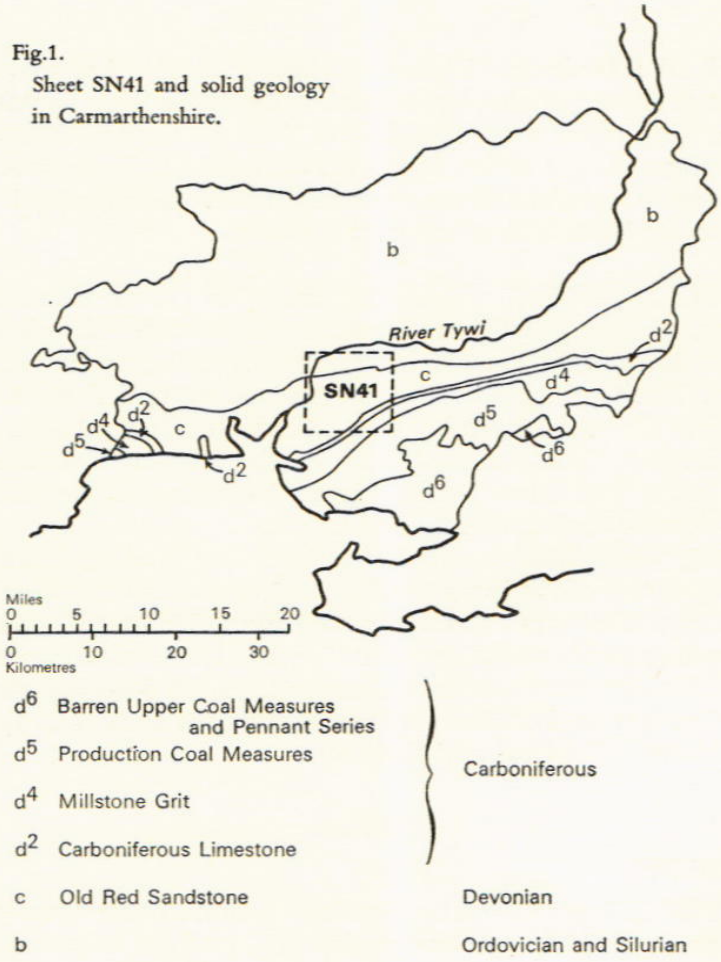
naissance by C. B. Crampton of the Black Mountain area adjoining south-west Brecon. Survey of key areas began with a sheet that extends from the northern outcrop of the western end of the South Wales Coalfield to the Ordovician rocks of the Tywi valley at Carmarthen. It straddles the belt of Old Red Sandstone, regarded as one of the most productive areas of the county.

A preliminary study of the sheet is nearly complete and a legend will be constructed. Observations were made at close intervals in areas typical of the different landscapes, and profiles described in pits located on a coarser grid over much of the sheet.

In Fig. 1 the area is shown on an outline map of the solid geology of Carmarthen. In the south-east, narrow outcrops of Carboniferous Limestone and Millstone Grit form a prominent composite scarp rising to 260 m O.D. on the rocky, quartzite ridge of Mynydd Llangyndeyrn. The dipslope of Millstone Grit and Coal Measure shales is deeply cut by the mining valley of the Gwendraeth-fawr. To the north-west, ground falls to the parallel, strike valley of the Gwendraeth-fâch, which drains the southern part of the Old Red Sandstone belt of strongly undulating

Fig.1.
Sheet SN41 and solid geology in Carmarthenshire.



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country with many moderate and strong slopes (3–11°). Further north the O.R.S. and Ordovician rocks form a drift-mantled plateau at 120 to 150 m O.D. drained west to the north–south course of the Tywi. Along the northern boundary of the sheet, parallel to the east–west course of the Tywi, summits are lower and the ground falls to the valley floor on the next sheet. Although most ground is below 150 m O.D., average annual rainfall is everywhere between 1270 and 1520 mm.

The Ordovician rocks are shales with small areas of sandstone and grits. More than half of the outcrop is covered with fine silty or clayey glacial drift from similar rocks to the north, and surface-water gley soils and humic gley soils are widespread. In the earlier survey of Llangunnor parish the Cegin series was most extensive. Similar drift extends onto the northern part of the O.R.S. belt between Cwm-ffrŵd and Llanddarog where gley soils predominate.

There is a striking boundary at the southern edge of the northern drift to the red soils flanking the Gwendraeth-fâch valley. These are well drained and moderately well drained silty brown earths either from the siltstones and fine sandstones below or developed in a thin layer of mainly locally derived drift. There are gley soils on thicker drift deposits of similar origin, in depressions and on valley floors.

On narrow outcrops of Carboniferous rocks there is a variable cover of mixed drift; the soil pattern is very complex, and will need to be interpreted with reference to larger areas on adjacent sheets. (Clayden and G. D. Evans)

Pembrokeshire

Sheets SM 90 (Pembroke) and SM 91 (Haverfordwest). A further 140 profiles were described to test boundaries and contents of mapping units on Lower Palaeozoic rocks (17). Boundaries were tested along a 2 km traverse with observations at 20 m intervals, and coincided with maximum rate of change of soil properties, except in a complex of rough slopes where small areas of brown earths among gley soils had not been separated. Partially gleyed soils occupy smooth slopes between brown earths and gley soils, in bands up to 100 m wide. Table 1 shows that ungleyed soils are most common on the smooth slopes, fewer on the wetter and drier complexes, and fewest on the rough slopes, nine-tenths of which are covered by gley and partially gleyed soils. Rankers, brown earths and ungleyed surface horizons show similar trends.

TABLE 1

Proportions of soil groups related to mapping units on Lower Palaeozoic rocks

Mapping unit	Number of obser-vations	Gley soil	Partially gleyed soil	Un-gleyed soil	Ranker	Brown earth	Un-gleyed surface horizon
Smooth slopes	52	8	7	85	21	71	96
Drier complex	19	32	53	15	15	5	26
Wetter complex	25	44	44	12	8	20	32
Rough slopes	51	71	22	7	6	6	17

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Random observations on glacial gravels showed mainly brown earths with loam topsoils, and some slightly gleyed C horizons. Silty alluvium north of Haverfordwest is usually partially gleyed, but gley soils also occur.

Generalized catenas were constructed for the main parent materials showing areas occupied by plateau land, and convex, plane and concave slopes. Soil depth and group vary differently with facets on different parent materials. (Rudeforth and Bradley)

Sheets SM 80 (Angle), SR 99 (Castlemartin) and SS 09 (Manorbier). A further 40 profiles were described in the south, over Devonian red marls and Carboniferous Limestone. The additional profiles confirmed last year's conclusion that the freely drained soils are shallower than further north.

Montgomeryshire

Sheet SO 09 (Caersws). The initial reconnaissance survey started. (Lea)

Supporting research

Supporting research is described below under the headings employed in the current programme of the Soil Survey Research Board.

Identification

A 1. Soil morphology and chemistry

The Denchworth series. The usefulness of a soil map increases with the number and precision of statements that can be made about areas delineated. In present soil mapping, each area identified by a colour or symbol in the map legend represents a body of soil in which profiles of one or more specified soil series predominate. The usefulness of such a map depends on (a) the properties or property ranges defining series; (b) the extent to which variation in these is associated with variation in other properties of interest; (c) the proportion of each mapped area conforming to the series specified.

To improve the usefulness of soil maps, independent statistical studies of variability within mapped areas are needed. Undisturbed cores 15 cm diameter and 1 m deep were taken in a 0·4 km grid pattern within each of three areas mapped as Denchworth series on Oxford, Kimmeridge and Gault clays in Berkshire and Buckinghamshire. Morphological, chemical and physical measurements on each profile are being recorded for statistical analysis and to show the proportion of profiles conforming to the stated class limits. (Bascomb)

Clayey soil series. To assess the significance of soil series separations based on geological (stratigraphic) criteria, 100 samples from morphologically comparable subsurface horizons of clayey soil series formed in argillaceous sedimentary rocks of Tertiary to Silurian age, are being characterised by physical, chemical and mineralogical methods. Particle

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size distribution, cation exchange capacity, Atterberg limits and apparent surface area (by water retention) are being determined on < 2 mm samples, with cation exchange capacity, potassium content, apparent surface area and mineralogical constitution as estimated by X-ray diffraction, on < 2 μm clay separates. Intra-series variation in the properties so far determined is often considerable, and whereas some previously distinguished series can be united without loss of information, others can usefully be subdivided. (Avery, Bullock and Pritchard)

A 2. Methods of analysis. Papers entitled 'A laboratory index to manipulative texture of soil in the field' and 'Soil analysis in classification and mapping' were presented to the Agricultural Research Council's Working Party on Methods of Soil Analysis. (Bascomb, Pritchard and Hodge)

A 3. Micromorphology and mineralogy

Measurement of pore-size distribution and total pore space in thin section. Examination of thin sections of soils under the microscope at moderate magnification shows pores down to 2 μm in diameter. Methods of measuring their distribution and the total space they occupy in sandy soils were studied using fluorescent dyes that are not only miscible with the resin before impregnating soil samples, but also fluoresce strongly when the resin has set. Of 20 dyes examined the following are suitable: Uvitex SWN, Uvitex OB, MLS 465, Pontacyl Brilliant Pink 'B', Calcofluor White RWP Conc., Rhodamine 6 GD Base and Oil Colour 7 G.

Most present micromorphometric methods are very tedious, but measurements can be made quickly by analysing electro-optical images using Quantimet apparatus based on specific image-plane double spot scanning. With an absorption threshold system and polarity control, features of different optical intensity can be analysed in the same image. The apparatus was adapted for an ultra violet light source and preliminary measurements made with sandy soils from a compaction experiment. To measure pores, three-dimensional changes in their size and shape are noted as successive layers of known thickness are removed from the section. These results will be compared with those from other methods of pore-size measurement and work extended to soils of different textures. (Bullock and Lummus)

Microfabrics of palaeosol horizons. Many soils in unglaciated parts of southern England are developed in two distinct materials; an upper mantle of loess-like or solifluction deposits overlies older, more weathered material. Recent soil-forming processes have reorganised the upper mantle but where it is thick, the material below has been shielded and in it have been preserved palaeo-features produced during an earlier period of stable weathering and soil formation.

Soils with palaeosol horizons, belonging to the Batcombe and Winchester series (4), are classed as brown earths (*sols lessivés*) and the palaeosol horizon is usually argillic. The plasma is almost entirely of anisotropic clay, often with moderate to strong orientation. Strongly oriented parts

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are associated with void edges, whereas weakly to moderately oriented clay occurs in plasma concentrations unassociated with existing voids, or as plasma separations, which are attributed to stress. The basic fabric of the horizon is strong masepic to omnisepic porphyroskelic.

Red mottling is common in some palaeosol horizons. Such mottles are thought to have been formed in a warm Late Tertiary or pre-Saale interglacial period. They might have been directly inherited from red mottles in Eocene clays, but micromorphological study suggests that the two sets of mottles have a separate origin.

The next stage in this programme is to compare the microfabrics of soils developed in materials of known age, to determine whether a relationship can be confirmed between plasma reorganisation, as defined by the anisotropic/isotropic ratio of the plasma and the basic orientation pattern, and age of materials. (Bullock)

Microfabrics of Lake District soils. Microfabrics of the soils of three associations in the Lake District, Lowick, Brantwood and Grizedale, were examined.

The B horizon of sesquioxidic brown earths of the Lowick and Brantwood associations has an extremely porous microfabric with 30–40% of voids areally. Small discrete orange-brown pellet-like primary peds, 20–50 μm in diameter, are the basic structural units and these are often loosely clustered through bridges of yellowish brown plasma into secondary peds. Groups of secondary peds constitute the subangular blocky structure seen in the field. The microfabric of this horizon resembles that seen in some other sesquioxidic brown earth, e.g. Moretonhampstead (19) series in south-east England, Cymmer and Manod series (20) in Wales and the Linhope (21) series of the Ettrick association in Scotland.

The microfabric of the Bg horizons of the gley soils of the Lowick and Brantwood associations differs greatly from that of the B horizon described above. The Bg horizon lacks pellet-like peds and its pedality is poorly defined in thin section. Porosity is also less than in the sesquioxidic brown earth, with voids occupying 20–25% areally.

The peaty gleyed podzol of the Grizedale association has a microfabric similar to both the sesquioxidic brown earths and gley soils of the Lowick and Brantwood associations. Above the dense thin iron pan, the microfabric resembles that of the Bg horizon of the gley soils, whereas just below it, structure is well defined and the microfabric is identical to that of the B horizon of the sesquioxidic brown earths. A fragipan occurs in soils of all three associations. The horizon is of grey compacted rock fragments with voids occupying less than 15% by area. (Bullock)

A 5. Soil moisture characteristics. A pressure membrane unit, a sand bath and two sand-kaolin bath tension tables were installed to measure soil moisture release characteristics from saturation to wilting point.

In a survey for the Water Resources Board, bulk density, moisture content at 0·1 bar tension and stone content were determined for 240 soil samples from the catchment of the upper Dee in Wales. Wilting point was determined for 70 samples.

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Moisture release characteristics were determined on 45 samples from the Hanslope (8) series and 50 samples from the Ross (14) series. Available water capacity was calculated from release measurements and horizon thicknesses for individual profiles. Triplicate cores from each horizon of at least four profiles were obtained to assess the components of variation in measurements of this kind within a soil series. Statistical assessment of the results and experience with a wider range of soils may necessitate modification of the sampling programme. (Smith and Thomasson)

Estimating surface area by measuring moisture content at a single point on the water vapour adsorption isotherm (22) is being investigated as a soil identification test. (Pritchard)

A 6. Soil temperature characteristics. Apparatus for the continuous automatic recording of frost heave and a battery-operated Grant miniature temperature recorder were used in soil on Magnesian Limestone at Leeds University Farm, Bramham (in collaboration with the Department of Agriculture). The aim is to improve characterisation of soil by observing seasonal temperature changes and frost heave, including depth of frost penetration, and their effects on soil formation and fertility.

The frost heave recorder was placed in a shallow ($<$ 15 cm) rendzina soils over limestone (Wetherby (2) series) in the slope of a dry valley. Temperature probes nearby are at depths of 8 cm and 30 cm in shallow brown calcareous soil from limestone (Aberford (2) series), a deep brown calcareous soil from Head (Bramham (2) series) and Wetherby soils. (Matthews)

A 7. Air conductivity in soils. A permeameter was developed to assess the pedality and porosity of soil horizons, by measuring free air flow at set pressure through 100 cc of soil, *in situ* and exhumed, in standard 5 cm diameter tubes. Air flow is in the range 0·05–25 litre per minute, and the apparatus can be used on soils ranging from the scarcely porous and poorly structured to the well structured and with continuous earthworm holes.

The influence was determined of land use on the air conductivity of the A and upper B horizons of Hook (9) soils, one of a group of fine sandy to silty soils that readily cap at the surface under arable use and form pans at plough depth. Capped and panned layers had significantly smaller conductivities than soil at the same depths under pastures with well developed structure typical of old grassland. Seasonal conductivity changes, especially those from changes in moisture content, are being followed with plug-in attachments to tubing linked to buried instruments; moisture content and bulk density are also measured. Later, other soils and specific kinds of horizons, such as fragipans, will be studied. (Green and Fordham)

Classification

B 1. Soil classification. A new classification is being developed as a systematic basis for defining soil series. A draft scheme produced last year

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was tested by applying it to existing field and laboratory observations on some 2000 profiles classified according to current series concepts. After discussion with surveyors, the text will be published. (Avery)

Surveying

C 1. Air photography (Uplands)

Uplands soils. A unit to study techniques of air photography for soil survey in upland areas was established at Leeds in October, 1968. Work began in the West Riding Pennines and two sample areas, the Colne valley and the Penistone district, were studied in detail. These Millstone Grit and Coal Measures uplands provide excellent opportunities for air photo interpretation as shale and sandstone sequences, rarely complicated by glacial drift, give clearly defined land forms and much semi-natural vegetation remains.

Most boundaries located by photo-analysis were confirmed by later field work. Some, such as the boundary between deep peat and mineral soils, were much more accurate than when located by field work alone. It was usually possible to predict only large changes in soil drainage class or parent material, and further field work was needed to produce a map showing soil series. However, the use of air photographs saved up to 40% of the time usually spent in the field. The study will be extended to form the basis for part of the West Riding County soil map.

Special panchromatic photography at 1:20 000 scale was commissioned for Westmorland and part of the North Riding, and a further contract placed for photography of the Peak District using colour film. Panchromatic, colour and infra-red colour film will be compared in several sample areas. Close liaison was maintained with other organisations interested in the applications of aerial photography and other remote-sensing devices. (Carroll)

C 2. Air photography (Lowlands)

Lowland soils. The collection of oblique aerial photographs at the Cambridge University Unit for Aerial Photography was studied to define soil tone patterns commonly occurring on existing photographs.

Soil patterns found in East Anglia include: (a) a peat or formerly peat covered silted estuarine creek system in peat fen and its association with former large through-flowing rivers and meres; (b) polygons and stripes on heaved and soliflucted chalk and sandy chalk drift parent materials; (c) pseudomorph frost-wedge dessication cracks in terrace gravels; (d) braided stream channels in deposits of terrace gravels; (e) a bedrock jointing pattern in Jurassic limestone.

The use and potential of air photos as aids in soil mapping, and the degree of reliability to be placed on soil boundaries mapped directly from air photos was assessed, and variability within units investigated. (R. Evans)

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C 4. Sampling

The Sherborne series. This major mapping unit on Sheets 251 and 265 (Malmesbury and Bath) was studied to determine whether the variability within it is systematic either areally or non-areally. One hundred and twenty sample points were investigated and results are being examined using multivariate statistical techniques (principle component analysis, multiple regression and discriminant analysis) and trend surface analysis. Methods of measuring soil stoniness in the field were also tested. Post-mapping variability studies were made of two other important mapping units, the Chickerell and Coalpit Heath complexes, to assess the relative proportions of variants in each. (Courtney)

Sheet SX 65 (Ivybridge). During this survey auger observations are made at 100 m grid intersections, details of profile morphology and site being recorded for the programme of investigation of mapping and cartographic techniques. Free mapping is proceeding in parallel. Observations on this closely spaced grid call for an effort two or three times greater than usual and the benefits will need careful assessment. (Harrod and Staines)

C 5. Data storage

Sheet TQ 59 (Harold Hill). During this survey feature cards were used to store and analyse data on series and drainage class, and for texture, stoniness and calcium carbonate of top soil, subsurface and subsoil layers in profiles at 2000 sites.

This allowed graphical demonstration of the range of texture permitted in the various layers, and the amount of overlap between series, of groups of soil series on closely related parent material, e.g. Windsor, Wickham and Titchfield series. The extent to which existing criteria for depth to calcareous material were applied rigorously in the field to differentiate between Hanslope, Ragdale and Oak series, was also studied. Although there was considerable overlap between Hanslope and Ragdale soils, a large difference between Oak and both Hanslope and Ragdale soils confirmed field experience.

All available information (field card records and field map symbols) was used to show, on a map, sites of individual series (as taxonomic units), and, the numbers counted of each series within each area surrounded by a soil boundary (i.e. a map separate). The proportion of each series occurring in a map separate was calculated as a percentage, and a bipartite map symbol was compiled giving the proportions of the dominant and the subsidiary series. All map units are dominated by one series, which provides the name. The uniformity of each named unit can thus be shown on the map, as well as the 'within unit–between separates' variation.

Table 2 shows, for the whole map, percentage purity of the more important mapping units, averaged over all the separates in each, and arranged in decreasing order. (Sturdy)

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TABLE 2

Percentage purity of mapping units

No. of separates	Dominant series		Main subsidiary series		Other series
1	Fladbury	100			
5	Essendon	76	St. Albans	9	15
9	Oak	75	Ragdale	6	19
26	Windsor	74	Wickham	14	12
15	Hanslope	67	Ragdale	18	15
7	Curdridge	62	Swanwick	12	26
6	Ragdale	58	Hanslope	20	22
10	Wickham	55	Windsor	18	27
6	Titchfield	52	Windsor	20	28
7	Bursledon	46	Shedfield	32	22

Cartography

D 1. Automated cartography. The unit set up to study automated cartography and computer applications in soil survey is collaborating with the National Environment Research Council Experimental Cartography Unit.

Boundaries on the 1 : 10 560 scale field sheets of a part of the Reading district were digitized onto magnetic tape using the D-Mac pencil follower. After correction and editing, the map was re-drawn at a scale of 1 : 63 360 on a plotter controlled by a computer. Boundaries were labelled on the magnetic tape so that selections could be made. Colour masks were also scribed and a colour map prepared. Once the magnetic tape had been corrected and edited, map drawing was both accurate and quick.

Work started on automatic map production from sample surveys. Data are being collected in the Ivybridge area of Devonshire (Sheet SX 65). The area of 100 km² is being sampled on a regular grid of 100 m × 100 m. Texture, colour, mottling, stoniness and thickness of each horizon are being recorded, with landform and other site characters.

Preliminary studies using Oxford University's KDF 9 computer on small sets of similar data have compared different numerical methods for classifying soil profiles, and those embracing spatial proximity show greatest promise for mapping. Methods based on minimum variance are being developed to arrive at decisions on boundary frequency and location both for single character and multivariate class maps. (Webster)

Special surveys

Under a research contract with the Water Resources Board, soils of 1000 km² of the River Dee Catchment in Merioneth and Denbigh were studied. Five hundred pits on a grid pattern were examined and classified into six groups, and the properties and distribution of each group established. Table 3 shows area, mean slope angle and altitude for each soil group.

Mean thickness of selected horizons of hydrological interest for eight sub-catchments was calculated and further relationships between landscape and soils are being studied. Forty profiles were sampled to determine soil moisture characteristics. (Rudeforth, Lea and G. D. Evans)

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TABLE 3

Area, mean slope angle and altitude of soil groups of the River Dee Catchment in Merioneth and Denbigh

Soil group	Soil	Area (km²)	Mean slope (°)	Mean altitude (m)
1	Peat, peaty gley, peat over rock	268	7·0	427
2	Peaty gleyed podzol	106	10·4	457
3	Gley	62	5·8	282
4	Gleyed brown earth	144	6·8	223
5	Brown earth (mull)	284	10·6	278
6	Brown earth (mor)	136	16·5	374

A soil map of newly acquired land at the National Vegetable Research Station, Wellesbourne, is being prepared, necessitating revision of existing maps of the Station. Representative profiles were described and soil samples are being analysed at Wellesbourne. (Whitfield)

Reports and maps were prepared for Fison's East of England Arable Unit at Abbots Ripton, Hunts. It is largely on soils of the Hanslope (8) series with loamier soils in small re-entrants. (Hodge and Potter)

The Dead Mans Grave site near Bury St. Edmunds was surveyed for the Nature Conservancy. This is in the Breckland and covers some 200 ha with Worlington (8), Methwold (23) and Newmarket (8) soils on slopes, gravelly Worlington soils along dry valley floors and a small area of blown sand. (Corbett)

A survey was made and a map prepared at a scale of 1 : 2500 of 90 ha at Long Ashton Research Station. The 64 ha at present in use for field experiments were surveyed on a 35 m grid pattern and 20 pits were described. The soil separations were similar to those made in the original survey (24) and most units correlated with those mapped in the Mendip area (5). (Cope)

Other work

Miss Kathleen Baker, a student assistant, compiled a 1 : 250 000 map of England and Wales, showing the distribution of flat to rolling (most slopes less than 11°), hilly (most slopes between 11° and 22°) and steep (most slopes greater than 22°) land, by gauging contour intervals at each 1 × 1 km National Grid intersection. By separating areas of distinctive relief on a uniform basis, this map will help in constructing small-scale soil association maps.

By request of the Regional Soil Chemist, M.A.F.F., two training programmes in soil identification for agriculture were jointly organised for N.A.A.S. staff in Kent and Surrey. One hundred and twenty agricultural, horticultural and drainage officers from Kent, Surrey and West Sussex attended during five one-day meetings and some parties included officers of the Agricultural Land Service and County Planning Departments. (Green)

An exhibition of microfabrics of British Soils was prepared for the Field Meeting of the British Society of Soil Science at Lancaster.

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Many lectures and demonstrations were given and information was supplied to numerous public and private organisations.

The first numbers of two new series of publications appeared.

In the Cartographic Section four 3rd Ed. Sheets were published and work continues on four more and on nine maps at other scales.

Staff

B. R. Hall, D. M. Pepper and D. C. Greenway resigned. R. Hartnup, S. J. King, C. P. Stamper, J. M. Hollis, T. L. Potter, D. V. Hogan, G. A. Reaves and R. I. Bradley were appointed.

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