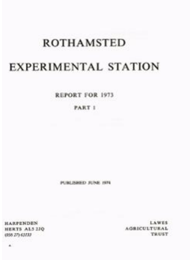
Report for 1973 - Part1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REPORT FOR 1973

PART 1

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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 are to describe, classify and map the different soils of the country.

A new classification, published in summary form this year (1), is now used to identify soil map units. Kinds of soil profile are differentiated at four successive categorical levels, termed major group, group, subgroup and soil series. Classes in the three higher categories are defined partly by the composition and mode of origin of the soil material, and partly by the presence or absence of particular horizons within specified depths, using properties that can be observed or measured in the field, or inferred from field examination by comparison with analysed samples. Soil series are distinguished by other characteristics, chiefly lithologic. Most soil groups (Table 1), the principal category above the soil series, are very like those in other European systems, in the United States Department of Agriculture system, or in both. When a map unit is identified by the name of a soil series or a class in a higher category, it is implied that most soil in each delineation on a map conforms to that class, and that unconforming inclusions belong to one or more closely related classes and are insignificant in area. More heterogenous units (complexes and associations) are similarly identified by the names of two or more classes. Map units based on soil or land attributes not differentiating in the profile classification are distinguished as phases.

The properties of the soils shown on maps are described in accompanying publications, 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 1m) and, with the additional information provided, are of use in agriculture, forestry, land-use planning, land drainage, geography and ecology.

The mapping programme continues, with the surveying of districts in each county chosen for their geomorphological and agricultural interest, and with the compilation of soil maps at a scale of 1 : 25 000. Forty-one such areas were worked on during the year, and the exceptionally pleasant summer allowed 1100 km² to be surveyed in detail in 28 of them. More ground might well have been covered, but effort was also needed in reconnaissance for County maps, and in the introduction of the new soil classification, which involved the re-definition of many soil series with greater precision. Thirty-eight maps at a scale of 1 : 25 000 have now been published, with explanatory publications—usually *Soil Survey Records*—for 19 of them. The progress in reconnaissance survey included compilation of maps of soil associations at a scale of 1 : 250 000 for the counties of Avon, Berkshire, Cheshire, Derbyshire, Norfolk, Pembrokeshire and South and West Yorkshire. When maps have been completed for all counties, regional and national maps will be compiled.

Northern England

Cheshire

Sheet SJ45E/55W (Burwardsley). A further 60 km² were mapped and representative profiles sampled.

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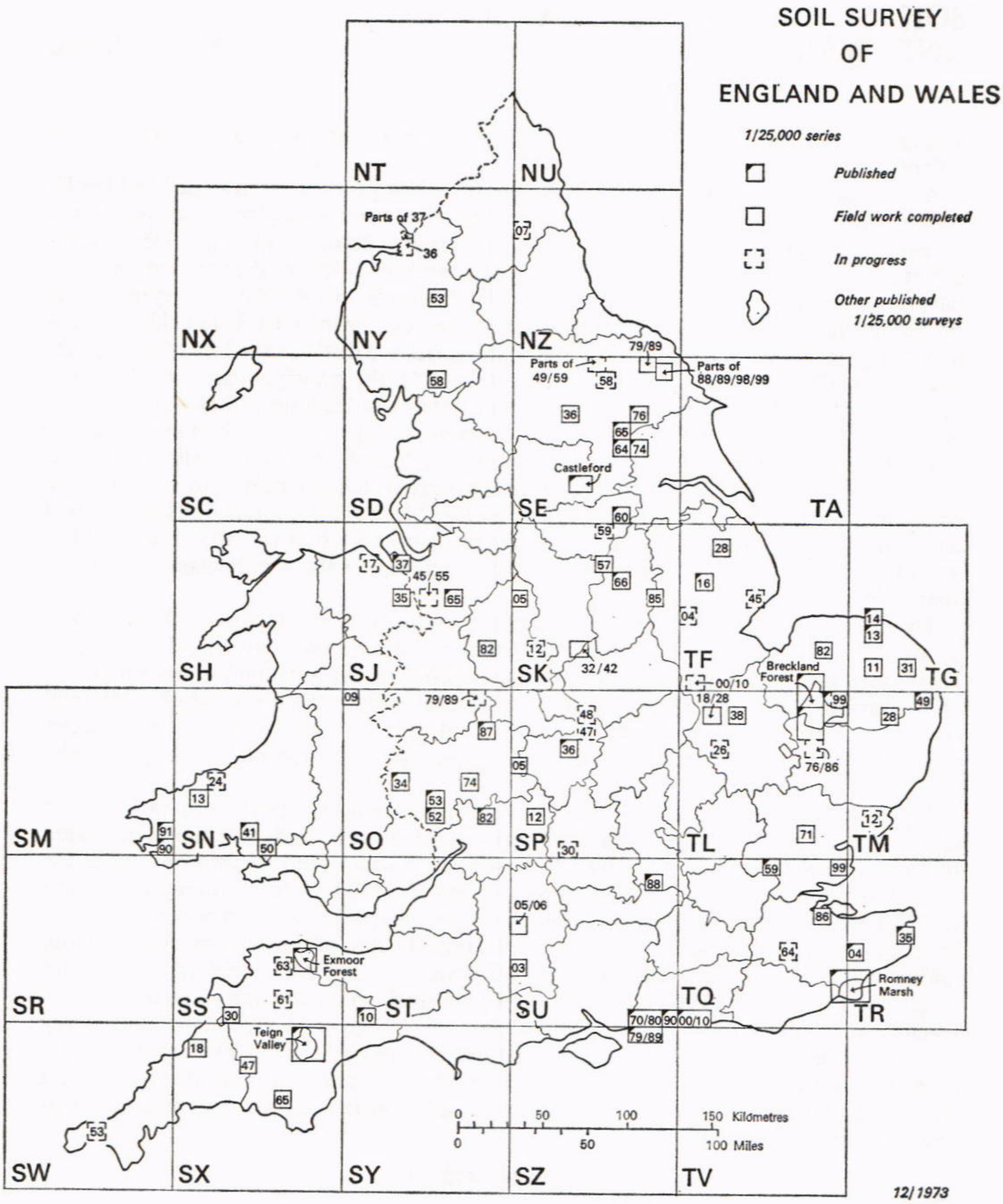

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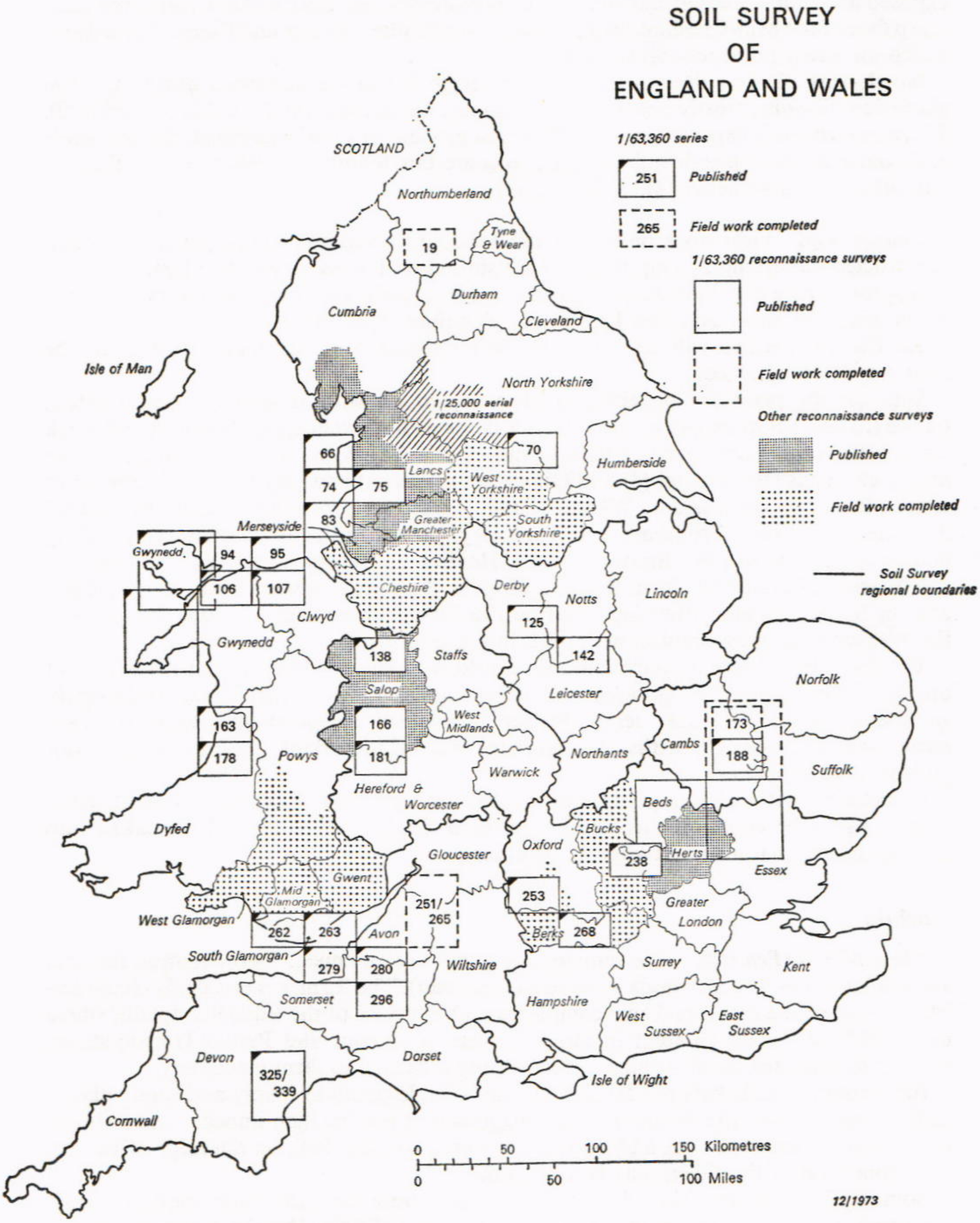
SOIL SURVEY OF ENGLAND AND WALES



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Soils are mainly in variable drift deposits, which cover 87% of the area and conceal the oldest rocks (Erbistock Beds and Lower Mottled Sandstone). The oldest rocks exposed are Pebble Beds at Barton. The Upper Mottled Sandstone above forms the main scarp face of the Mid-Cheshire ridge, an outcrop of faulted Bunter and Keuper Sandstones which markedly influence soil textures.

North-west of the ridge, in the direction from which ice advanced during the last glaciation, till soils, mostly fine loamy over clayey, are of the Flint (2) and Salop series (3). Where sandstone is exposed or where there is a mixture of sandstone Head, till and sandy and coarse loamy glaciofluvial deposits, soils are fine loamy and belong to the Escrick, Salwick and Clifton series (4). (S. J. King)

County map. Field work on the 1 : 250 000 county map was completed and a legend constructed describing 21 map units. Work started on the accompanying text.

Approximately 600 km^2 were mapped on a reconnaissance basis on the plain in the south-west and west, and 200 km^2 in the Pennines. Unpublished surveys of parts of north Cheshire, which will be used with the published detailed surveys to compile the final map, were checked.

Soils on the plain are on either reddish brown till with stagnogley soils (Clifton, Crewe (2) and Salop series), or glaciofluvial sands with brown earths (Newport and Wick series (4)). Humo-ferric podzols (Crannymoor series (4)) form subsidiary areas. Coarse loamy gley soils (Blackwood (4) and Quorndon (5) series) and gley-podzols (Reaseheath series (4)) are in depressions. Where Triassic sandstone protrudes through the glacial deposits, as between Frodsham and Tarporley, brown earths are common in a rolling landscape (Bridgnorth (4), Bromsgrove (4), Hodnet (3), Newport and Wick series).

Estuarine alluvial soils form a broad strip in the north between Frodsham, Helsby and the Mersey estuary. Elsewhere riverine alluvial soils were mapped along the Dee and the Weaver and, in association with peat, in the Gowy valley.

The Pennine soils are on Carboniferous sandstones, shales and derived drifts with peat on the highest ground. Stagnogley and stagnohumic gley soils (Brickfield, Hallsworth, Roddlesworth and Wilcocks series (6)) are widespread except on the steep sandstone escarpment where brown earths (Rivington (6) and Swindon Bank (5) series) and stagno-podzols are commoner.

Correlation with adjoining areas of Lancashire and West Yorkshire showed many map units to be common throughout northern England and this will be taken into account in the final map and legend. (Furness)

Cumbria

Sheet NY 53 (Penrith). The remaining 60 km^2 were mapped. Two common features are stoniness and discontinuous induration (fragipan). The former is especially characteristic of soils of the moraine–kame complexes on both sides of the Eden floodplain, where up to 70% of the drift parent material consists of igneous and Permo-Triassic stones up to 2 m diameter. Such stoniness is inevitably a hazard to farm machinery.

Induration, usually between 50 and 230 cm, is widespread in loamy and sandy glacial drift. Gleying above the indurated layer suggests that the fragipan impedes water movement, even on slopes. Ponds and a large peaty area on Wan Fell, on the ridge of Penrith sandstone west of the Eden, may be due to this.

Some soils were provisionally correlated with those on drift from Permo-Triassic sandstone in other counties. However, the presence of Lake District igneous material in the fine sand fraction, and probably in the clay, and the presence of induration may call for new series.

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TABLE 1

Soil classification in England and Wales

Major group	Group	Subgroup
Lithomorphic (A/C) soils Normally well drained soils with distinct, humose or organic topsoil and bedrock or little altered unconsolidated material at 30 cm or less	*Rankers* With non-calcareous topsoil over bedrock (including massive limestone) or non-calcareous unconsolidated material (excluding sand)	Humic ranker Grey ranker Brown ranker Podzolic ranker Stagnogleyic (fragic) ranker
	Sand-rankers In non-calcareous, sandy material	Typical sand-ranker Podzolic sand-ranker Gleyic sand-ranker
	Ranker-like alluvial soils In non-calcareous recent alluvium (usually coarse textured)	Typical ranker-like alluvial soil Gleyic ranker-like alluvial soil
	Rendzinas Over extremely calcareous non-alluvial material, fragmentary limestone or chalk	Humic rendzina Grey rendzina Brown rendzina Colluvial rendzina Gleyic rendzina Humic gleyic rendzina
	Pararendzinas Over moderately calcareous non-alluvial (excluding sand) material	Typical pararendzina Humic pararendzina Colluvial pararendzina Stagnogleyic pararendzina Gleyic pararendzina
	Sand-pararendzinas In calcareous sandy material	Typical sand-pararendzina
	Rendzina-like alluvial soils In calcareous recent alluvium	Typical rendzina-like alluvial soil Gleyic rendzina-like alluvial soil
Brown soils Well drained to imperfectly drained soils (excluding Pelosols) with an altered subsurface (B) horizon, usually brownish, that has soil structure rather than rock structure and extends below 30 cm depth	*Brown calcareous earths* Non-alluvial, loamy or clayey, with friable moderately calcareous subsurface horizon	Typical brown calcareous earth Gleyic brown calcareous earth Stagnogleyic brown calcareous earth
	Brown calcareous sands Non-alluvial, sandy, with moderately calcareous subsurface horizon	Typical brown calcareous sand Gleyic brown calcareous sand
	Brown calcareous alluvial soils In calcareous recent alluvium	Typical brown calcareous alluvial soil Gleyic brown calcareous alluvial soil
	Brown earths (sensu stricto) Non-alluvial, non-calcareous, loamy, with brown or reddish friable subsurface horizon	Typical brown earth Stagnogleyic brown earth Gleyic brown earth Ferritic brown earth Stagnogleyic ferritic brown earth
	Brown sands Non-alluvial, sandy or sandy gravelly	Typical brown sand Gleyic brown sand Stagnogleyic brown sand Argillic brown sand Gleyic argillic brown sand
	Brown alluvial soils Non-calcareous in recent alluvium	Typical brown alluvial soil Gleyic brown alluvial soil

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TABLE 1 (*continued*)

Major group	Group	Subgroup
	Argillic brown earths Loamy or loamy over clayey, with subsurface horizon of clay accumulation, normally brown or reddish	Typical argillic brown earth Stagnogleyic argillic brown earth Gleyic argillic brown earth
	Paleo-argillic brown earths Loamy or clayey, with strong brown to red subsurface horizon of clay accumulation, attributable to pedogenic alteration before the last glacial period	Typical paleo-argillic brown earth Stagnogleyic paleo-argillic brown earth
Podzolic soils Well drained to poorly drained soils with black, dark brown or ochreous subsurface (B) horizon in which aluminium and/or iron have accumulated in amorphous forms associated with organic matter. An overlying bleached horizon, a peaty topsoil, or both, may or may not be present	*Brown podzolic soils* Loamy or sandy, normally well drained, with a dark brown or ochreous friable subsurface horizon and no overlying bleached horizon or peaty topsoil	Typical brown podzolic soil Humic brown podzolic soil Paleo-argillic brown podzolic soil Stagnogleyic brown podzolic soil Gleyic brown podzolic soil
	Gley-podzols With dark brown or black subsurface horizon over a grey or mottled (gleyed) horizon affected by fluctuating groundwater or impeded drainage. A bleached horizon, a peaty topsoil, or both may be present	Typical (humus) gley-podzol Humo-ferric gley-podzol Stagnogley-podzol Humic (peaty) gley-podzol
	Podzols (*sensu stricto*) Sandy or coarse loamy, normally well drained, with a bleached horizon and/or dark brown or black subsurface horizon enriched in humus and no immediately underlying grey or mottled (gleyed) horizon or peaty topsoil	Typical (humo-ferric) podzol Humus podzol Ferric podzol Paleo-argillic podzol Ferri-humic podzol
	Stagnopodzols With peaty topsoil, periodically wet (gleyed) bleached horizon, or both, over a thin ironpan and/or a brown or ochreous relatively friable subsurface horizon	Ironpan stagnopodzol Humus-ironpan stagnopodzol Hardpan stagnopodzol Ferric stagnopodzol
Pelosols Slowly permeable non-alluvial clayey soils that crack deeply in dry seasons with brown, greyish or reddish blocky or prismatic subsurface horizon, usually slightly mottled	*Calcareous pelosols* With calcareous subsurface horizon	Typical calcareous pelosol
	Argillic pelosols With subsurface horizon of clay accumulation, normally non-calcareous	Typical argillic pelosol
	Non-calcareous pelosols Without argillic horizon	Typical non-calcareous pelosol
Gley soils With distinct, humose or peaty topsoil and grey or grey-and-brown mottled (gleyed) subsurface horizon altered by reduction, or reduction and segregation, of iron caused by periodic or permanent saturation by water in the presence of organic matter.	1. Gley soils without a humose or peaty topsoil, seasonaly wet in the absence of effective artificial drainage	
	Alluvial gley soils In loamy or clayey recent alluvium affected by fluctuating groundwater	Typical (non-calcareous) alluvial gley soil Calcareous alluvial gley soil Pelo-alluvial gley soil

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TABLE 1 (*continued*)

Major group	Group	Subgroup
Horizons characteristic of podzolic soils are absent		Pelo-calcareous alluvial gley soil Sulphuric alluvial gley soil
	Sandy gley soils Sandy, permeable, affected by fluctuating groundwater	Typical (non-calcareous) sandy gley soil Calcareous sandy gley soil
	Cambic gley soils Loamy or clayey, non-alluvial, with a relatively permeable substratum affected by fluctuating groundwater	Typical (non-calcareous) cambic gley soil Calcaro-cambic gley soil Pelo-cambic gley soil
	Argillic gley soils Loamy or loamy over clayey, with a subsurface horizon of clay accumulation and a relatively permeable substratum affected by fluctuating groundwater	Typical argillic gley soil Sandy-argillic gley soil
	Stagnogley soils Non-calcareous, non-alluvial, with loamy or clayey, relatively impermeable subsurface horizon or substratum that impedes drainage	Typical stagnogley soil Pelo-stagnogley soil Cambic stagnogley soil Paleo-argillic stagnogley soil Sandy stagnogley soil
	2. Gley soils with a humose or peaty topsoil, normally wet for most of the year in the absence of effective artificial drainage	
	Humic-alluvial gley soils In loamy or clayey recent alluvium	Typical (non-calcareous) humic-alluvial gley soil Calcareous humic-alluvial gley soil Sulphuric humic-alluvial gley soil
	Humic-sandy gley soils Sandy, permeable, affected by high groundwater	Typical humic-sandy gley soil
	Humic gley soils (sensu stricto) Loamy or clayey, non-alluvial, affected by high groundwater	Typical (non-calcareous) humic gley soil Calcareous humic gley soil Argillic humic gley soil
	Stagnohumic gley soils Non-calcareous, with loamy or clayey, relatively impermeable subsurface horizon or substratum that impedes drainage	Cambic stagnohumic gley soil Argillic stagnohumic gley soil Paleo-argillic stagnohumic gley soil Sandy stagnohumic gley soil
Man-made soils With thick man-made topsoil or disturbed soil (including material recognisably derived from pedogenic horizons) more than 40 cm thick	*Man-made humic soils* With thick man-made topsoil	Sandy man-made humus soil Earthy man-made humus soil
	Disturbed soils Without thick man-made topsoil	
Peat soils With a dominantly organic layer at least 40 cm thick, formed under wet conditions and starting at the surface or within 30 cm depth	*Raw peat soils* Permanently waterlogged and/or contain more than 15% recognisable plant remains within the upper 20 cm	Raw oligo-fibrous peat soil Raw eu-fibrous peat soil Raw oligo-amorphous peat soil Raw eutro-amorphous peat soil

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TABLE 1 (*continued*)

Major group	Group	Subgroup
	Earthy peat soils With relatively firm (drained) topsoil, normally black, containing few recognisable plant remains	Earthy oligo-fibrous peat soil Earthy eu-fibrous peat soil Earthy oligo-amorphous peat soil Earthy eutro-amorphous peat soil Earthy sulphuric peat soil

Brown earths in reddish Triassic sandstone and glaciofluvial drift and stagnogley soils from loamy and clayey drift predominate east of the Eden. To the west the soils are mainly podzols, typical brown earths and gleyic brown earths on sandy and loamy drift from igneous and Permo-Triassic rocks. There are also stagnogley soils from fine loamy and clayey drift.

The best agricultural soils are typical brown sands and brown alluvial soils in 2·6 m of river Eden alluvium. (Matthews and Kilgour)

Northumberland

Sheet NZ 07 (Stamfordham). Mapping done up to 1966 for O.S. 3rd edition Sheet 14 (Morpeth) was resumed for a 1 : 25 000 sheet area; 25 km^2 were mapped, bringing the total to 87 km^2. Eleven proline cores representing the main soil series have been obtained for description.

The area is part of the gently rolling Northumberland plain. On the ridges better natural drainage gives soils provisionally correlated with the Nercwys (7) series. This also occurs where drift is thin, usually about 1 m, over permeable sandstone. On valley sides, and elsewhere where the drift is thick or over impervious shale, the Brickfield (6) series was mapped.

The drift is mainly non-calcareous, but in some places, usually over limestones, calcareous gley soils occur. The predominant texture is fine loamy but there are small areas of clayey drift with much weathering shale material, giving the Hallsworth (6) series. There are also small areas of shallow soils on sandstone and limestone, calcareous and non-calcareous peat soils and soils on calcareous lake sediments and riverine alluvium. (George)

Yorkshire (North)

Sheets SE 58 (Rievaulx) with parts of SE 49 and 59 (Ryedale). Two composite sheets were chosen to study the use of air photography in mapping the soils at the western end of the North York Moors. Previous mapping by G. D. Anderson (8) and Forestry Commission Staff will be incorporated. An initial reconnaissance was made and 15 km^2 mapped in detail. Map units from the Pickering Moor/Troutsdale area were used and no new units have so far been needed, which suggests that the whole of the North York Moors can be rapidly mapped by small-scale reconnaissance survey. (Carroll and Bendelow)

Sheets SE 79E/89W (Pickering Moor) and SE 88NE/89SE/98NW/99SW (Troutsdale). A further 60 km^2 were mapped and the survey completed; a *Record* is in preparation. (Carroll and Bendelow)

Yorkshire (South)

Sheet SK 59 (Maltby). A reconnaissance survey was made and 17 map units established. By October 55 km^2 was mapped. Soil series include many of those already estab-

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lished on Carboniferous (Coal Measures) and Permian rocks, while many soils in the east are the same as those mapped on Sheet SE 60 (Armthorpe), namely typical, cambic and humic stagnogley soils in sorted Late-Glacial deposits. (Hartnup)

County maps. The 1 : 250 000 map of the West Yorkshire Metropolitan County was compiled. Mapping (350 km^2) in the uplands of the South Yorkshire Metropolitan County was completed. (Carroll and Bendelow)

East Anglia

Cambridgeshire

Sheet TL 18E/28W (Stilton). Fifteen square kilometres of detailed mapping and a further six representative profile descriptions completed this sheet. The *Record* was prepared. Three organic and 25 mineral soils were recognised including three new series. (Seale and Burton)

Sheet TF 00E/10W (Barnack). This district, between Stamford and Greater Peterborough, partly in Cambridgeshire and partly in Kesteven (Lincs.), is over Jurassic rocks extending from the Upper Lias to the Oxford Clay. A reconnaissance was made by traversing geological outcrops shown on Sheet 157 of the Geological Survey. In this relatively drift-free upland, soil and rock type correlate well except at a few boundary zones found by close-spaced augering.

The clay soils of the Upper Lias, Upper Estuarine Series, Blisworth Clay, Kellaways Clay and Sand and the Oxford Clay formations vary greatly in morphology and map units have still to be worked out. The soils usually occur in characteristic positions, as bands between limestone soils, capping hills or in valley bottoms.

The Northampton Sand Ironstone gives a shallow loamy soil over ironstone (Banbury (9) series) in narrow bands on valley sides and on one minor plateau site.

The Lower Estuarine Series has coarse loamy and sandy topsoils over deep, non-calcareous sands.

Soils on limestone are sandy and coarse loamy and often non-calcareous at the base of the Lower Lincolnshire Limestone (Collyweston Slate), calcareous and loamy on the Lincolnshire Limestone plateau, fine loamy and clayey on the Blisworth (Great Oolite) limestone, and clayey on the Cornbrash (Sherborne (9) series). In dry valleys the soils are similar but deeper.

The Upper Estuarine Series also gives whitish, prominently mottled, soils of very variable textures.

Two areas of Chalky Boulder Clay of less than 1 km^2 give soils mainly of the Ragdale (9) series with rare chalk stones.

Larger valleys have fine loamy, highly calcareous, limestone Head soils or recent peat, very calcareous poorly drained loamy alluvium or tufa.

About 30% of the area is covered by loamy and clayey soils on fen or terrace gravels and in alluvium associated with the river Welland issuing into the fenland basin. The sand and gravel is extensively excavated. (Burton)

Norfolk

Sheet TG 11 (Attlebridge). The map and legend were prepared and the *Record* written. Loamy sand or sandy loam topsoils with 15–30% silt and 5–10% clay are common to most of the upland soils as the area is marginal to the Cover Loam district of north-east Norfolk. Two new series were recognised. A typical brown podzolic soil, formerly described as the Freckenham steep slope phase around Beccles (10), was re-

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classified because of much pyrophosphate-extractable aluminium, iron and carbon in the B horizon. Profiles are truncated and associated with slopes steeper than 10°. The second soil is a typical brown earth, coarse loamy over fine loamy formed in drift over fine loamy till. It occurs on flat uplands near the Chalky Boulder Clay–Norwich Brick-earth boundary. (Eldridge)

***Sheet TL 99* (*Caston*).** Following a reconnaissance, 60 km² were mapped by detailed field survey aided by aerial photograph interpretation. The soils are mainly those previously established in the Breckland Forest Survey (11), parent materials being similar. On high ground Freckenham, Worlington and Methwold soils occur; on slopes, Worlington, Moulton, Newmarket and Swaffham Prior (12) series. On low ground hummock and hollow topography is found with complexes of Chippenham (12), Ollerton (formerly Row), Blackwood (formerly Highlodge), Reach (12), Isleham and Adventurers' series. Because the relief in the district is subdued, regional groundwater can influence soils on parts of the relatively high ground. Chippenham and Ollerton series occur in such places, the former in chalky loamy drift and the latter in sand. In the river valleys, Adventurers', Isleham and Willingham (12) soils occur. (Eldridge)

***County map*.** Work on the 1 : 250 000 county map continued and reconnaissance survey was completed for Sheets TF 60, 62, 71, 73, 74, TL 79, TM 08 and TM 48. A mosaic of sampled sheets now covers Norfolk except one in the fens and two half sheets on the north-east coast.

West of the chalk scarp in west Norfolk there are two landscapes. The uplands of the Sandringham Sands have Freckenham and Redlodge series (11) with Adventurers' and Midelney (12) series in peat and clayey alluvium on the adjacent valley floors. The Gault upland has a varying thickness of sandy surface drift and St Lawrence and Wicken series (12) occur. Adjacent valley floor soils are the Ollerton (formerly Row), Blackwood (formerly Highlodge) and Isleham series. These also occur in the smaller valleys of the Sandringham Sands landscape.

The boulder clay landscape in east Norfolk carrying Aldeby (10), Beccles (10) and Ragdale (9) soils extends into Suffolk. In coastal Suffolk a gravel landscape occurs in the area covered by Sheet TM 48 south-east of Wrentham on Crag gravels which include the Westleton Beds. Freckenham soils occur, with loamy sand surface horizons indicating some incorporation of windblown material. (Corbett)

Suffolk

***Sheet TL 76E/86W* (*Risby*).** A reconnaissance was started in May on this Sheet which is immediately adjacent to the eastern margin of 7th Edition Ordnance Survey Sheet 135 (Cambridge and Ely), previously surveyed by reconnaissance. The new district stretches eastwards to Bury St Edmunds and includes the Broom's Barn Experimental Station. The southern part is over Chalky Boulder Clay but the north-west fringes Breckland so that the soils are sandy over chalky or sandy drift, while more loamy soils over similar parent materials occur in the north-east quadrant. Most soils so far recognised were placed within previously described series; Hanslope (9) and Stretham (12) over the Chalky Boulder Clay, Worlington, Moulton, Methwold, Newmarket and Freckenham (11) over the chalky and sandy drift. However, adjacent to the margins of the boulder clay, soils over chalky drift (sometimes calcareous sands) occur with thick red-brown or strong brown non-calcareous flinty clay or sandy clay horizons, sometimes as much as 2 m thick, generally immediately over the chalky parent material and covered in turn by sandy and loamy surface horizons. Such soils occur extensively on Broom's

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Barn Experimental Station Farm, the red-brown clayey horizon possibly being a paleo-argillic B horizon. (Seale)

East Midlands

Derbyshire

County map. Reconnaissance survey for the 1 : 250 000 county map was begun in the High Peak district. About four observations were made per square kilometre and boundaries between associations were mainly drawn from air photographs. The area is over shales, sandstones and gritstones of the Millstone Grit with wide peat-covered plateaux dissected by the Derwent, its tributaries and tributaries of the Mersey.

The blanket hill peat is mainly a raw oligo-fibrous Eriopherum-Sphagnum peat of the Winter Hill (6) series up to 4·5 m thick. In places it extends down to 275 m O.D.

Cambic stagnohumic gley soils of the Wilcocks (6) series are found on hill-tops devoid of peat, while on upper slopes of valleys dissecting the upland, ironpan stagnopodzols (Belmont (6) series) are dominant. The latter are associated with humic rankers of the Revidge series and stagnogleyic brown earths of the Heapey (6) series. Lower slopes on shale-grits often carry typical brown earths of the Ambergate (13) series, while major outcrops of shale carry cambic stagnogley soils of the Dale (5), Bardsey (14) and Ticknall series.

The county includes open moorland with sparse sheep grazing, which is mainly water catchment for the Ladybower and Woodhead reservoir systems. Valley farms are mainly in cattle rearing, with occasional milk holdings. The map will delineate associations dominated by single soil groups (1) with defined proportions of individual soil series. (Thomasson and Reeve)

Lincolnshire

Sheet TF 28 (Donington on Bain). A further 55 km² were mapped in detail. Much of the district is on the deeply dissected Lower and Middle Chalk dipslope, and brown rendzinas of the Andover (15) series are extensive. There are small areas of grey rendzinas of the Upton (15) series but humic rendzinas of the Icknield series (12) are rare. Soils originally mapped as the Icknield brown variant (15) are now placed in the Andover series. Aerial photographs are invaluable for the delineation of dry valleys which contain deep brown calcareous earths of the Coombe (15) series; a shallow phase was also mapped. Hamble (15) soils occur on silty (loessial) drift in some valley heads.

Outcrops of Red Chalk and Carstone on the steep scarp slopes are narrow and are important mainly as sources of drift over the more extensive Lower Cretaceous deposits on footslopes and in the Bain valley. Where these lower deposits are drift-free, calcareous and non-calcareous pelosols were mapped on the Tealby Clay. The Spilsby Sandstone gives typical brown sands and typical brown earths. Soils of the Denchworth (15) and Rowsham (9) series are found on the Kimmeridge Clay, the only Jurassic bed in the district.

Three distinct glacial tills were recognised. The Calcethorpe Till (17) occurs as patches on the Wolds and as a more extensive spread to the west. This very chalky till gives brown rendzinas and brown calcareous earths, the latter occurring also on associated outwash materials. The Wragby Till (17) is of limited extent in the district and gives soils of the Hanslope (9) series. Reddish till of the last (Weichsel) glaciation is in dipslope valleys to the east of the district. A pelo-stagnogley soil with matrix colours of 7·5 YR hue was mapped on this deposit and provisionally called the Hallington series. An unnamed calcareous stagnogley soil was also mapped. A similar till also appears in isolated patches on the lower dipslopes of the Wolds. Flinty silty drift on the Wolds

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gives Rewell (16) and Charity (15) series with soils similar to the Winchester (15) and Wallop (16) series in flinty clayey drift. (Heaven and Robson)

***Sheet TF 45* (*Friskney*).** A reconnaissance survey was made and about 5 km² mapped in detail. The sheet was chosen to represent the silt land of south-east Lindsey and north Holland and has some of the most fertile soils in Britain.

The district can be divided into three: marsh reclaimed from the sea at different times, toft land slightly higher than the marsh and with the main settlements, and fen on the landward side of the toft land. Variation in relief is slight in this flat land and part of the fen is below sea level.

The marsh parent material is mainly calcareous silty or fine sandy alluvium deposited in a tidal environment. The toft land, which was probably a series of low ridges or islands in Roman times, has similar parent material. The fen was originally an estuarine marsh and the deposits here are more variable with non-calcareous clay and calcareous fine sand in complex patterns.

Calcareous alluvial gley soils and calcareous sandy gley soils are in the most recently reclaimed (1947) marsh but gleyic brown calcareous alluvial soils of Romney (18) series with fine sandy silt loam texture are in the earlier reclaimed areas. Romney soils also occur on the toft land with unnamed gleyic brown calcareous sands of loamy fine sand texture. Typical humic-alluvial gley soils of the Downholland (19) series are present in the fen but the plough layers of many clayey soils are no longer humose and Timberland soils were mapped. Romney soils occur on former creek ridges. Grid survey mapping is being used in the fen areas. The district is noted for the production of high quality potatoes and horticultural crops and the toft and marsh land can produce three brassica crops in two years. (Robson)

Nottinghamshire

***Sheet SK 57* (*Worksop*).** The remaining 55 km² of non-urban land were mapped and the final map and legend are being prepared. Twenty-seven soil series were recognised, of which five are new.

The Magnesian Limestone contains many thin reddish mudstone partings which weather to give the soils a brownish colour. As a result, soils formerly correlated with the Wetherby (14) series were renamed Elmton. Loamy brown calcareous earths of the Bramham (14) series are found in valley sites where Head from limestone accumulates to thicknesses greater than 80 cm. Where these soils are of sufficient extent, they form class 1 agricultural land, but they are usually in association with class 2 and 3 soils of the Aberford and Elmton series respectively. Partly de-calcified reddish soils having coarse loamy upper horizons were recognised on certain bands on the limestone but precise classification awaits fuller analytical data.

In coarse loamy drift from Permian sandstones, gleyic brown earths and typical cambic gley soils were mapped as the Arrow and Quorndon series (5) respectively. Where drift from sandstone bands overlies interbedded Permian sandstones and mudstones, the Greinton (20) series, a cambic stagnogley soil is found. Typical podzols of the Crannymoor (4) series occur on parts of the Bunter sandstone outcrop formerly under heath vegetation.

Small areas of Compton (20) and Trent series were delineated on alluvium while fine loamy and fine silty alluvium over limestone gravel was mapped as Creswell series (typical brown calcareous alluvial soil) or Worksop series (gleyic brown calcareous alluvial soil).

Escrick (4) and Flint (2) series were mapped on small patches of till. (Reeve)

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West Midlands

Herefordshire and Worcestershire

Sheet SO 74 (Malvern). Some 70 km² were mapped in detail and the map and *Record* are now being prepared for publication. The legend includes 39 soil series, ten of them new; 25 representative profiles were sampled and nearly 4000 auger borings made which, excluding built-up areas and disturbed land, give an average density of about one boring every 2 ha.

The most extensive map unit is the Bromyard (21) series developed in Devonian marl, occurring mainly around Bosbury and Cradley in the west. The Eardiston (21) series occupies several hundred hectares in the north-west, generally on hills over 152 m O.D. where the shallow phase, with sandstone at less than 40 cm is common.

East of the Malverns around Leigh, Newland and Madresfield soils in fine silty and fine loamy Head over clayey Keuper Marl have been correlated with the Whimple (22) and Brockhurst (3) series. The Welland (23) series has been redefined to include gley soils in very stony fine loamy Head over clayey Keuper Marl and stagnogleyic argillic brown earths in similar parent materials are included in a new, as yet unnamed, series. These two series are extensive in the parishes of Malvern Wells, Hanley Castle and Welland.

Small areas of Newport (4) series occur on terrace remnants at about 91 m O.D. along the Cradley Brook valley. They are closely associated with Newnham (21) soils in reddish brown outwash sands and gravels.

On the Malverns there are brown podzolic soils in Head from a variety of igneous and metamorphic rocks (24) including diorites, granites and hornblende gneiss. The soil pattern is complex but two main soils similar to the Moretonhampstead (22) and Bowden (21) series have been recognised.

The scarp and vale topography formed in Silurian strata west of the Malverns is mostly drift free and soils are in the country rock. Here, previously described soil series were redefined to fit the criteria of the new classification. The Speller and Stanway series (21) are now both defined as stagnogley soils, the Speller series being dominantly clayey over clay shales and mudstones and the Stanway series dominantly silty over siltstones, silty shales and mudstones.

Moisture release characteristics were measured for samples from 20 of the representative profiles and the results will be published in the *Record.*

Samples for thin sections were taken from selected horizons of 22 of the representative profiles. Examination of the sections has helped to confirm the classification of the soils. (Palmer)

Shropshire/Staffordshire

Sheet SO 79E/89W (Claverley). A short reconnaissance survey identified most parent materials present and enabled nine profiles to be described using the new *Handbook* (25).

The area is mainly over reddish sandstones of Bunter and Keuper age, which give a number of prominent escarpments running north to south and north-east to south-west across the sheet. In the south-centre, however, a major fault brings in a wedge of Upper Coal Measures rocks, the Enville Beds, consisting of red marls, sandstones and conglomerates. The district is astride the southern margin of the last glaciation and much land is covered by drift, mainly till and glaciofluvial sand and gravel. Reconnaissance, however, has shown that glaciofluvial deposits are probably far more widespread than previously recorded and that many areas mapped as till are masked by outwash. The drift is reddish and contains many rounded Bunter quartzites and igneous pebbles.

The river Worfe, with its tributaries the Claverley and Stratford brooks, form the main

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drainage system of the region. These valleys are floored by coarse loamy alluvium and flanked by low terraces of sandy material.

The reddish sandstones, till and glaciofluvial deposits all give soils of well established series. The Upper Coal Measures marls, sandstones and conglomerates were not studied in detail, however, and may give a more complex soil pattern, though many soils are also reddish and can probably be correlated with existing series. In the nine profiles described, soils of the Bromsgrove, Blackwood, Newport, Crannymoor (4), Arrow, Quorndon (5) and Clifton (4) series and an unnamed typical alluvial gley soil were identified. Samples for micromorphological and physical studies were taken from all the profiles to assist in their classification using the new system (1). (Hollis)

Staffordshire

Sheet SJ 82 (Eccleshall). The remaining 15 km² were mapped in detail and the map and explanatory text prepared for publication. The soil pattern is complex, with 20 soil series and three miscellaneous land types.

The Clifton (4) series is the most extensive map unit with the Whimple (22), Salwick (4), Wick (4), Flint (2), Brockhurst (3), Salop (3), Quorndon (5), Arrow (5) and Worcester (9) series covering much of the remaining land.

Soil moisture release characteristics for 15 soils were determined and will be published in the *Record*; 64 thin sections for the same series have been examined at Headquarters. They proved valuable in identifying argillic horizons, and contributed significantly to the successful application of the new classification. (Jones)

Sheet SK 12 (Draycott in the Clay). This district was chosen to represent soils in the Upper Keuper Marl and drift deposits east of Cannock Chase. A reconnaissance survey has been made, and 3 km² mapped in detail.

The district is over Keuper Marl, with outcrops of Tea Green Marl and Rhaetic shales along the Marchington escarpment. Further east at Tutbury, where this scarp becomes less pronounced, gypsum occurs in bands within the Keuper Marl in commercially exploitable quantities. In the south-east, near Dunstall, the first terrace of the Trent is represented whilst in the north the Dove winds across a broad valley filled with alluvium at the foot of the Keuper scarp. The area on Keuper Marl is dissected by the river Swarbourn and Pur Brook which flow southward to the Trent. Much is covered by glacial till with a limited extent of glaciofluvial deposits.

Soils of the Worcester (9) and Spetchley (23) series were identified where the Keuper Marl is drift-free and on the till the Salop (3) series appears to be dominant, though profiles of the Crewe (2), Clifton (4) and Flint (2) series were also observed. At the crest of the scarp near Hanbury, Chalky Boulder Clay gives soils of the Ragdale (9) series. The Brockhurst (3) series occurs where thin drift overlies the Keuper Marl and soils approximating to the Hurcot and Belvoir series (9) occur on Tea Green Marl and Rhaetic shales respectively. The Newport (4), Ollerton (3), Blackwood (4) and Quorndon (5) series were identified on glaciofluvial deposits and an unnamed series on brown silty alluvium occurs in the Dove valley. Eight representative profiles were sampled for physical, chemical and micromorphological analyses. Field descriptions of the soils were made in accordance with the new *Handbook* (25). (Jones)

Sheet SK 05 (Onecote). A further 28 km² were mapped in detail and the map and *Record* prepared for publication. Twenty-two map units were recognised of which four were composite and 18 characterised by a single soil series. Wilcocks (6), Dale (14) and Brickfield (6) map units are by far the most extensive. Dunkeswick (14), Malham (26), Alton (27) and Onecote are less important but cover substantial areas.

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The legend includes 20 series, five of which, the Wetton, Revidge, Grindon, Ipstones and Onecote were established during the survey.

Soils of the Roddlesworth (6) series are of limited extent; they are similar to those of the Wilcocks series and are included in that map unit. Many soils provisionally correlated with the Nordrach (20) series earlier in the survey proved on analyses to be clayey throughout, with very clayey Bt horizons developed entirely in limestone residue; they are now correlated with Ogwell (22) series. The Lulsgate (20) series over limestone is divided into two small groups in the new classification; most profiles qualify as brown rankers and are correlated with the Crwbin (28) series, others are typical brown earths and are included with the Malham map unit.

Physical characteristics of the soils were determined using 72 triplicate samples from selected horizons of 27 profiles and thin sections for micromorphological analysis were made for all but five of the series present. The results proved very useful in classifying many soils, especially the surface-water gley soils and those in argillic subgroups. (Hollis)

Warwickshire

Sheet SP 47/SP 48 (Rugby West/Wolvey). This district is mainly on Wolstonian tills and outwash deposits of Devensian age with small outcrops of Lower Lias clay and Keuper Marl.

A reconnaissance survey on selected farms established 19 map units and half of the 200 km^2 were mapped in detail. Soils of Evesham (9) series were mapped on small exposures of Lower Lias clay in the southern parishes, with stagnogley soils of the Rowsham (9) series where thin clayey drift overlies the clay *in situ*. Small areas of Worcester (9) series occur on the Keuper Marl at Princethorpe. The northern part, including most of sheet SP 48, is covered by Chalky Boulder Clay and thin cover sands. Small streams have cut into the till and exposed the Wolston Sands along the valley sides. The soils in the tills are mainly of the Oak (29), Beccles (10) and Ragdale (9) series. Fine loamy cambic gley soils occur in the thin interglacial sand deposits and Wick (4), Arrow (5) and Newport (4) soils in the outwash sands of Wolvey Heath. The southern part is covered by reddish till derived mainly from Triassic rocks and there are extensive sandy outwash caps on the high ground of Dunsmore Heath. Salop (6) and Flint (2) soils are mapped on the till and Arrow series and gley-podzols, tentatively correlated with the Reaseheath (2) series, were mapped on the Dunsmore Gravels. Astley Hall (2) soils occur where the coarse loamy drift thins over till at the edge of the gravels.

The Avon has cut a valley about 2 km wide from Brandon to Rugby along which are a series of gravelly terraces. Soils are mainly the Wick and Arrow series with Fladbury (9) series in the clayey river alluvium. (Whitfield and Beard)

South-east England

Berkshire

County map. The engineering tests on samples from horizons of different soil series have been extended to include soil strength tests. The Rothamsted computer calculated means and variances of soil properties such as stoniness and depth to calcareous horizons for soil profile data at grid intersections. (M. G. Jarvis and Hazelden)

Essex

Sheet TL 71 (Little Waltham). The remaining 9 km^2 were mapped, and a further five pits described and sampled. Subgroup names of the new classification (1) were applied

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and parent materials grouped to aid identification of soil series. The information will contribute to the County map and *Bulletin*. (Allen and Sturdy)

***Sheet TM 12* (*Weeley*).** Some 45 km² were mapped in detail, and 16 pits and 17 proline cores described.

Further mapping revealed a more complicated pattern of soil distribution than the initial reconnaissance indicated. The cover loam is relatively thin (<70 cm) and much affected by the lithology of the deposits immediately below. These vary within the upper 1–1·5 m, reflecting cryoturbation and a pattern of deposition not fully worked out. Around Horsley Cross in the north-west on a slight ridge of higher ground, cover loam overlies reddish loamy and clayey gravel, and gives paleo-argillic stanogley soils, stagnogleyic paleo-argillic brown earths, and locally to typical paleo-argillic brown earths. Here the compact nature of the reddish gravel seems to be the cause of stagnation of surface water. At lower elevations, towards Great Bentley and Thorpe-le-Soken, a nearly stoneless grey or grey and yellowish mottled clayey or fine silty deposit, apparently patchily distributed, gives typical stagnogley soils and stagnogleyic brown earths which resemble the Ratsborough series in the Burnham-on-Crouch district.

Gravels with a sandy matrix underlie these more loamy and clayey deposits and constitute an aquifer, giving springs at the surface in local patches on valley sides. Cambic gley soils, sandy gley soils and gleyic brown earths or gleyic brown sands were mapped. Underdrainage has controlled the height of the water-table in most of the area, but occasional humic gley soils occur on undrained land.

Downslope from the gravels, Windsor, Wickham (29) and Althorne series (a pelosol on London Clay) were mapped, with Ferrel (29) series on clayey footslope deposits, and an unnamed stagnogley soil in grey fine silty deep colluvium. (Allen, Sturdy and Krul—student worker)

Kent

County map. About 15% of this large county (3730 km²) has been mapped at 1 : 25 000 (Sheets TR 04 (Ashford), TR 35 (Deal), TQ 86 (Rainham), TQ 64 (Paddock Wood) and Romney Marsh). With help from the detailed surveys, geological maps and air photographs surveying was directed towards a soil association map of the county at 1 : 250 000. A provisional map and legend with 15 soil associations was prepared, five of which were tested by random sampling. Seven hundred square kilometres were mapped, the observations averaging 1·5 borings per km². In some places, as on the London Clay plateau of the Blean, subordinate soil series proved less common than anticipated. Surveying along selected traverses largely confirmed the provisional soil associations and boundaries.

Wide trenches to install a sewage pipeline from Leeds to Kingswood yielded much useful information about paleosols in or over Angular Chert drift, and five representative profiles were described and sampled.

The character of brickearth in many places reflects the particle-size characteristics of associated solid strata; those near or over sandy Woolwich Beds tend to be less silty than usual (sandy silt loam and/or clay loam) and others associated with London Clay tend to be relatively clayey (silty clay loam). Also, some brickearth associated with paleosols in Angular Chert drift has an unusual reddish hue, and profiles have been sampled for further investigation.

Clayey alluvial gley soils of selected North Kent Marshes were randomly sampled to determine salinity and surface organic matter content means and variances. Calcareous profiles occur sporadically in these mainly non-calcareous marshlands, some roughly

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aligned with infilled chalk valleys nearby and probably in alluvium laid down by former streams.

Deep valleys traversing the Greensand ridge south of Maidstone have complex, cambered slopes with belts of contrasting soils aligned with contours. Wide clefts or gulls between ragstone masses have varied soils in thick drift, partly brickearth, which contrast sharply with shallow to moderately deep soils over the ragstone. Where the latter is quarried the drift-filled gulls are left as free-standing ridges arranged *en echelon*. Ridge-and-hollow relief is another natural phenomenon giving widely different soils. It was briefly examined on high valley slopes west of Maidstone where there are natural hollows up to 40 m wide and 6 m deep, some extending over 300 m. (Green and Fordham)

***Sheet TQ 86* (*Rainham*).** The soil map and *Record* were completed, and a land use capability map and report prepared jointly with ADAS staff. (Fordham and Green)

Oxfordshire

***Sheet SP 30* (*Witney South*).** Seventy-two square kilometres were mapped and 17 profile pits described and sampled. Water levels were monitored throughout the winter at eight dipwell sites and at each the soil profile was described and sampled for determination of moisture characteristics. Draw-down tests to assess permeability were attempted but were only partially successful because of low water levels during the winter.

Pelo-stagnogley soils (Denchworth series) and typical calcareous pelosols (Evesham series) in Oxford Clay are scarcer than previously reported and most of the clay country is covered by thin fine loamy or clayey Head with typical stagnogley soils (Rowsham series) common. There are many clayey calcareous pelosols (Evesham series) in Forest Marble clay in the north-west of the district however. (M. G. Jarvis and Hazelden)

South-west England

Avon

***County map*.** Approximately 15% of the unmapped portion of the county, 80 km², were mapped in detail. Twenty sample blocks of 4 km² each were arranged to examine all the major soil associations predicted from existing soil surveys and by inference from geological maps. In each block a free survey established the soils present and their relationship to landscape. In the next stage these patterns will be extended to the remaining areas using geological maps and aerial photographs. The content of soil groups in the most extensive associations will be checked by means of grid sampling. (Colborne)

Cornwall

***Sheet SW 53* (*Hayle*).** A reconnaissance survey was made and 27 km² mapped in detail. The district covers part of lowland west Cornwall and is important horticulturally. Devonian slates underly much of the land but part of the Lands End granite outcrops to the west and a small but prominent granite boss occurs in the south-east. Blown calcareous shell-sand forms about 2 km² of dunes north of Hayle. The ground is gently undulating and mostly below 105 m with a few granite hills rising to 180 m.

The Devonian slates carry soils like those in south Devon and north Cornwall on similar formations (22). These soils are normally acid or neutral in reaction but a long tradition of heavy liming with dune sand from Hayle has produced many calcareous topsoils. Similarly, parts of Gulval and Ludgvan are occupied by man-made humus soils which have resulted from the addition, over long periods, of seaweed, town refuse and less calcareous beach sand from Mounts Bay on the south coast. Surface textures are

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coarse loamy or sandy with fine loamy B horizons. Complex soil patterns are found in and around the Hayle estuary where blown sand, sandy and silty alluvium occur together.

Moretonhampstead (22) soils are widespread over much of the lower granite outcrop whilst the higher moorlands support Moorgate, Hexworthy and Rough Tor series. Coarse loamy humus-ironpan stagnopodzols and typical podzols also occur. In places soils on the granite have large silt contents, probably from Pliocene deposits at around 130 m.

Relicts of 19th-century mining abound in the district and soil samples were taken with which to establish the extent of pollution by arsenic and other metals. (Staines)

Devonshire

***Sheet SS 61* (*Chulmleigh*).** This district occupies part of the middle Taw valley and is over the Carboniferous Welcombe Formation. A reconnaissance survey was made and a mapping legend adopted, about 30 km² being mapped in detail.

Unlike other parent materials of Carboniferous age in Devon, the Welcombe Formation has as yet received little study. It comprises even-bedded sandstones and shales, broadly similar to the Crackington Formation.

The Chulmleigh district represents the rolling plateau country of mid-Devon, rising above 200 m O.D. but sharply dissected along the Taw valley to below 30 m. Remnants of the plateau are extensively preserved on the Taw–Torridge interfluve near Ashreigney and Burrington.

Soils on the plateau remnants are comparable with those mapped on similar land around Holsworthy over the Bude Formation (30). Head from sandstones, siltstones and shales, thicker than 1 m, is the main parent material, soils with rock within the profile being of limited extent. Gently convex areas have fine loamy typical brown earths of the Pyworthy series and stagnogleyic brown earths of the Holsworthy (fine loamy), Stanley (fine loamy over clayey) (22) and Halstow (clayey) (22) series. Individual series are not separable at the scale of mapping adopted. Similarly, broad concave basins and some flat ridge crests carry cambic stagnogley soils of the Tedburn (clayey) (22), Brickfield (fine loamy) (6) and Greyland (fine loamy over clayey) series. Unlike the Holsworthy district, the major group of brown soils is most extensive, particularly along the plateau margins where it merges to stronger slopes down to the Taw and its tributaries.

Along the steep valley sides parent material is thick rubbly Head, comparable in composition with that on the plateau remnants, though rock is close to the surface on abrupt convexities (naps in local parlance). Soils are well drained and fine loamy. Typical brown earths of the Pyworthy series, having drab ill-differentiated B horizons occur near profiles (classed as typical brown podzolic soils) in which B horizons are brightly coloured and react to the allophane test.

Along the marshes of the Taw floodplain thick silty and loamy alluvium contains stoneless typical brown alluvial soils, with gleyic brown alluvial soils and typical alluvial gley soils confined to backlands close to the valley sides and along narrow linear depressions (pans) on the floodplain. (Harrod)

***Sheet SS 63* (*Brayford*).** A reconnaissance survey was made and 32 km² mapped in detail. The district lies between Barnstaple to the west and Exmoor to the east and across a variety of Upper Devonian rocks. From north to south Morte Slates, Pickwell Down Beds (sandstones), Baggy Beds (slates, cleaved sandstones and siltstones) and Pilton Beds (slates) form parallel outcrops trending WNW–ESE across the area and dipping to the south. The landscape consists of a plateau at about 150 m in the south-west rising to 300 m in the north-east but strongly dissected in the east by the river Bray and its tribu-

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taries draining southwards and in the west by the river Yeo and its tributaries draining westwards. In the extreme north-east, the land rises to 400 m on the flanks of the Exmoor upland whereas valley floors in the south-west are at about 30 m.

Soils in the southern part of the district are mostly from slaty rocks and similar to those described in South Devon (22). They are loamy typical brown earths with brown podzolic soils on steep valley sides and brown rankers on ridge crests. Alluvium is confined to narrow strips and is loamy and sandy with an intricate pattern of soils ranging from well to poorly drained.

The coarser grained rocks of the Pickwell Down Beds give soils similar to those on slaty rocks with the addition on some flat or gently sloping interfluve land, more recently enclosed, of cultivated ferric and ironpan stagnopodzols and cambic stagnogley soils of loamy and sandy texture. Typical podzols occur on steep slopes with northerly or easterly aspect, though opposite facing slopes have typical brown podzolic soils.

The Morte Slates have loamy typical brown earths and brown podzolic soils on a variety of ground. Discrete flush sites on the Exmoor flanks have loamy cambic stagnogley and stagnohumic gley soils, and peat soils in which the peat is about 50 cm thick. (Hogan)

Wiltshire

Sheet SU 05N/06S (Devizes). A further 25 km^2 of mapping completed the survey of this district. About one-third is on Lower Chalk, thin marly beds overlain by harder greyish chalk. Shallow fine silty rendzinas (Wantage (12) series) are extensive on gentle to moderate convex and even slopes. On concave slopes in shallow combes and on foot-slopes at lower levels fine silty deep rendzinas (Gore (15) series) are common and grade locally into clayey variants; both developed in soft marly chalk or derived marly Head or colluvium. On the northern side of the Vale of Pewsey these soils pass downslope into clayey gleyic rendzinas in which the chalky drift is temporarily waterlogged as indicated by ochreous mottling. (Findlay and Cope)

Wales

The new counties and districts introduced this year by the Local Government Act 1972, result in amalgamation of the sparsely populated former counties, while Glamorgan is subdivided into three. In most cases the old boundaries, and some of the old names, are preserved in the districts within the new counties. The programme of county mapping, at an advanced stage in Pembrokeshire, will continue so that, for example, the 1 : 250 000 county sheet for Carmarthenshire will now include the Carmarthen, Dinefwr and Llanelli Districts of Dyfed.

Clwyd

Sheet SJ 35 (Wrexham). Field work was completed with the mapping of a further 35 km^2 and the *Record* is being prepared.

Soils with paleosol features, described in northern England (31) were recognised in the district and at places elsewhere. A distinct reddish brown to yellowish red (5 YR 4/4–4/6) clay-enriched (Bt) horizon occurs above calcareous gravel in sand and gravel pits on the Wrexham Delta, especially in an esker near Gwersyllt where the stones are cemented by efflorescent calcium carbonate. Above the clay, a more recent profile has developed with a weathered B horizon. (Lea and Thompson)

Sheet SJ 17 (Holywell). Reconnaissance began with the mapping of 3 km^2 and the description of 20 profiles.

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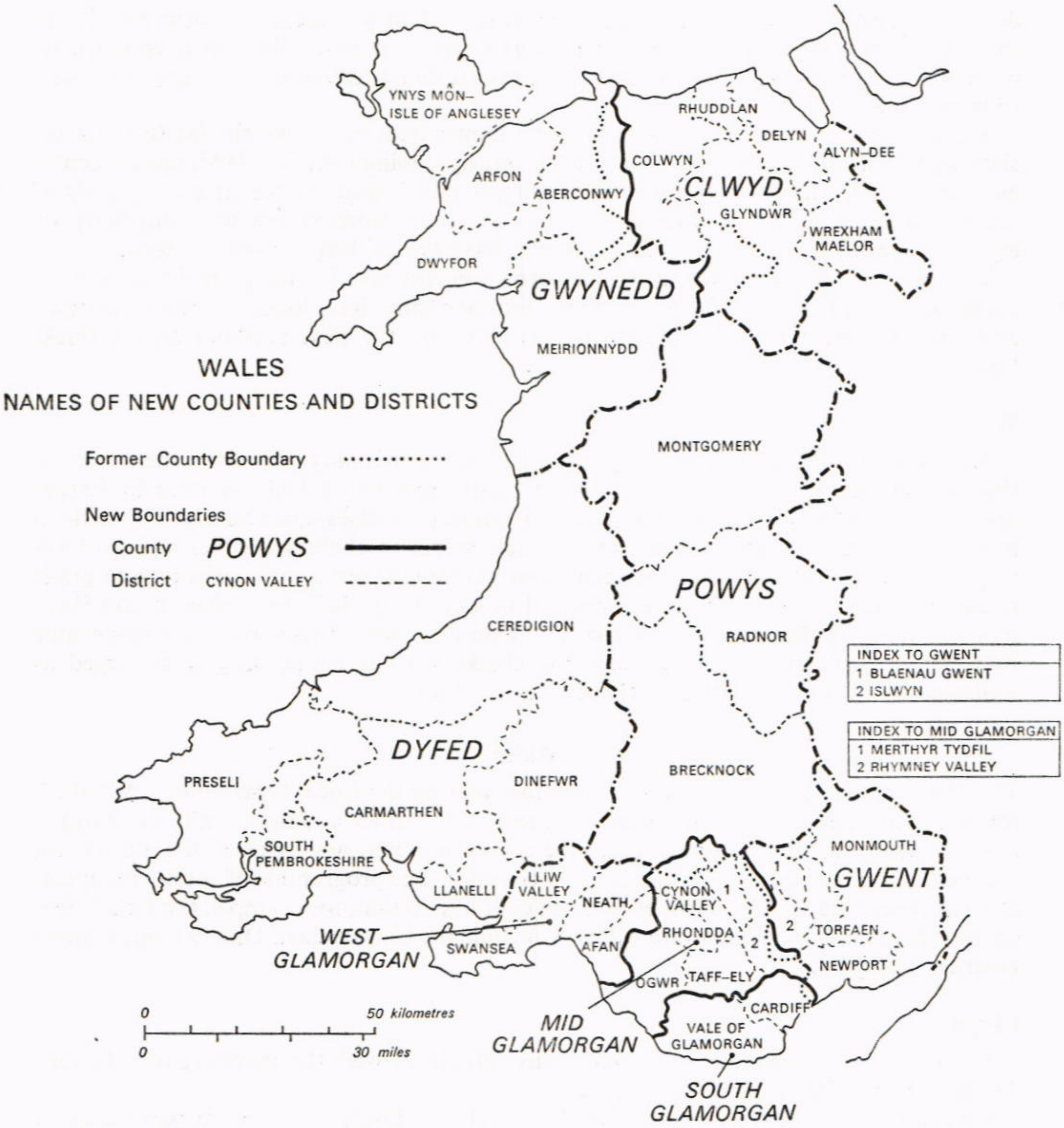

(From Welsh Office map, Crown Copyright 1973)

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The district, which lies west of the Rhyl and Denbigh sheets (32), is between the Clwydian range and the Dee estuary. The highest ground (400 m) is in the south-west and forms part of the Clwydian range of Silurian mudstones. A broken ridge running from south-east to north-west marks the easterly extent of the Carboniferous Limestone and adjoins Lower Palaeozoic rocks to the west. The land between the limestone ridge and the Clwydians is at 180–220 m. Limestone can be reached within 1 m over much of this ground but is covered by thicker drift to the north-west; there is also a thick drift mantle extending from the Dee estuary south-west to the limestone ridge. The glacial history of the district is complex and glaciofluvial deposits are extensive along the limestone ridge and in the main valleys.

The soils in drift over massive limestone are mainly loamy and rendzinas, brown calcareous earths, brown earths and argillic brown earths have been recognised. In some there is a thin layer of reddish brown clay above the limestone while, in others, yellowish brown clay occurs. Indurated layers are found in many profiles both over limestone and in thick drift. Cambic stagnogley soils of the Cegin (32), Hallsworth (6), Brickfield (6 and Dale (14) series are present, as are typical stagnogley soils of the Salop (6) and Clifton (6) series. Soils in the red sands and gravels of the Wheeler valley are of the Newport (4) and Crannymoor (4) series. (Thompson)

Dyfed

Sheet SN 24 (Llechryd). Initial reconnaissance of the district (121 soil profiles described at 1 km intervals) showed considerable variation in soil parent material which includes sand and gravel, lake clay deposits, and local drift from Lower Palaeozoic mudstones and sandstones. The sand and gravel are of Pleistocene age (Upper Devensian) but their distribution and origin have been the subject of much speculation. Theories are divided into those attributing their origin to a south Wales end-moraine and those suggesting the mounds are kames, developed from stagnant ice. Laminated clays demonstrate the existence of glacial Lake Teifi. They were mainly found across the south, up to 3 km from the present course of the Teifi, and were also noted in profiles near the sand and gravel deposits in the north-west. The Teifi flows through two subglacially cut gorges at Cilgerran and Cenarth, which are paralleled by drift-plugged former courses at Castle Malgwyn and Coed-y-cwm. Seismic investigations of these channels have shown a maximum of 70 m of glacial material over the Ordovician rock floor of the pre-glacial Teifi. (Bradley)

Sheet SN 50 (Llanelli North). A further 45 km^2 were mapped. The remaining 10 km^2 of agricultural land is mainly east of the Loughor in West Glamorgan. Among the typical brown earths in glaciofluvial deposits of the Loughor valley, coarse loamy soils (Radyr (33) series) are distinguished from soils in coarse loamy material over gravels (Ellerbeck (6) series), though difficulty was experienced in following the distinction made in Glamorgan between shallow Neath and deep Radyr soils (33). Correlation with soils in similar materials in England was stimulated by a meeting of the Northern Soils Discussion Group devoted to soils in non-calcareous Carboniferous rocks and derived drifts. (Clayden and Gibson)

Pembrokeshire. A further 255 profiles were described and sampled at 1 km intervals to complete the grid survey of the former county, now the Preseli and South Pembrokeshire districts of Dyfed. Map units from aerial photographs are being drawn for a 1 : 250 000 map and will be described in terms of the proportions of soil classes they contain as estimated from the grid profiles.

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Some soils in the north-east (SN 14) are in materials not found elsewhere in the survey. Hard Silurian greywackes give stony and occasionally bouldery soils related to the Denbigh (34) series but with darker brown, locally humic, topsoils over strong brown subsoils which are distinctly sesquioxidic in places. Sporadic thin iron pans emphasise the traditional nature of the more humic of these soils towards podzols. Drift associated with the southern edge of Devensian ice is widespread as hummocky sands and gravels on the north Pembrokeshire plateau, pink-tinged Irish sea boulder clay, and lacustrine clay and sands of the former ice-dammed Lake Teifi south of Cardigan. Soils on the sands and gravels are related to the Cashfield series but those in the other deposits have not yet been named. The drift deposits continue on to Sheet SN 24 (Llechryd), where they will be studied in more detail.

Soils were examined on Skomer island and relationships with vegetation noted. Shallow and deep stony rankers and brown earths (some sesquioxidic) underlie much of the bracken and dry grassland; gley and humic gley soils were recorded in the wetter hollows with *Molinia* tussocks. Hummocky and soft land surfaces with many rabbit warrens, with sea bird colonies and a lack of farm animals for some 15 years make the island of particular interest for soil studies. (Rudeforth and Bradley)

***Sheet SN 13* (*Eglwysw-rw*).** Mapping was completed (5 km^2) and the *Record* prepared.

A number of sites were re-examined to apply the field criteria in the new classification for the separation of brown podzolic soils from brown earths and gley soils from stagnogley soils. While most well drained soils with Ap horizons (mapped in mull phases) have subsoils meeting the chemical requirements of podzolic Bs horizons, field assessments of structure and consistence suggest that the complementary pellety fabric is often absent and the soils intergrade between podzolic and brown soils. By contrast the B horizons of the soils under heathy grassland distinguished as mor phase units generally have stronger podzolic characters and are unequivocally typical brown podzolic soils.

The hydromorphic soils map units named by stagnogley or gley series include some aberrant soils in which the cause of wetness is not clearcut. (Bradley)

Supporting research

A2. General soil classification

The new classification (1) was used to construct legends for eight completed 1 : 25 000 soil maps and others in hand, two county maps (1 : 250 000) and a national map (1 : 1 000 000). To apply the system consistently, many established soil series concepts were redefined to accord with the prescribed class limits, some were abandoned or combined, and others created.

The experience gained in applying the system indicated where minor amendments seem desirable. A *Technical Monograph* describing it in detail is well advanced. (Avery)

A3. Land capability classification

Alternative maps were drawn by computer showing land use capability classes automatically assigned to 1600 profiles in the former county of Pembrokeshire. The first maps follow the Survey guidelines (35) with and without the suggested limit of 50 in. annual rainfall for class 3 and better land. A second series of maps were derived by scanning site and soil properties with selected crops for maximum and minimum values, then plotting all other sites whose properties lie within the range for each crop. In this way maps are produced of potential crop land under present economic conditions. Alternative strategies for this feedback technique are being studied. (Rudeforth)

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Crop yield and soil type. Soil maps with a simplified legend were prepared for eight farms in the Weeley district of Essex (Sheet TM 12) and farmers interviewed using a standard questionnaire. Details of management practices and problems were related to soil map units and estimates of average cereal yields later checked by measurement within map units. For wheat, the greatest yields (average over several varieties—5·9 t/ha) were on soils of the Windsor series (29), and the smallest (average 4·9 t/ha) on paleo-argillic stagnogley soils in cover loam. The same pattern emerged for barley, although yields were less, and as expected yields of both crops were small for map units with mainly sandy soils, but were not always the least recorded. (Allen, Sturdy, Krul (student worker) and ADAS staff)

Measurements of barley yields on Freckenham (10), Hall (10) and Sheringham soils occurring within the same field on the Cromer Ridge (Sheet TG 13/14) showed significant differences in yield in 1972, attributed to differing soil moisture resources associated with the different silt contents. In south Norfolk (Sheet TM 28) barley and wheat yields in 1972 from fields on Aldeby (10), Beccles (10) and Ragdale (9) map units showed a non-significant trend of increasing yield from the Aldeby to the Ragdale units, these being over Chalky Boulder Clay with decreasing proportions of sandy drift incorporated in upper horizons. The sampling was repeated in 1973 as far as possible within the same fields. (Eldridge and Allison—student worker)

A4. Data storage and retrieval

A computer program was prepared for calculating accumulated temperature, above a base temperature of 6°C, and accumulated frost, at both station altitude and at 61 m contour intervals above for stations listed by the Meteorological Office. (Webster and Bendelow)

A6. Soil moisture and soil temperature studies

These were started at Calthwaite in Clifton (4) soils. In the mild 1972/73 winter there were 36 frost heaves, all less than 5 mm. As in Yorkshire in the previous 10 years there were no heaves before early November; but in October 1973 a heave occurred in mid-month when the ground was frozen to 3 cm depth. (Matthews)

B1. Soil water/air regimes

Over much of mid-Devon cambic stagnogley soils are weathered in the upper part of thick (1–4 m) Head from the Carboniferous rocks below. The lower layers of Head are often open and can be aquiferous. On the shaly Crackington Formation the soils are uniformly clayey (Tedburn (22) series) but on the more arenaceous Bude Formation stagnogley soils can be of coarser texture.

Local practice over much of the district is to place drains at 2–3 m depth without permeable fill, to remove underwater which is a problem locally because it reaches the surface under hydrostatic head. Substantial outfalls of water can be produced and carried by this type of drainage system, which, however, contrasts with the shallower drainage adopted elsewhere in the country on fine textured stagnogley soils where the intention is to remove surface water.

At Strawberry Bank near Holsworthy sufficient hydrostatic potential was confirmed beneath a field of Tedburn soil to raise water above the ground surface. Subsequent drainage at >2 m depth removed the potential although improvement of surface soil over most of the field was not dramatic. It seems likely that in shaly areas with a continuous clayey soil mantle water is effectively sealed into the basal Head. However, over

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the Bude Formation stagnogley soils are varied in texture and in coarser textured profiles upward movement of water to the soil surface could occur more readily.

To determine the proportion of mid-Devon stagnogley soils having groundwater with high hydrostatic head, piezometer observations were started. Tubing was inserted into the more permeable and little weathered basal Head to depths as great as 3 m at 20 sites around Holsworthy and Chulmleigh. Shallow dipwells will be observed at several sites to investigate the relationships between soil surface wetness and groundwater regimes, particularly where positive hydrostatic potential is present. (Harrod)

The hydrology of a group of soils mapped on Sheet SX 47 (Tavistock) and similar soils subsequently recognised on Sheet SS 63 (Brayford) was studied. These are loamy soils in slate and slaty Head, and intergrades between the stagnopodzol and stagnogley soil groups. Analyses indicate the presence of a podzolic B horizon in some places. The upper horizons are mottled with grey colours, ochreous weathered stones and local incipient ironpan formation. Profiles become browner and less mottled with depth. It is not known if the gleying is relict or indicates the current hydrologic situation. Dipwells of varying depth were put in and water levels are being recorded over complete wetting and drying cycles throughout the year. Shallow wells to 30 cm into mottled horizons are to contrast with deeper wells below 60 cm into brown subsoil horizons in similar soils. (Hogan)

Winter water-levels were recorded at 41 dipwells in Escrick, Foggathorpe and Thorner soils (14) in the Boroughbridge district. (Hartnup, Bendelow and Briggs)

Water-level readings were continued for a third year in 9 soil series at the Cheshire College of Agriculture. (Furness and S. J. King)

Water table levels were observed in 22 places in Essex during the winter of 1972/73, four with the help of the Drainage Arm of ADAS. Abnormally little rainfall in the winter led to a late return to field capacity or even failure to return at all, and observations will be continued for a second winter. Undrained Ragdale and Windsor soils (29) showed the highest levels and are likely to conform to the poorly drained class in a normal winter. (Allen and Sturdy)

During 1973 records of water-tables in the Dale, Ticknall, Fladbury, Quorndon and Arrow soils were accumulated from the Melbourne area (Sheet SK 32E/42W).

Water-table observations from the whole of England and Wales from 1963 to 1973 were analysed in relation to soil profile morphology and selected climatic parameters. These include some 300 site/years and form a unique body of information. We are grateful to other organisations cooperating including the Agricultural Development and Advisory Service, the Meteorological Office and the Forestry Commission. (Thomasson)

Water-table levels in Brockhurst and Whimple series were recorded on four sites near Leamington Spa. (Whitfield)

C1, 2. Particle-size and chemical analyses

Soil sample preparation and storage facilities were moved to the new Service building recently completed.

Horizon samples from 400 profiles described in the mapping programme were analysed. Samples from Rothamsted and elsewhere were also analysed, at the request of the Nematology, Pedology, Chemistry and Insecticides and Fungicides departments.

Determinations were made as requested by surveyors and others. On mineral soils they included: air-dry moisture; particle-size distribution; loss on ignition; organic carbon; exchangeable cations; cation-exchange capacity; pH in water and in 0·01M $CaCl_2$; Fe, Al and C extracted by 0·1M potassium pyrophosphate; dithionite-extractable Fe and Mn; $CaCO_3$ (in the <2 mm sample and other particle-size fractions), water- or

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acid-extractable sulphate and analyses of saturation extracts. Bulk density, water-holding capacity, 'rubbed' and 'unrubbed' fibre contents, dry matter, ash, pH, nitrogen and colour of pyrophosphate extract were determined on peat soils. (Bascomb and Thanigasalam)

C3. Mineralogical analysis

The mineralogy of the $<2\ \mu m$ fraction of 80 samples from 46 profiles taken from four districts in Devon and Staffordshire was determined by X-ray diffraction supported by measurements of cation-exchange capacity and non-exchangeable potassium.

The clay fractions from soils from Carboniferous rocks in the Holsworthy district of Devon had at least twice as much mica and less expansible minerals than those from near Onecote in Staffordshire. The soils from Triassic mudstones from the Eccleshall district of Staffordshire contained mainly mica and chlorite (including swelling chlorite) in their clay fractions and a similar mineral suite in the associated soils in reddish drift confirmed that the drift is largely derived from Triassic mudstones. The clay mineralogy of the soils from the Tavistock district of Devon was more variable, and reflected the variation in parent material. On granite, the crystalline clay fraction was mainly kaolinite, chlorite and mica, on dolerite chlorite with less mica and kaolinite, and on Devonian slates mica. (Bullock and Mrs. P. Murphy)

An investigation has begun to see how the mineral content of soils in Permo-Triassic drifts in Cumbria and Cheshire varied and if soil series can be differentiated by their mineralogy. Heavy mineral analysis was started on the fine sand fraction of 20 samples and an analysis of clay content begun on selected soils. So far there are marked differences in mineral content, augite being especially prominent in the Cheshire soils. (Kilgour)

C4. Soil micro-structure

Five hundred thin sections of soil samples were made of which 240 were described in detail. The remainder were described by field staff or added to the reference collection. Samples described were mainly from districts in Essex, Kent, Norfolk, Staffordshire and Warwickshire, of soils encountered in the current mapping programme, and particularly help to identify argillic horizons containing translocated clay. Thin sections were also made to measure and characterise voids. With the acquisition of an image analysing computer ('Quantimet'), this aspect of the work is being given more emphasis. (Bullock, C. P. Murphy and S. C. Smith)

C5. Physical measurements (volumetric basis)

Moisture release properties were determined for eight soil profiles from Avon, Derbyshire, Essex, Gloucestershire, Herefordshire and Warwickshire.

A laboratory method of determining unsaturated hydraulic conductivity using a double membrane pressure apparatus was examined. It proved very difficult to obtain meaningful results from normal soil cores submitted for moisture release determinations and work has been discontinued for the present.

Measurements of shrinkage in clay subsoils were made using clods of about 200 cm^3. Results are reproducible provided the original sample is taken at near field capacity and does not require wetting in the laboratory.

Determinations of saturated hydraulic conductivity were made in Dale, Ticknall, Fladbury and Quorndon soils on Sheet SK 32/42 by the auger hole method. (P. D. Smith)

The Survey now has two Gamma Transmission sets to measure bulk density, in use in Wales and the South-west Region.

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D2. Shallow soils over chalk

Particle size and mineralogical analyses of three different rendzinas (Icknield, Andover and Upton (15)) over Upper Chalk in central Wiltshire showed they contain much non-calcareous silt composed of detrital quartz grains, some alkali feldspar, and some flint, with small amounts of non-opaque heavy minerals dominated by epidote and chlorite. This composition is different from either that of the Upper Chalk residue or of the Clay-with-flints fine earth. The assemblage is similar to that of the silty upper horizons of Carstens soils over Clay-with-flints, and of other silty soils over a wide range of substrata in southern England, including the buried loess at Pegwell Bay, Kent. This qualitative resemblance, with the fact that the Chalk soils also contain similar amounts (9–30%) of non-calcareous clay-size particles, to the weathered loess at Pegwell Bay (9–24%) suggests that the non-calcareous silt and clay-size fractions are mainly loess-derived. Thus, brown (Andover series) and humic (Icknield series) rendzinas are thought to contain loess mixed with moderate amounts of calcium carbonate (chalk) and 16–25% by volume of chalk-derived flints. Grey rendzinas of the Upton series are mainly of chalky (chalk-derived) fine earth with minor contributions from loess. (Cope)

D4. Acid brown soils of the Uplands

Many well drained, strongly leached soils on slopes in Upland Britain have ochreous or brownish friable B horizons with a pellety micro-fabric characteristic of loamy podzolic B (spodic) horizons (36), and contain more pyrophosphate-extractable iron, aluminium and carbon than those of typical brown earths from similar rocks (37), but lack an overlying bleached (albic) horizon. These soils were considered as intergrades between brown earths and podzols and are now classed as brown podzolic soils (1). They commonly show no clear evidence of illuviation of sesquioxides, and in this and other respects resemble Andosols that have a mainly amorphous clay fraction formed by weathering of pyroclastic rocks. To characterise them further, the clay-size fractions in successive horizons of four brown podzolic soils from granite, dolerite, Devonian slate and Silurian siltstone were analysed mineralogically and chemically and compared with those from typical brown earths from similar materials. A podzol from Silurian siltstone was also examined.

Clay fractions from the brown podzolic soils on igneous rocks had almost twice as much amorphous alumina plus silica (7–19%), determined by the Hashimoto and Jackson method (38), as those from the corresponding brown earths. The soils from slate and siltstone had less (2–7%) in their clay fractions and amounts in the brown podzolic soils and brown earths were similar. The crystalline clay minerals in the soils reflected the mineralogy of the parent rocks, and the results showed no consistent distinction between brown podzolic soils and brown earths. (Loveland and Bullock)

D6. Cover Loam and sands in East Anglia

As several profiles on Cover Loam had been described for Sheet TG 13/14, correlation was attempted of the silt content of these soils with other site and profile factors using the Rothamsted MLP program written for the ICL 4-70 computer. The regression:

$$z = -3{\cdot}91 + 0{\cdot}62d$$

where z = % silt (2–50 μm) and d = thickness of Cover Loam (cm) accounted for 51% of the variance at 15 places where Cover Loam is over sand. Correlation of silt with thickness on Norwich Brickearth was so poor that over all 29 sites only 20% of variance in silt content could be accounted for.

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Of the variates studied, best correlation was obtained between silt content and thickness of Cover Loam and the three-figure eastings coordinate of the grid reference of the sites. The silt content of the Cover Loam in this district increases from west to east.

The regressions obtained were:

for 15 sites, $z = -27{\cdot}42 + 0{\cdot}19e + 0{\cdot}51d$ accounting for 79% variance
for 29 sites, $z = -13{\cdot}29 + 0{\cdot}21e + 0{\cdot}30d$ accounting for 57% variance

where z = % silt (2–50 μm), d = thickness of Cover Loam (cm) and e = eastings coordinate.

A similar analysis was attempted for depth of sand in the surface of soils in Chalky Boulder Clay on Sheet TM 28. This was less successful but the north-west quadrant of this sheet has been resampled to see whether additional data will improve the analysis. (Corbett and Hodge)

The local variation of depth of sandy upper soil on boulder clay was measured in ten random sites within Aldeby, Beccles and Ragdale-dominated map units by 100 bores at each site space on a 10 × 10 m grid. The local variation in subsurface texture and depth to boulder clay was presented in map form for each site after being processed by the SYMAP program adapted to the Rothamsted ICL 4-70 computer. There is a gradual change in pattern across the landscape from one map unit to the next. (Corbett)

A similar sample pattern is being used in central Suffolk at selected sites to determine whether the observed variation in depth and texture of the upper layers of soils over boulder clay coincides with different field drainage designs. (Corbett and Sheilds—ADAS Drainage Arm)

Trend surface analysis of the silt and sand fractions of samples from north-east Norfolk collected in 1972 showed an increase in silt content from south-west to north-east but also the desirability of further samples. Seventy-one were collected during 1973 in clusters of three on upland sites in north-central Norfolk west of East Dereham. Samples were collected from 30–40 cm depth and the 10–50 μm fraction determined by pipette analysis. These samples should help to locate the general position of the Cover Loam boundary west of Norwich and after consolidation with the previous data a further analysis will be attempted. (Corbett with Ridding and Thorpe—student workers)

D9. Paleosols

Many soils in southern England have strong brown to red subsurface (B) horizons containing translocated clay. These horizons have been called paleo-argillic because they commonly occur beneath thin loess-like deposits attributable to the last (Weichsel) glacial period and appear to have acquired their distinctive features in an earlier phase of pedogenesis, either *in situ* or prior to local movement of the soil material by solifluxion. Soils that have such horizons are distinguished at group or subgroup level in the new classification (1).

The paleo-argillic horizons can usually be recognised in the field by their macromorphology and stratigraphic or geomorphic relationships. Where evidence of the latter kind is lacking or inconclusive, colour is a good general guide but does not alone provide an adequate basis for identification, especially in gleyed soils. Previous work has shown that paleo-argillic horizons can be distinguished from argillic horizons of Weichsel or Holocene origin in similar materials by micro-structural features, and this possibility was further investigated.

In thin sections studied so far, the main distinctive features are the distribution and orientation of clay-size material (plasma). In typical argillic horizons in loamy (e.g.

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loess-derived) deposits of Weichsel age, illuvial clay occurs mainly as argillans associated with existing voids, and the few concentrations of oriented clay in the generally argillasepic (weakly oriented) matrix are readily explicable as channel infillings or as the result of incorporation by biological activity. Analogous horizons in clayey materials have a sepic plasmic fabric in which parts show a striated extinction pattern due to orientation by stress. In B horizons classed as paleo-argillic on stratigraphic and geomorphic grounds, the matrix encloses many papules or disrupted argillans, and any void argillans present can usually be attributed to a relatively recent period of deposition. In those that are clayey, almost all the plasma shows evidence of pedological reorganisation, with stronger preferred orientation and masepic to omnisepic fabrics predominating. Also, some show reddened zones absent in ordinary argillic horizons. (Avery and Bullock)

E2. Soil variability

The traverse of close-spaced observations previously reported was extended to the north in the Preseli District of Dyfed at 1, 10 and 100 m from each of a further 23 sites at 1 km intervals to assess frequency of soil variations. (Rudeforth)

E3. Use of air photos and other remote sensing techniques

Reconnaissance survey continued in the Yorkshire Pennines and the results will be incorporated in the county maps of South and West Yorkshire. A pilot study of moorland and arable land in the North York Moors has been extended to the Hambleton Hills. First results suggest that the rest of the North York Moors can be rapidly mapped by reconnaissance methods. Multispectral imagery of the Sedgwick area of Cumbria was obtained and the results will be evaluated in collaboration with research workers at the University of Aston. (Carroll and Bendelow)

Soil patterns on air photographs. Pseudomorph ice-wedge polygonal patterns of large diameter were noted in Hampshire and Kent; previously no sites were known south of the Thames. New sites were noted in Lincolnshire and Oxfordshire. The small polygonal pattern has now been observed in Northumberland, Nottinghamshire, Staffordshire, Lincolnshire, Northamptonshire, Buckinghamshire and Oxfordshire.

Stripes were noted in Wiltshire, Hampshire, Lincolnshire and Kent; these are within the known area of occurrence but fill gaps in the coverage.

A rectangular bedrock jointing pattern is common in Jurassic limestone north of Lincoln. (Evans)

Soil mapping. An air photo interpretation of the soils of Kent was plotted at a scale of 1 : 63 360 to aid in the production of the County Map at 1 : 250 000. Photographs at scales of 1 : 50 000 and 1 : 60 000 were used. Units were defined by their morphology, drainage network, tone patterns, presence or absence of field drains, absence or presence and relative proportions of pits, and land use, including field size and type of field boundary. Comparison with the geological map shows that the major geological formations were adequately represented but much subdivided in the photo-interpretation. This seems to be because the geological unit usually contains a number of soil parent materials in different proportions, and forming subdivisions recognisable by different land use. (Evans)

Photography of bare ground. To obtain full benefits from air photo interpretation the surveyor must know the reasons for changes in tone. Photographs were taken on the ground, and occasionally from the air, of several sites from October 1972 to May 1973

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to assess (a) which soil factors contribute to phototone; (b) the best time for photographing bare soil; and (c) the usefulness in soil survey of multiband photographs in the blue, green, and orange/red wavebands. Panchromatic and colour infra-red photographs were also obtained. Information was collected on surface colour, surface roughness, direction of cultivation, surface stoniness, soil texture and soil moisture. The visibility of patterns is also related to the distance between viewing point and site.

In north Bedfordshire light tones on photographs are due to (a) amounts of fine sand in adjacent soils; (b) surface stone content, and (c) the presence of finely divided chalk and chalk stones within the plough layer. (Evans with Dirkzwager—student worker)

Photography of pastoral land. Air photographs were taken during 1973 of several places near Exeter, previously mapped, to see how growth of grass is linked to differences in soil properties, especially soil drainage. Panchromatic and colour infra-red photographs were taken from the air and on the ground in March, June, July and October. Initially it appears that the timing of photography is important when recording differences in pastures. The use of air photos for mapping soils in pastoral land will be assessed, as will the relative value of panchromatic and colour infra-red photographs. (Evans and Harrod)

Infra-red linescan imagery. Previous work showed that infra-red linescan imagery in the 3–5 μm waveband was not satisfactory for recording ground temperatures. In April 1973 infra-red linescan imagery in the 8–14 μm waveband was taken at 1300 hours of ground near Warboys, Cambridgeshire, on the edge of the Fens. Soil temperatures were monitored on the Chatteris and Downholland series in the Fen, on the Wicken series on the clay upland, and in pasture on the Wicken series. A second series of flights were made in May at 0600 and 1600 hours over brown calcareous earths and rendzinas of the Swaffham Prior association near Balsham, Cambridgeshire. Temperatures were measured at the soil surface and within barley. Generally, the apparent temperatures of the imagery, lighter tones equating with warmer temperatures, correlate with measured temperature, but there are problems of interpretation, especially of imagery taken at 0600 hours. (Evans)

During the survey of Sheet TL 18E/28W (Stilton) two isolated adjacent elliptical depressions were discovered with raised ramparts marginal to the peat fenland near Conington, Cambridgeshire. First seen on aerial photographs because the paler soil tones of the low ramparts contrasted with the dark tones of the peat infilling the basin, these landforms are about 1 km in diameter. Because of the subdued relief it is doubtful whether they would have been noticed without the aerial photographs.

Under arable cultivation at between 4·5 and −2·5 m O.D. the depressions are divided into many fields drained by ditches. Each basin is enclosed except for a break in the ramparts at the downslope extremity. The more complete basin was partly levelled and deep bores made to determine the thickness of the contained peat. The lowest part of the mineral floor of the basin was found to be 0·5 m lower than the lowest portion of the lip. These features could be fossil ground-ice forms. (Burton)

E4. National soil map

A generalized 1 : 1 000 000 soil map of England and Wales, based on the new classification (1), was compiled in consultation with Regional Officers and will be published with an extended legend including summarised definitions of the terms used to describe kinds of soil.

The soils are initially divided into:

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1. soils of river floodplains, coastal flats (recent alluvium, blown sand and shingle beaches) and fenlands;
2. other soils of the drier lowlands with an average maximum potential soil-moisture deficit of 100 mm or more;
3. other soils of the uplands and humid lowlands with an average maximum potential soil-moisture deficit less than 100 mm.

Within these divisions, the 71 map units are soil associations characterised by (a) dominant and subdominant soil groups; (b) parent material as expressed by the geological origin of soil horizons and/or substrata; (c) agriculturally important soil properties, including texture (particle-size class), effective depth and water regime; (d) relief as expressed by range of slope and elevation. The legend also lists, for each soil association, dominant land use according to the map compiled by Church *et al.* (39). (Mackney, Findlay and Avery)

G1. Minor elements in Pembrokeshire soils

Total trace element contents in topsoil and subsoil samples from the north-west of the Preseli District of Dyfed were plotted and relationships with some soil and site factors studied. Some elements show a marked association with drainage class: there is more manganese in well drained than in poorly drained topsoils. Soils over acid igneous rocks, especially rhyolite, generally have less of many elements. However, elements such as yttrium and gallium stand out as unrelated to drainage, underlying rock or altitude, and yet show regional patterns. Histograms were prepared to study statistical distributions. Average values indicate a division of the elements into three sets: those generally with more in topsoil than in subsoil (Pb, As, Zn, Cu, Ni, Mn), those generally with less in topsoil than subsoil (Y, Sr, Br) and those with about equal amounts (Fe, Rb, Zr, Ga). (Rudeforth, Bradley and C. Williams, Pedology Department)

G3. Soil compaction in pastures

Studies begun in 1972 with ADAS soil scientists in Devon and Cornwall continued, with some modification. Sites examined on Highweek, Tedburn and Swindon Bank soils (22) in 1972 were re-examined prior to the first grazing of 1973 to measure any over-winter changes in bulk density. Measurable but incomplete recovery (in terms of spring 1972 density) was common. A site near Crediton (Swindon Bank series) was visited before each grazing in 1973, and measurement of bulk density made with penetrometer and shear tests. At five places in Devon and Cornwall yields of grass were measured on plots with varying degrees of soil compaction and poaching of the sward. (Harrod and Staines)

Special surveys

The University College of Wales Farm (120 ha) at Trefloyne, South Pembrokeshire, was mapped at the request of the Department of Agriculture. Although slightly east of the main early potato-growing areas, the soils represent much of the southern part of the former county. They are in drift over Carboniferous Limestone, Devonian red siltstones and Ridgeway Conglomerates. Deep, well drained fine loamy and fine silty soils of Pembroke and Milford series predominate on gentle slopes, but shallower soils of the Ridgeway series and Pembroke shallow variant also occur. Steep slopes and poor drainage limit the use of about one-third of the farm. (Rudeforth)

A map at 1 : 10 560 of soils of the National Institute for Research in Dairying Farm at Shinfield near Reading was produced.

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Soils of the Warburg Nature Reserve at Bix Bottom near Henley were surveyed. (M. G. Jarvis and Hazelden)

A further 3 ha were surveyed on a 30-m grid at Luddington Experimental Horticultural Station to assess the variability of soils on experimental plots. (Whitfield)

A soil map at 1 : 3200 was made of Mores Wood, Coxtie Green, Essex, 20 ha of woodland used by students of Queen Mary College, London University, for ecological studies, and linked with vegetation distribution studies. The survey coincided with a request for information from the Nature Conservancy, as the wood is involved in motorway development. (Sturdy and Allen)

A soil map and land capability map of Stratton House, Radstock, Somerset (140 ha) was compiled (in conjunction with ADAS soil staff) at a scale of approximately 1 : 7500. (Colborne)

Other work

The soils of Broom's Barn/British Sugar Corporation sugar beet trials were recorded in East Anglia and in other regions. (Seale and others)

Soil investigations on a medieval and Roman archaeological site at Middleton Stoney were made on behalf of the Oxford and City County Museum. (Hodgson)

Advice was given on soil drainage to ADAS drainage officers and also to archaeologists from Exeter University. A survey was made of a trial site on Bodmin Moor and soil water levels are being monitored in collaboration with ADAS to assess the effect of subsoiling on granite soils. (Staines)

Parent material and pedological features were identified and described at sites of archaeological interest in Oxfordshire for the M40 Archaeological Research Group, the Oxford City and County Museum, Woodstock, and the Oxfordshire Archaeological Unit. (M. G. Jarvis and Hazelden)

Soils at experimental sites were described for the Weed Research Organisation and the Letcombe Laboratory. Assistance in selecting new experimental sites was also given to the Letcombe Laboratory. (M. G. Jarvis and Hazelden)

Ditch cleaning by the Great Ouse River Authority revealed a cross-section of the Little Ouse rodham in Burnt Fen north-east of Prickwillow and the opportunity was taken to describe and sample the deposits of this former river course. (Seale)

Help has been given to a joint MAFF–Imperial College project investigating the relation between unthriftiness in stock and soils rich in molybdenum. (Carroll)

Advice was given to Mr. Anderson, a technical officer for IMI Ltd about the distribution of very acid soils (pH less than 4·5) in the British Isles. (Hodgson)

Advice on the classification and distribution of soils in the Chaddersley Corbett area was given to an officer of the Nature Conservancy. (Hollis)

At the request of ADAS, visits were made to several land drainage schemes. (M. G. Jarvis and Hazelden)

An exercise with students conducted on behalf of the Geographical Associaton showed that good growth in sugar beet seen on air photographs of Hole Farm, Hempstead, Norfolk, corresponded with the deepest patches of Cover Loam over sands. (Corbett and Eldridge)

The annual meeting of the British Society of Soil Science was held at Wye and the Survey helped to organise excursions, demonstrate soils and prepare a *Handbook*. An exhibition demonstrated Soil Survey work in Kent with maps, models, sections and representative monoliths, and is now on permanent display at the Wye Centre, housed in an exhibition room much used by teachers and other visitors. (Green and Fordham)

The annual two-day meeting of the North of England Soils Discussion Group was arranged on the theme of the classification of soils associated with Carboniferous rocks,

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and typical soils were demonstrated near Leek, Staffordshire. (Hollis) Four papers were read. (Carroll, Clayden, Harrod and Hollis)

A course to instruct soil surveyors in making and interpreting soil physical measurements was held in February and attended by ten surveyors with several workers in related fields. (Reeve, P. D. Smith and Thomasson)

A two-day field course for MAFF drainage officers was arranged. (R. A. Jarvis)

A one-day course on soil texture and other profile features was given to the staff of Levington Research Station. (Hodge, Sturdy, Allen and Burton)

A field excursion was led on behalf of the British Grassland Society during their Annual Meeting at Hereford. (Hodgson)

A display of maps and monoliths was exhibited at Bristol (12 July) and Starcross (25 July) as part of Open Days at the ADAS Centres. (Harrod and Findlay)

The work of the Survey was exhibited at the *Farmers' Weekly* 18th National Spring Demonstration held at Appleton near Oxford on 26 April. (M. G. Jarvis and Hazelden)

The work of the Soil Survey was illustrated as part of an exhibit on the Soils of Norfolk at the Royal Norfolk Show in June. (Corbett and Eldridge)

A second forward-control Land Rover, fitted with a fully hydraulic Proline Soil Coring machine under the guidance of the Design Department of the National Institute of Agricultural Engineering, was brought into use. The existing machine was in operation from February to November, mainly for sampling soils in connection with the current mapping programme. The Agricultural Development and Advisory Service, East Malling Research Station, and various educational institutions also made use of the equipment during the year. (Bascomb)

At the request of the Institute of Hydrology a new version of the 1 : 1 000 000 Potential Winter Rain Acceptance Map was prepared, incorporating the national grid. (Mackney and Thomasson)

A *Technical Monograph* on the use of soil surveys in drainage design was prepared, in cooperation with the Drainage Arm of ADAS. Drainage design and soil and other properties which affect it are discussed, as are ways in which soil classification, maps at different scales, and related texts supply advisers with information about the soil and hydrologic conditions where underdrainage is projected. (D. B. Trafford and R. A. Walpole, Drainage Arm, ADAS, Thomasson and Mackney)

A course in air photo interpretation for Survey staff held in 1972 is being used as a basis for a *Technical Monograph.* (Carroll, Evans and Bendelow)

The part of *MAFF Bulletin* No. 107 referring to soils in the West Midlands was revised and brought up to date for the Agricultural Development and Advisory Service. (Hodgson)

The register started last year at Lincoln to aid exchange of information between surveyors mapping on similar parent materials in different parts of the country was continued and a list of all published series to date was prepared. (Robson, George and Heaven)

One *Memoir*, five *Records*, two *Special Surveys* and one *Technical Monograph* were published. Two *Memoirs*, eight *Records*, one *Special Survey* and three *Technical Monographs* are in preparation.

Fourteen maps at a scale of 1 : 25 000 and three at a scale 1 . 63 360 have appeared. Twenty are in preparation.

Staff

D. J. Briggs, W. P. Gibson, D. T. Pritchard and P. D. Smith left and J. W. Allison, D. G. M. Hall, C. P. Murphy and P. S. Wright were appointed.

R. A. Jarvis went to Spain for ten weeks to advise on soil survey at the Estacions

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Experimental del Zaidin, Granada. He also visited soil survey and other research workers at Madrid, Murcia and Salamanca.

J. M. Hodgson took part in a study tour of the Pleistocene Deposits and soils of the Alpine Foreland of West Germany organised by the Quaternary Research Association.

Bradley spent a week with pedologists in Belgium to see soils in the field, to compare methods of soil survey, and to visit laboratories and departments of soil science. A lecture on the quantitative approach to soil mapping was given at the International Training Centre for soil scientists in Gent.

Supported by the British Council, UNESCO and the Polish Academy of Sciences, P. Bullock participated in meetings of the International Working Group on soil micro-biology in Wageningen, Netherlands and Zakopane, Poland. He also attended the 4th International Congress of Soil Micromorphology at Kingston, Canada, and presented two papers, for which he received grants from ARC and the National Research Council of Canada.

B. W. Avery, C. L. Bascomb and R. G. O. Burton attended a symposium on peat and peatland classification in Glasgow organised by the International Peat Society. Various classifications of peat and peat soils were presented, most based on botanical composition of plant remains and degree of decomposition.

John Hazelden visited British Honduras (Belize) during April and May as a member of an archaeological project sponsored by the British Museum.

K. Thanigasalam attended a course on Atomic Absorption Spectrophotometry.

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