THE MACAULAY INSTITUTE FOR SOIL RESEARCH

FOUNDED 1930

ANNUAL REPORT 1950-1951

The Macaulay Institute is situated in Countesswells Road, about three miles from the centre of Aberdeen. Buses (Route 18) run at frequent intervals from Union Street to the Seafield terminus which is within 10 minutes walk of the Institute.

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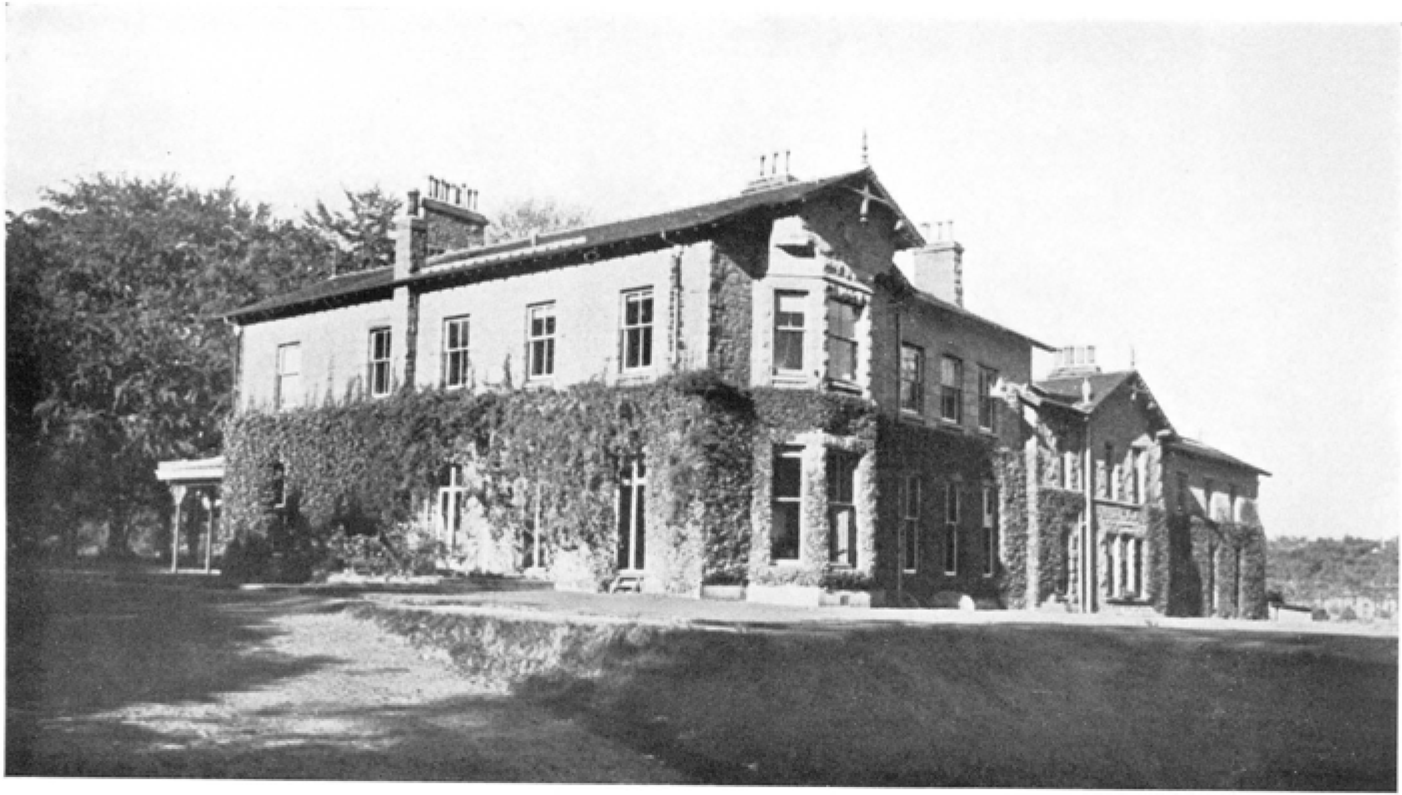

THE MACAULAY INSTITUTE FOR SOIL RESEARCH

THE MACAULAY INSTITUTE FOR SOIL RESEARCH

CRAIGIEBUCKLER, ABERDEEN
(Founded 1930)

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1950-1951

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*Appointed 1951 †Resigned 1951 ‡Retired 1951

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E. ERIKSSON (Royal Agricultural College, Uppsala, Sweden).

R. A. HIGAZY (University of Alexandria, Egypt).

L. H. P. JONES (University of Melbourne, Australia).

S. G. KRISHNAMURTY (Presidency College, Madras, India).

M. MUÑOZ TABOADELA (Instituto de Edafologia y Fisiologia Vegetal, Madrid, Spain).

J. RAMIREZ MUÑOZ (University of Madrid, Spain).

D. V. K. RAO (Agricultural Research Institute, Coimbatore, India).

SUSANA M. de SALAS (University of Buenos Aires, Argentina).

W. M. H. SAUNDERS (Department of Scientific and Industrial Research, Wellington, New Zealand).

G. SEMB (Agricultural College, Vollebekk, Norway).

J. SPECTOR (Imperial College of Tropical Agriculture, Trinidad).

D. J. SWAINE (University of Melbourne, Australia).

I. T. TWYFORD (Colonial Office, London).

A. C. VENN (Colonial Office, London).

ORNELLA VERGNANO (University of Florence, Italy).

R. P. ST. J. WATKIN (Government Chemists' Department, Tanganyika).

J. WYLLIE (Queen's University, Kingston, Ontario, Canada).

O. YAMANLAR (University of Istanbul, Turkey).

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INTRODUCTION

The Council of Management of The Macaulay Institute is again grateful to the Department of Agriculture for Scotland, to the Agricultural Research Council, and to the Forestry Commission for grants in aid of the work, and to other benefactors for their generous support.

The Institute was visited during the year by representatives of many research and experimental stations in Australia, Canada, India, New Zealand, South Africa, Argentina, Chile, France, Germany, Pakistan, Norway, Sweden, Turkey, and the United States of America. Visiting parties included members of the Society of Applied Bacteriology, the Advisory Nutrition Chemists' Conference, the Scottish Advisory Horticultural Conference, the Huntly Branch of the National Farmers' Union of Scotland, and the Le Play Society. The Agricultural Research Council held its autumn meeting on 17th September, 1951, at The Macaulay Institute and thereafter met members of staff.

VISITING RESEARCH WORKERS

Research workers from many countries have collaborated in the work of the Institute:—

Department of Pedology—

Soil Survey—

Mr A. C. Venn, Colonial Office, London.
Mr R. St. J. Watkin, Government Analytical Chemist's Department, Tanganyika.
Mr O. Yamanlar, University of Istanbul, Turkey.

Physico-Chemical and X-ray Investigations—

Dr M. Muñoz Taboadela, Instituto de Edafolgia y Fisiologia Vegetal, Madrid, Spain.

Soil Geology and Mineralogy—

Mr G. Semb, Agricultural College, Vollebekk, Norway.

Department of Spectrochemistry—

Mr R. A. Higazy, University of Alexandria, Egypt.
Dr S. G. Krishnamurty, Presidency College, Madras, India.
Dr J. Ramirez Muñoz, University of Madrid, Spain.
Dr S. M. de Salas, University of Buenos Aires, Argentine.
Mr J. Spector, Imperial College of Tropical Agriculture, Trinidad.
Mr D. J. Swaine, University of Melbourne, Australia.
Professor J. Wyllie, Queen's University, Kingston, Ontario, Canada.

Department of Plant Physiology—

Dr Ornella Vergnano, University of Florence, Italy.

Department of Soil Fertility—

Mr E. Eriksson, Royal Agricultural College, Uppsala, Sweden.
Dr L. H. P. Jones, University of Melbourne, Australia.
Mr D. V. K. Rao, Agricultural Research Institute, Coimbatore, India.
Mr W. M. H. Saunders, Department of Scientific and Industrial Research, Wellington, New Zealand.
Mr I. T. Twyford, Colonial Office, London.

REPRESENTATION ON COMMITTEES

The Institute was represented on the following Committees, appointed by—

(1) *Agricultural Research Council;*

(*a*) Conference on Fertilizers.
(*b*) Conference on Mineral Deficiencies of Agricultural and Horticultural Crops.
(*c*) Land Drainage Conference.
(*d*) Soil Survey Research Board.

(2) *Department of Agriculture for Scotland;*

(*a*) Scottish Agricultural Improvement Council.
(*b*) Field Trials Sub-Committee.
(*c*) Scottish Grassland Sub-Committee.
(*d*) Sugar Beet Sub-Committee.
(*e*) Consultative Committee for the Development of Spectrographic Work, and its Technical Sub-Committee.

(3) *Forestry Commission;*

The Sub-Committee dealing with Nutritional Problems in Tree Nurseries.

(4) *Colonial Office;*

Soils Sub-Committee of the Committee for Colonial Agricultural, Animal Health and Forestry Research.

(5) *Development Commission;*

Survey of Agricultural, Forestry and Fishery Products and their Utilization.

(6) *Secretary of State for Scotland;*

(*a*) Hill Farm Research Committee and its Sub-Committees dealing with (*i*) Trace Elements and (*ii*) Heather.
(*b*) The Scottish Standing Committee for the Calculation of the Residual Values of Fertilizers and Feeding Stuffs.
(*c*) The Scottish Peat Committee, and Sub-Committee on the Survey of Peat Deposits in Scotland.
(*d*) The Nature Conservancy (Scottish Committee).
(*e*) The Standing Advisory Committee, Fertilizer and Feeding Stuffs Act, 1926.

STAFF

The following changes in personnel took place:—

(*a*) *Resignations;*

Department of Pedology;

Dr G. F. Walker (X-ray Section), on appointment to the staff of the Commonwealth Scientific and Industrial Research Organization, Australia.

Mr P. C. Harper (Soil Survey Section), on receiving a scholarship (Department of Agriculture for Scotland).

(*b*) *Retirement;*

Department of Soil Fertility—

Mr H. D. Welsh.

(*c*) *Appointments;*

Department of Pedology—

Mr W. A. Mitchell, B.Sc. (X-ray Section).
Mr R. A. Robertson, B.Sc. (Soil Survey Section).
Mr J. M. Ragg, B.Sc. (Soil Survey Section).
Mr D. Laing, B.Sc. (Soil Survey Section).

Department of Spectrochemistry—

Dr I. W. M. A. Black.

Department of Soil Organic Matter—

Mr T. W. Wright, B.Sc. (Forest Soils Research).

Dr J. G. Hunter, *Department of Plant Physiology*, spent three months in the United States of America, and visited the University of California and various research centres in the United States under an award made to him in terms of the Fulbright and Smith-Mundt Acts, U.S.A.

THE WORK OF THE INSTITUTE

The maintenance and improvement of soil fertility continues to be the main objective of the work of the Institute. The staff has collaborated with sister Research Institutes, the Scottish Colleges of Agriculture and the Forestry Commission, and in the work of the various Committees of the Department of Agriculture for Scotland. Facilities have been provided for the training of research workers in various branches of soil research and for post-graduate study. Research students from overseas are studying at the Institute for higher degrees of the University of Aberdeen.

PEDOLOGY

SOIL SURVEY (SCOTLAND)

Soil survey has continued on the reconnaissance scale of 2.5 inches to 1 mile in Morayshire (Sheet 95), Aberdeenshire and Kincardine (Sheet 66), Angus (Sheet 57), Roxburghshire (Sheet 17) and Ayrshire (Sheet 22); a total area of approximately 455 square miles has been mapped. One hundred and thirty representative profiles have been collected from the survey areas.

NORTH-EAST SCOTLAND

Morayshire (*Geological Survey Sheet* 95)

An area of approximately 70 square miles has been surveyed. It consists of a relatively narrow coastal strip (4-7 miles wide) bounded on the north by the Moray Firth shore from Buckie to Lossiemouth and in the south by the northern foothills of the Grampians.

The topography of the area is varied. Two prominent ridges rising to over 200 feet run in a south-south-west direction from Spynie and Lossiemouth. Between them stretches the broad fertile flat of the Laich of Moray, the drained bed of the former Loch Spynie. To the south and east of the River Lossie low, smooth mounds and short ridges of sand and gravel cover the lower slopes, the ground gradually rising to a height of over 600 feet to form the foothills of the Grampians.

The two rivers of importance are the Spey and the Lossie, both flowing northwards. The wide valley of the Spey contains several well-defined terraces, while associated with the Lossie are considerable wide flat spreads of alluvium which are extensively drained by a system of artificial ditches.

The rocks are predominantly of Old Red Sandstone age and are almost everywhere covered by a thick mantle of drift. They have little direct influence on the soils of the district. Red sandstones and conglomerates of the Middle Old Red Sandstone formation occur in a three mile wide belt east of the River Spey and in smaller masses on the west bank. The rest of the area is mainly underlain by coarse-grained sandstones of the Upper formation, often with pebble bands, and fine white sandstones. The ridges near Elgin are of yellow and white sandstones of Permo-Triassic age, the latter sometimes very hard. A cherty calcareous rock in a small area near Elgin was formerly quarried and used as burnt lime. At Stotfield and Meft a cherty rock containing galena occurs.

Superficial deposits of water-sorted end-glacial material are very extensive in this area. Most widespread are morainic and fluvio-glacial sand and gravel. Lateral and terminal moraines can be traced from Loch Na Bo by Sleepieshill Wood to the Binn Hill near Kingston, and east of the Spey to Auchenhalrig. The sand covers the greater part of the area, often in the form of mounds and ridges, a fifty-foot section of bedded sand being exposed near Lesmurdie. Boulder clay probably underlies most of these spreads, but outcrops are rare. It is only important as a soil parent material in the south-east and on the higher ground. Raised beach sand, dunes, and river-terrace gravels are also extensive.

The climate of the area is characterized by a low rainfall (25 to 28 inches) and much sunshine; the annual mean temperature at Elgin is 49°F. Light-textured soils are subject to drought.

The agriculture practised is largely mixed farming, with emphasis on the raising and fattening of cattle. Cereal crops include wheat, with the usual oats and barley, while rye is grown on the poorer sands. Seed potatoes are an important cash crop. Dairy farming, supplying local needs, is confined to alluvial land. Normal holdings are approximately 150 acres, but small 20-acre crofts tend to be located on certain agriculturally poor sites.

Small plantations of Scots pine in policy woodlands are found throughout the district, and to the west of Elgin there is a large, semi-natural oak-beech wood.

The following soils are found in the area:

Associations

1.	Foudland	*see* Annual Report, 1940-1941.
2.	Boyndie	*see* Annual Report, 1942-1943.
3.	Strichen	*see* Annual Report, 1943-1944.
4.	Corby	*see* Annual Report, 1944-1945.
5.	Tynet	New Association.

Links

Undifferentiated alluvium

Skeletal soils

These soils are described in more detail in the Appendix to this report.

Aberdeenshire and Kincardine (*Geological Survey Sheet* 66).

An area of approximately 95 square miles was re-surveyed in Deeside between Banchory and Ballater. Soil Associations and boundaries previously mapped were checked.

The country traversed extended from Hirn through Kincardine o' Neil to the south end of Loch Davan, across the Dee at Cambus o' May and southwards to Gathering Cairn. The southern boundary ran from Gathering Cairn to Forest of Birse, along the Water of Feugh to the Dee at Banchory, and thence north-east to Hirn.

Arable farming is largely restricted to the valleys of the Dee and its tributary Water of Feugh. The intervening upland and hill country consists mainly of steep heather-covered hills where grouse, deer and sheep are common. On the lower hills plantations are abundant.

The Dee in this area flows over quartzose schists and calc-silicate rocks, bounded on the north by granite and granitic gneiss. To the south of the Dee stretch hills of coarse porphyritic red granite, tailing out into granitic gneiss between the lower Feugh valley and the Dee.

Superficial deposits of glacial till, gravelly moraine and spreads of river gravel are most extensive in the river valleys. There is thin till on the hillsides tailing out into rock rubble or bare rock at an elevation above 1,500 feet.

The following soils are found in this area:

Associations

1. Countesswells *see* Annual Report, 1943-1944.
2. Corby *see* Annual Report, 1944-1945.
3. Deecastle New Association.

Skeletal Soils

Hill Peat

These soils are described in more detail in the appendix.

EAST SCOTLAND

Angus (*Geological Survey Sheet* 57)

An area of about 60 square miles has been surveyed in Angus. About 23 square miles north of the Highland Boundary Fault, between Glenquiech and Glen Lethnot, consist of hill country. The remaining area between the foot-hills south of the Boundary Fault and a line roughly between Brechin and Tannadice is arable land, with scattered, though sometimes extensive, woods and plantations.

The hill country consists of steep heather-covered hills composed of flaggy quartzites and quartz mica-schist, with a thin but persistent covering of till, excepting on the upper slopes and summits where the soils are skeletal.

The arable land, an area of broad east to west undulations subdivided into many minor ridges and hollows, reflecting the general regional strike of the solid rock, shows a gradual fall of slope towards the river South Esk. It is underlain by Lower Old Red Sandstone beds with conglomerate and subordinate calcareous strata. The soils are developed on superficial deposits of red water-sorted material and light-textured till. South of the hills gravelly moraines are found sporadically overlying the till throughout a belt of country two miles wide; they are most common in the areas immediately south of the glens.

The hill farms are mainly concerned with sheep grazing, such arable land as is available being restricted to a limited rotation. There were extensive plantations in Glen Ogil but these are now mostly felled, and only partially replanted. On the low ground to the south, arable farms are of moderate size, about 200 acres being the average. Wheat, oats, barley, turnips and seed potatoes are among crops regularly grown; sugar beet and, to a much lesser extent, raspberries are important variants. Large dairy farms are found throughout the area.

The following soils are found in this area:

Associations

1. Corby *see* Annual Report, 1944-1945.
2. Strichen *see* Annual Report, 1944-1945.
3. Stonehaven *see* Annual Report, 1946-1947.
4. Strathfinella *see* Annual Report, 1947-1948.
5. Auchinblae *see* Annual Report, 1947-1948.
6. Craigo *see* Annual Report, 1947-1948.
7. Balrownie New Association.

Undifferentiated Alluvium
Skeletal Soils
Hill Peat

These soils are described in more detail in the appendix.

SOUTH-EAST SCOTLAND

Roxburghshire (*Geological Survey Sheet* 17)

Approximately ninety-five square miles have been surveyed this season in Roxburghshire. The area is bounded in the south-east by the River Teviot from Kalemouth to Hawick, and in the north by a line from the River Ettrick near Selkirk through St. Boswells to the vicinity of Kalemouth. In the west it is bounded by a line from the Ettrick near Selkirk to just west of Hawick.

The area is underlain by sedimentary rocks of Silurian and Upper Old Red Sandstone ages, and sporadically by intrusive necks and lavas of Carboniferous age. These have a marked effect upon the topography. To the east, where the underlying sedimentary rocks are Upper Old Red Sandstone, the topography is broadly rolling to hilly, but to the west, where they are Silurian, the topography is hilly with subsidiary ridges clearly defined on the hill slopes. The ridges are a direct result of the highly folded nature of the Silurian strata with an exceptionally regular south-west to north-east strike. Rock, usually the highly resistant greywacke, commonly outcrops at the apex of the ridges.

The principal drainage systems are the River Teviot with its tributary the Ale, and the River Ettrick. All these rivers flow mainly in a south-west to north-east direction.

Most of the area is covered by superficial deposits. Glacial till, which tends to become thin on the ridge tops and where the angle of slope is high, is by far the most extensive. Small isolated spreads of lacustrine deposits are scattered throughout the area covered by till of Silurian origin. These are often quite shallow and change to till at a depth less than three feet. Peat is found only under waterlogged conditions in the hollows. The rivers have extensive spreads of recent alluvium associated with them. In addition, the River Teviot has a comparatively wide fluvio-glacial terrace for most of its course.

Stock-rearing is the dominant activity in this area. Large flocks of breeding-ewes and smaller herds of hill cows are kept. Most of the young stock is sold off in the autumn. The holdings are large and cropping is, in general, directed towards the provision of winter keep for the breeding stock. A few farms in the vicinity of Ancrum crop extensively for cash sales, but this is undoubtedly exceptional for the area as a whole.

The following soils are found in this area:

Associations

1. Bowmont	*see* Annual Report, 1948-1949.
2. Hindhope	*see* Annual Report, 1949-1950.
3. Minto	New Association.
4. Hawick	New Association.
5. Jedburgh	New Association.
6. Denholm	New Association.

Skeletal Soils

These soils are described in more detail in the appendix.

SOUTH-WEST SCOTLAND

Ayrshire (*Geological Survey Sheet* 22)

The soil survey of Ayrshire has been continued both in the north and south. Approximately 90 square miles have been mapped in the north and 45 square miles in the south on a scale of 2½ inches to 1 mile. For simplicity of description, the areas are treated separately.

Northern Region

The River Garnock between Dalry and Lochwinnoch forms the western edge of the area and it extends eastwards to the neighbourhood of Mearns village and Dunwan Dam.

The topography in the south-west is gently undulating but the greater part of the area consists of hilly moorland with Neilston Pad in the north rising to 854 feet and Ballagiach Hill in the east to 1084 feet.

The area is drained by the Garnock, Dusk, Lugton and Annich Waters, all of which flow from north-east to south-west.

Basic and intermediate lavas of the Calciferous Sandstone Age underlie the greater part of the region. Carboniferous sediments (Upper and Lower Limestone and Limestone coal groups) are confined to the west and south-west. Two faulted strips of the latter also occur in the vicinity of Lochwinnoch and in the Lugton-Loch Libo area.

The northern part of the area is relatively drift free with boulder clay limited to local depressions and the more gentle slopes. In the east occurs a large tract of hummocky moraines. Other superficial deposits of alluvium, fluvio-glacial sands and gravels, and peat cover the region.

Dairy farming is the main agricultural activity, but on the higher ground where the soils tend to become shallower and pastures poorer, it gives way to sheep farming.

The following soil associations are found in this area:

1. Ashgrove — *see* Annual Report, 1949-1950.
2. Darleith — *see* Annual Report, 1949-1950.
3. Kilmarnock — *see* Annual Report, 1949-1950.
4. Glenmount — *see* Annual Report, 1949-1950.
5. Anlaird — New Association.

These soils are described in more detail in the appendix.

Southern Region

This area extends from the coast between Irvine and Monkton eastwards as far as Hurlford.

In the coastal region and for some distance up the Irvine valley, the topography is mainly flat with a few scattered drumlins. The remainder of the country is rolling, except at Dundonald and Craigie, where it abruptly alters to hilly—Wardlaw Hill, 477 feet and Craigiehill, 507 feet.

The Rivers Irvine and Cessnock are the main drainage systems of the area. Sedimentary rocks predominate, with Productive Coal Measures underlying the coastal and northern parts. Barren Red Sandstone rocks are found both in the north and south, with basalt of Millstone Grit Age and Upper Old Red Sandstone occupying the centre. Craigiehill and the rounded hillocks south of Dundonald are the result of teschenite and olivine dolerite intrusions.

The area is covered with superficial deposits, consisting of raised beach and windblown sands, boulderclay, fluvio-glacial sands and gravels, alluvium and peat.

Dairy farming is practised throughout the area.

The following soils are found in this area:

Associations

1. Kilmarnock	*see* Annual Report, 1949-1950.
2. Dreghorn	*see* Annual Report, 1949-1950.
3. Rowanhill	New Association.
4. Dundonald	New Association
5. Bargour	New Association.

Links
Alluvium
Hill and Basin Peat

These soils are described in more detail in the appendix.

HEATHER SURVEY

Mr R. A. Robertson, ecologist, has commenced a study of heather in collaboration with the Hill Farm Research Committee. The survey has begun in the north-east and aims at collecting data on approximate age, health, habit, type and stability of vegetation and on methods of management and stocking, as a preliminary to large-scale experiments on management of heather moors.

SPECIAL SURVEYS

The following special surveys have been made and reports submitted:

1. A textural survey of sugar-beet fields in the Lothians to assist in the investigation of the incidence of "strangles," a disease of sugar beet.
2. A survey of the haughland (alluvium) of the Spey valley; this area may at some future date be reclaimed.
3. A survey of an area between Nairn and Inverness to ascertain the extent of a calcareous (marl) subsoil.
4. An investigation of the soils of Montreathmont Forest, Brechin, where extensive areas of Scots pine have died out.
5. A survey of estuarine clay on the South Esk estate, Montrose, to determine its suitability for ceramic purposes.

LABORATORY INVESTIGATIONS AND COLLABORATIVE WORK

Work has continued on the study of the hydrologic sequence of soils with reference to (*i*) the pore space distribution, (*ii*) the fractionation of the phosphate content, and (*iii*) methods of investigating free sesquioxides.

Collaboration with the X-ray and Physico-Chemical Sections has been maintained in supplying a collection of weathered granites, manganese oxide and also clay samples from selected soil profiles. Additions have been made to the collection of rock specimens characteristic of the soil associations. Assistance in the selection of sites for field experiments has been given to the Department of Soil Fertility.

Co-operation has been maintained with the Departments of Soil Science, Geography, and Botany of the University of Aberdeen, and with the Scottish Colleges of Agriculture.

Soil monoliths were collected for exhibition at the Royal Highland Show in Aberdeen.

An account of the soils of Bowmont Forest, Roxburghshire, was given to the Forestry Section of the British Association.

Seven members of the Survey staff attended the Soil Surveyors Conference in Lancashire from 9th-14th September, 1951.

MAPS

1 inch to 1 mile Soil Survey maps of Ordnance Sheets 86 and 96 (3rd ed.) have been completed, and line copies have now been supplied by the Ordnance Survey for checking[33]. A descriptive Memoir of the areas is being prepared.

ANALYTICAL SECTION

Routine analyses of the soil samples taken by the Soil Survey Section during the 1949 season have been completed. During 1950 some 470 samples, representing 100 profiles, were taken by the soil surveyors, and on these moisture, loss on ignition, pH, carbon, nitrogen and readily soluble phosphorus have been determined. Mechanical analyses and exchangeable cation determinations have been completed on 70 of the profiles.

A start has been made to the routine analyses of some of the soil profiles taken by the Soil Survey Section during 1951.

Clay samples from typical wet and dry profiles of the Insch, Foudland, Tarves and Hatton Associations have been separated and analysed for silica-sesquioxide ratios. Free sesquioxide determinations have also been completed on the soils from these profiles.

Special Investigations

(1) Nine profiles—36 samples—have been examined for moisture, loss on ignition, pH value, mechanical analyses, exchangeable cations, carbon, nitrogen, total and readily soluble phosphorus, in connection with a survey at Faskally, Pitlochry, for the Brown Trout Research Laboratory (Scottish Home Department).

(2) Routine analyses have been made of 6 profiles—27 samples—from Bowmont Forest, Roxburghshire, on behalf of the Forestry Commission.

(3) At the request of Lord Southesk, Brechin, mechanical analyses and exchangeable cation determinations have been carried out on eight samples from Arrat's Mill, with a view to their possible utilization as china clay.

(4) Two samples from Darnaway Estates, Morayshire, taken in connection with the corrosion of a copper pipe-line, have been analysed for water-soluble salts and pH values determined.

(5) Loss on ignition determinations and mechanical analyses have been carried out on 60 samples from East Lothian taken during a textural survey of sugar beet areas.

(6) Loss on ignition determination, pH values and mechanical analyses have been carried out on 42 samples from a drainage scheme being undertaken in the Spey Valley by the Engineering Staff of the Department of Agriculture for Scotland.

(7) Eighteen clay samples from Zanzibar and four from Spain have been analysed for their free sesquioxide and silica content.

SOIL GEOLOGY AND MINERALOGY

The study of the mineralogy of the fine sand fractions of soils and their parent materials has been continued. The parent materials were mainly glacial drifts of mixed lithological origin and the results served to characterize the soil associations.

In conjunction with Mr Gunnar Semb of the Agricultural College, Vollebekk, Norway, an investigation of the mineral content of certain soils and their parent materials from Rogaland County, Norway, was carried out. The soil parent materials were glacial drifts, mainly sandy moraines and till, and raised beach deposits. A variety of rock types, gneiss, granite, gabbro and schists, was associated with these deposits. Striking differences in the mineral assemblages of the soils and the glacial deposits associated with them were found and the results indicated that it would be possible to characterize the parent materials by this method. It is proposed to extend and complete this investigation on Mr Semb obtaining more material for study.

An investigation was made in conjunction with Mr E. A. Fitzpatrick, a research student of Soil Science Department of the University of Aberdeen, on the soils of Glen Muick, Aberdeenshire, where he had carried out a field survey. The basal rocks in this area are serpentine, granite and schists and these are partly overlain by till and morainic deposits. The fine sand fractions from various horizons of typical profiles were studied in detail and the various soil types characterized by the minerals present and their proportions in the fine sand fraction.

Co-operation has been maintained with the other departments in the examination of materials submitted for investigation.

North-east Scotland

The field examination of the soils of north-east Scotland was continued to determine the nature of their parent materials. Areas where serpentine and gabbroitic rock types occur were visited and samples of soils and rocks collected for further investigation in collaboration with the Plant Physiology Department.

West Scotland

A survey was made of the soils and their parent materials on various farms situated on the Campsie, Fintry and Kilsyth Hills, Stirlingshire, in the course of a joint investigation with the Animal Diseases Research Association, Edinburgh. Samples of soil and herbage from typical areas were collected for laboratory investigation. The area is underlain by rocks of the Calciferous Sandstone Series of the Carboniferous Formation and these consist of sandstone, shale, cementstone, limestone, basalt, tuff and dolerite. The lower ground is generally covered by glacial deposits and these are of very mixed lithological origin, always containing an admixture of sedimentary and igneous rock types.

South Scotland

Field work in connection with the sheep pining investigation was carried out in Selkirkshire and Dumfriesshire. The areas visited lie in the upper valley of the Ettrick and the neighbouring valleys of the Tima and Rankle Waters. These districts lie in a belt of Silurian rocks, consisting of shales, sandstones and greywackes. Soil samples were collected for laboratory investigation before further experimental work is carried out in this locality.

X-RAY INVESTIGATIONS

The survey of Scottish soil-clays has been extended and soils have now been studied from areas in Aberdeenshire, Angus, Ayrshire, Banffshire, Stirlingshire and Roxburghshire. Soil-clays from outside the north-east area, which has been the most intensely studied, show little difference in composition despite the different parent materials. Variations within the profiles show the breakdown and formation of clay minerals in the soil, for example, vermiculite forms at the expense of trioctahedral illite, and kaolinite at the expense of illite. Montmorillonite is seldom found and halloysite is even rarer. On Old Red Sandstone parent material, that is the Laurencekirk, Ordley, Stonehaven and Strathfinella Associations, haematite is found in the soil-clays. Haematite generally breaks down to goethite, lepidocrocite or amorphous material, but the fine coating of haematite on the sand grains typical of the Old Red Sandstone series must be more stable in soils than the commoner, coarser form. The difficulty of identifying lepidocrocite and boehmite (the γ iron and aluminium hydroxides) by their reflections near 6A is greater as calcium oxalate trihydrate appears on peroxidizing some soil-clays, especially those from top-soils, and gives a strong diffraction pattern with a reflection at 6.1A. New methods of separating the clays are being tried to avoid precipitating the insoluble calcium oxalate.

Among foreign soils studied have been samples from Norway, Sweden, Newfoundland, India and Spain. The Newfoundland soil-clays are similar to Scottish ones but the Scandinavian soils show clearly the importance to the soil-type of the parent material. Where, as in India, the soil processes are very advanced, kaolinite is the only silicate present, the most common minerals being iron and aluminium oxides.

Some samples from the West African Road Research Laboratory investigated by differential thermal analysis and X-ray diffraction, showed that the soils contained large amounts of a montmorillonite. This is in agreement with the field properties of the soils.

The study of granite weathering in Aberdeenshire has now been extended to samples from the pre-glacial deep weathering of this area and from rocks under peat.

Work on the structure of vermiculite has been continued with particular attention to the arrangement of the interlayer water associated with small cations and to the tetrahedral layer. Single crystal photographs have shown the same random shift of $\frac{nb_o}{3}$ in the b-axis direction as is shown by chlorites so that spot (hkl) reflections only occur where $k=3n$. Where $k \neq 3n$ the reflections are streaks and are unlikely to appear at all in powder photographs.

A note on the adsorption complexes formed by vermiculite with different organic compounds[3] and a review of the knowledge of the mineral[4] have now been published.

Iron oxides prepared under varying conditions by the Physico-Chemical Section have been studied, but many of these are amorphous to X-rays and others give poor diffraction patterns.

In a preliminary study of manganese pans, one, in a gravel deposit, contains a cryptocrystalline compound. This gives a diffraction pattern identical to a hydrated manganese oxide not previously found naturally and known only as the end product of the oxidation of manganous ion in excess sodium hydroxide. Many "manganese pans" seem to consist of quartz with a fine coating of manganese oxide.

In collaboration with the Physico-Chemical Section, the effects of dry-grinding for periods of up to 24 hours on muscovite, biolite and vermiculite have been studied by differential thermal analysis, X-ray diffraction and cation-exchange determinations. Biotite and vermiculite seem to be affected only slightly, the cation exchange capacity of biotite increasing slowly as more of the crystal edges are broken. The structure of muscovite seems to break down completely after 8 to 9 hours grinding, and on further grinding an illite is formed.

PHYSICO-CHEMICAL SECTION

Differential Thermal Analysis

The apparatus, briefly described in last year's report, continues to function very satisfactorily, and reproducibility both of rate of temperature increase and of results continues to be good. During the year two new types of specimen holder have been tested. One of these has proved quite satisfactory, although some adjustment of the programme controller will be necessary to obtain the required rate of heating. As this type is now available commercially, it is intended to make the adjustments necessary for its use.

A considerable number of thermograms of pure minerals and mixtures have been obtained, both for use as standard data and to investigate impurities. Among the more interesting samples were some of kaolin from Pugu, Tanganyika, where both kaolinite and "fireclay mineral" were found in one and the same deposit. No information as to the iron oxide impurity in some of these samples could, however, be obtained from these thermograms. The work on iron oxides has been considerably extended. Since relatively inconclusive results as to the conditions of formation and stability of "cold-precipitated" hydrated ferric oxide resulted from an extended study of soil clays from various soil types, it was considered that a more intensive investigation on the pure laboratory-prepared material might help to solve some problems. While the type of ferric oxide formed depends very considerably on the alkali employed, the ferric salt used does not seem to be critical, although anomalies have been observed in the presence of sulphate and phosphate. The effect of the former is difficult to explain, but the interference of the latter ion is to be expected. Oxides precipitated by ammonia, potassium hydroxide and diethylamine were found to be amorphous to X-rays while that precipitated by sodium hydroxide was partly crystalline. The 350°C peak on the cold-precipitated material appeared to be due to crystallization into haematite, although some abnormalities have been observed. This work is continuing and is being extended to cover aluminium oxides on which a few preliminary results are now available. A paper on the results then available was read at a meeting of the Clay Minerals Group of the Mineralogical Society in April 1951.

Scottish soil-clays investigated showed, in general, the usual features—a mineral of the kaolinite group, illite, and in a few cases montmorillonite. In addition to those clays, some from other localities, including Africa, India and Sweden, have been examined. The Swedish clays were essentially micaceous, giving very little thermal reaction; the Indian and African clays were montmorillonitic or kaolinitic, depending upon their origin and development. For example, an Indian Black Soil had a clay of montmorillonitic composition while a red clay showed kaolinite. Lateritic clays in addition usually show pronounced peaks due to the presence of the hydrous iron and aluminium oxides, goethite and gibbsite. In this connection it may be remarked that the differential thermal analysis method generally becomes more valuable the more highly weathered the soil being investigated. Arctic or Sub-arctic clays give thermograms with very little character apart from a few diffuse peaks, the clays being essentially micaceous and relatively unweathered; soil-clays of the Temperate Zone give curves with some character, showing peaks of, for instance, kaolinite, illite, etc., but it is obvious from the curve that not all the components are accounted for; clays from Tropical or Subtropical regions, however, give sharp. well-defined peaks, and it is noticeable that, in most cases, all the components can be identified from their differential thermal analysis curve alone. This generalization is naturally very broad and subject to exceptions, but the results of Dr M. Muñoz Taboadela, while working here on the differential thermal analysis examination of minerals and soil-clays from Spain and from Spanish Morocco, have tended to confirm that the configuration of the thermogram may give some indication of the intensity of weathering.

The Differential Thermal Analysis Sub-Committee of the Comité International pour l'Etude des Argiles, referred to in last year's report, continues its work on the standardization of differential thermal analysis apparatus and a preliminary correlation of the results available for the "standard" minerals has been performed. A short paper on this preliminary correlation was read at a meeting of the Clay Minerals Group of the Mineralogical Society in November, 1950.

A paper on the possible application of differential thermal analysis to dust research is now in the press[23].

Other Studies

A description of the micro-method for the determination of cation exchange capacities of clays has now been published[5], and the method has been successfully applied to various samples including ground micaceous minerals, diatomites, and Spanish clays. The semi-micro technique has been applied to the chemical analysis of clays, in connection with the problem of removal of free iron oxides. This technique has proved very useful in determining the chemical composition of the clay before and after treatment and the composition of the extract, and has given valuable information. Further work along these lines is envisaged.

Investigations on the possibility of using electrophoretic mobilities for separation of the clay minerals in mixtures have proceeded. Initially the behaviour of suspensions of pure minerals under electric fields was studied in order to give some indication of the conditions, if any, under which separation of a mixture might be expected. Investigations were confined to kaolinite and montmorillonite suspensions, since the properties of these minerals are so widely different. Several types of apparatus were tested to discover the best for quantitative measurement of mobilities using the moving-boundary method. One which had a narrow capillary tube between the two electrode compartments proved most satisfactory, although by no means ideal. Considerable difficulty was experienced in observing the boundary, especially in the case of montmorillonite, and although considerable time was spent in trying to make this boundary more visible, no success was obtained. In spite of these difficulties, however, it appeared that variation of monovalent exchangeable cation, electro-motive force, concentration of suspension and pH (over a limited range) did not permit sufficiently different rates to allow separation of a mixture, but in view of the rather crude measurements more accurate determinations were desirable. These were obtained through the courtesy of Dr T. R. Bolam, Department of Chemistry, University of Edinburgh, in granting facilities for the use of the ultramicroscope there to determine electrophoretic velocities. Making no allowance for electro-endosmosis, it was confirmed that differences sufficiently large to give hope of separation could not be obtained using clays saturated with the monovalent ions Na^+, K^+, NH_4^+ or H^+ (all clays were given a preliminary electrodialysis to remove excess salts and were then, at least partially, H-saturated), although there were indications that saturation with divalent ions, such as Ca^{++}, offered greater possibilities. Further investigations along these lines are in progress. To avoid contamination of the suspensions with excess salt (thus lowering the effective e.m.f. across a cell), all saturations were performed by means of ion-exchange resins.

A paper dealing with theoretical aspects of the hydration of montmorillonite has been published[6].

SPECTROCHEMISTRY

The past year has been marked by a further increase in the diversity of the methods in use. During the initial period of the development of spectrographic methods applicable to the analysis of soil and plants, covering the years from 1935 until 1947, the only methods employed in the Department were the Lundegårdh flame emission technique (for the determination of alkali and alkaline earth metals in above-trace amounts) and the cathode layer direct current arc method (for the determination of trace elements in soils and plant materials). These methods are still in use, and have adequately demonstrated the ability of spectrographic methods to provide reliable analysis of soils, plants and related materials. The development of electronic techniques has, however, led in the last few years to the introduction of quicker and more efficient methods for certain specific purposes, such as flame photometry for the determination of potassium, sodium and calcium, and triggered alternating current arc emission for zinc and other volatile constituents. This development of methods has been further facilitated recently by the precision workshop which has been able to provide numerous items of equipment of new or improved design.

Liaison with other workers on spectrochemical methods and their applications to agricultural research has been maintained through the meetings of the Consultative Committee for the Development of Spectrographic Work, sponsored by the Department of Agriculture for Scotland, but also embracing workers from Northern Ireland, as well as through the Spectrographic Discussion Group in Glasgow, the Interservices-D.S.I.R. Panel for Emission Spectroscopy, and other groups. The Institute will be represented on the Agricultural Research Council Group for Mineral Deficiencies and Excesses in Animals.

The demands on the Department for training in spectrochemical methods have continued to be embarrassing in their number. Post-graduate workers from Argentina, Egypt, Spain, Australia, Canada, India and Trinidad have spent periods of study in the laboratory, and there have been numerous short term visitors.

A brief account of the work of the Department, presented to the International Microchemical Congress at Graz in 1950, has been published[7]. A revised version of Professor Lundegårdh's monograph on Leaf Analysis, which deals in some detail with flame emission methods of determination, has been translated and published[8].

FLAME EMISSION METHODS

The flame photometer described in earlier reports has been in continuous use for the determination of potassium, calcium and sodium in extracts of plants and soils. It has proved reliable in operation and required little electronic maintenance. Some 8600 samples have been dealt with during the year, chiefly from the Departments of Soil Fertility, Plant Physiology and

Pedology. This number is considerably below the capacity of the equipment. When determinations of other elements, particularly magnesium and manganese, are required in the extracts, the original Lundegårdh flame technique is employed, and this has been the case with about 3000 samples. This method is considerably slower, and as it necessitates prior concentration of soil extracts, investigations have been initiated into the possibility of employing some more sensitive method; the spark technique discussed below appears promising. The application of interference filters to flame photometry is being investigated, and to facilitate this work, a third flame unit is being produced in the workshop.

ARC EMISSION METHODS

The combination of the direct current cathode layer arc source with chemical concentration by organic reagents has provided a versatile method covering many of the trace elements of biological importance. The elements which can normally be determined in soil or plant materials by these methods, directly or after concentration, include cobalt, nickel, molybdenum, tin, lead, zinc, copper, manganese, titanium, vanadium, chromium, silver, iron, barium and strontium. The possible inclusion of other elements is being studied. A reliable method for the determination of the *available* copper in soils is one of the more complex problems being investigated.

Work has continued on the application of pulsed, that is triggered alternating current, arcs to the determination of zinc and other volatile constituents in powder samples. A tentative method for zinc in plant ash, using cadmium as internal standard, and a line breadth method of photometry, detects as little as 3 p.p.m. zinc.

A step sector on a stand which allows of its adjustment independently of the lens carried on the same stand has been designed and constructed. Modifications to the lathe, involving the tailstock, drive, and cutting equipment have led to faster and more accurate production of carbon electrodes, with fewer breakages. The demand for these is of the order of 12,000 pieces annually, of several different shapes, and, in view of the increasing cost and scarcity of suitable carbon rods, economy in their production is essential. Carbon electrodes are more difficult to machine than the graphite electrodes employed by many spectroscopists, but found unsuitable in this Department for the direct current arc technique.

A description of the method employed for the determination of copper, barium, strontium, manganese, and other elements in plant ash has been published[9].

SPARK EMISSION METHODS

Spark emission had not hitherto been found applicable to the problems encountered, but preliminary results suggest that a modification of a porous cup technique using spark excitation may be suitable for the determination of magnesium in soil and plant extracts. A spring-loaded clamp to carry the electrodes required in this method has been designed and constructed in the workshop, and a description submitted for publication[26].

PHOTOMETRY

It is the practice in the Department to evaluate spectral line intensity by determining blackening curve separation at a specific photographic density. This involves the conversion (Ann. Rep., 1942-43 Appendix B) of microphotometer readings of galvanometer deflections (i) to logarithmic ratios (log i_o/i) followed by the plotting of 3 points to provide a reliable blackening curve. The so-called Seidel transformation, which involves the plotting of log ($i_o/i - 1$) rather than log i_o/i against the logarithm of the relative exposure, results in approximately parallel straight lines being obtained, and it may prove necessary to read only two steps instead of three to obtain the requisite accuracy, but adequate information regarding this point is not yet available. The transformed blackening curve separation is obtained in the usual manner, and should give the same value as the original method.

Values of log ($i_o/i - 1$) for $i_0 = 50$ and i=values up to 50 can be tabulated, or a drawing board with a vertical scale on a sliding perspex set-square for the direct conversion of galvanometer readings to these values can be employed. The value of log ($i_o/i - 1$) can be found from Appendix B of Ann. Rep., 1942-43 and Appendix C of Ann. Rep., 1943-44 by obtaining log i_o/i corresponding to the galvanometer reading i and entering the $(\delta - \gamma)$ table with this. The value obtained in the table is then log ($i_o/i - 1$).

Correction for spectral background can be carried out exactly as with the earlier method (Ann. Rep., 1943-44, Appendix C), or the $(\delta - \gamma)$ values can be read directly from an appropriately divided scale.

The new method appears to possess advantages of speed and simplicity, particularly if graphical calculating boards of adequate reliability for routine work can be produced. Results so far show good agreement between the two methods, and suggest that the new methods may be somewhat less liable to subjective errors, because of the greater degree of reproducibility of straight lines compared with the toed blackening curves. The method has however not yet been adopted for routine use.

The advantages for certain purposes of a wavelength:density chart such as is provided by a recording microphotometer have been noted by numerous workers, who have pointed out the difficulties of measuring very weak lines, or lines appearing as a shoulder on a stronger, adjacent line. The slowness for this purpose of the standard type of pen-recording instrument has resulted in the development of mechanically scanned photometers with cathode ray display. A display microphotometer with electronic scanning, eliminating all mechanical movement of the plate and employing an image converter followed by a photomultiplier tube for this purpose, is being developed in the Department, and preliminary results appear promising.

TRACE CONSTITUENTS IN SOILS, PLANTS AND BIOLOGICAL MATERIALS

An account of the geochemical distribution of trace elements in the rocks of the Skaergaard Intrusion, East Greenland, has been published[10] in collaboration with Professor L. R. Wager of the University of Oxford. This basic igneous intrusion is strongly differentiated, with rocks varying in composition from ultra-basic to acidic, and the analyses of the rocks and their constituent minerals have provided important information of wide general application on the occurrence of trace elements. The study of the changes in trace element solubility during soil formation, as displayed in a series of soil profile investigations, is nearing completion, and will be presented as a doctorate thesis by one of our visiting research workers. The text of a lecture given in 1947 on trace elements in soils and their uptake by plants has been published.[11]

Collaboration with other departments within the Institute has included the comprehensive examination of bracken samples and the determination of nickel in a considerable number of soil extracts and plant materials for the Department of Plant Physiology. Determinations of cobalt, molybdenum, copper and other trace elements have been made on numerous samples of plant materials and soils from areas where animal disorders are suspected to be due to abnormal trace element contents, and the possibility of cobalt or copper deficiency or molybdenum excess has been noted in several instances. Very low contents of copper and manganese have been found in crops from machair lands in N.W. Scotland. These investigations are carried out in collaboration with the Department of Soil Fertility. A few peat profiles have been examined for the Department of Soil Organic Matter.

The Animal Diseases Research Association has continued to supply samples of animal organs for analysis, and various types of samples from the Hannah Dairy Research Institute, the Rowett Research Institute, and the Torry Research Station have been examined.

Enquiries from National Agricultural Advisory Service sources in England and Wales have included several from areas where excesses of zinc, copper and lead appear to be affecting plant growth. Samples of composts, seaweed meals and fertilizers such as Chilean nitrate have been among the miscellaneous materials examined. From overseas, analyses have included those of samples of rubber leaves on behalf of the Rubber Research Institute of Malaya, soils and herbages from the south of Ireland where unusual animal disorders are reported, and grasses, animal organs and bore-hole waters from Kenya.

ABSORPTION SPECTROMETRY OF SOIL ORGANIC MATTER

The question of the occurrence and nature of the lignin in sphagnum has been further investigated. The usual lignin reactions are obscured by the formation under acid conditions of furfuraldehydes and dark polymerization products from the readily hydrolysable carbohydrates present in sphagnum (60 per cent. of sphagnum is converted into soluble products by ethanolysis). The presence of phenolic ketones can, however, be distinguished among the ethanolysis products and it has been shown that these cannot arise from carbohydrates under the experimental conditions. The nature of the phenolic nucleus present is being investigated.

Preliminary work on the changes in birch lignin produced by wood-rotting fungi has commenced, in collaboration with the Microbiology Section.

A simple technique has been developed for the estimation of scattered light in a photoelectric spectrophotometer, using a 0.2 per cent. solution of sodium hydroxide as the filtering medium. The transmission of such a solution falls rapidly to zero between 220 and 210 m.μ., and thus the apparent transmission between 210 and 200 m.μ. gives a measure of the scattering in this region within the instrument.

SOIL ORGANIC MATTER

CHEMICAL INVESTIGATIONS

Carbohydrates. The unknown sugars obtained from the soluble carbohydrate fraction of the soil have been separated on a cellulose column and small amounts obtained relatively free from contaminants. Colour reactions on the paper chromatogram were similar to those shown by methylated sugars (Hough, Jones & Wadman, *J. Chem. Soc.*, 1702, 1950) and micro-methoxyl determinations on the fractions gave values approximating to that required by a monomethyl hexose. Demethylation with hydrobromic acid and examination of the products by paper chromatography (Hough *et al*, *loc. cit.*) indicated that the parent sugars were aldohexoses, probably glucose and galactose. In this connection, it has been pointed out (Bayly, Bourne & Stacey, *Nature*, **168**, 510, 1951) that the indications of identity obtained by paper chromatography require confirmation, for example by determination of the physical constants of crystalline specimens, and this is now being done. The methylated hexoses were found in eight out of nine soils examined. A soil rich in organic matter (6.4 per cent. C, 4.5 per cent. H_2O) contained approximately 0.006 per cent. of these substances. The discovery of unknown methylated hexoses in soil is of interest in that comparatively few methylated carbohydrates occur in nature (Hirst, Hough & Jones, *J. Chem. Soc.*, 323, 1951) and so a wider distribution is indicated than was hitherto thought likely. In view of the difficulty of preparing these "trace carbohydrates" from soil, further progress will probably be slow, and a preliminary publication is now being prepared.

Work on the carbohydrate metabolism of various fungi has been continued in collaboration with the Microbiological Section. Investigation of the "fungus cellulose" of *Polyporus betulinus* fructification by the classical technique of methylation followed by hydrolysis and separation of the products by the newer chromatographic methods has shown the presence of 1 : 3 linked anhydro-glucose residues. The optical rotation of the methylated product indicates the presence of a proportion of α linkages in contrast to β linkages present in previously known 1 : 3 glucosans such as laminarin and yeast glucan. The yield of crystalline 2 : 4 : 6 trimethylglucopyranose from the methylated material was poor and the presence of modes of linkage other than the α-1 : 3 type cannot be excluded without further investigation.

Nitrogenous Compounds. The study of the amino-acid content of soils has continued and improvements in technique have resulted in the better separation of the amino-acids on paper chromatograms. Progress has been made in placing the investigations on a quantitative basis.

A new naturally occurring amino-acid has been isolated and identified as L-piperidine-2-carboxylic acid (pipecolinic acid). This substance, which was first prepared synthetically by Mende in 1896, was detected as an unidentified ninhydrin-reacting substance in paper chromatograms of extracts of the leaves of white clover (*Trifolium repens*) which were being examined for amino-acids on behalf of Mrs Oxford, Agricultural Research Council Microbiological Unit, University of Aberdeen, in her studies of actinomycetes in relation to composting. It was subsequently found in the acid hydrolysate of a moist woodland soil having *Allium* and *Anemone* as the dominant ground vegetation. Pipecolinic acid has been detected in a number of other plants, notably the *Leguminosae*; of some 30 plants selected from a range of representative genera in just under a half no pipecolinic acid could be detected, while those in which it was found included besides all the *Leguminosae* (*Trifolium*, *Lathyrus*, *Laburnum*, *Vicia*), *Rosa*, *Petasites*, *Nicotiana*, *Urtica*, *Allium* and *Agrostis*. There is at present no evidence that this amino-acid is a constituent of protein; it occurs free in the plant and no suggestion can at present be made as to its origin or function. A preliminary communication on this work has been made to the Biochemical Society[27].

The Humus Complex. The action of oxidizing agents on humic acid is being studied and an attempt made to characterize its oxidative degradation products in the hope that these may yield some information bearing on the constitution of this substance.

Further work on humus is being carried on in conjunction with the Department of Spectrochemistry and the Microbiological Section and is discussed in the appropriate sections of the report.

MICROBIOLOGICAL INVESTIGATIONS

Rhizosphere Work. In this work the aim has been to follow the development of the soil microflora during the progress of succession from the colonization of open ground by flowering plants to a relatively complex community. For this purpose a sequence of communities representing the course of succession on sand dunes has been selected. Special attention has been given to the demonstration and analysis of rhizosphere flora associated with colonizing species and with successive dominants of early stages in the succession. The following points have been established.

(1) From dune systems near Newburgh, Aberdeenshire and Tentsmuir, Fifeshire, sets of samples were taken along transects passing inland from the bare sand above high-water mark. Bacterial and fungal populations showed a marked increase with the start of plant colonization. Numbers rose steadily with the development of the vegetation and increasing complexity of the plant community. The colonization of dune grassland by heather, however, was accompanied by a fall in bacterial numbers, although the fungal population continued to rise in dune heath and in a pine plantation on this.

(2) Rhizosphere floras were demonstrated round the root systems of three species colonizing the shore just above highwater mark, namely *Atriplex babingtonii*, *Agropyron junceum* and *Ammophila arenaria*, the last two of which became the dominants of later stages in the succession. The numbers of organisms obtained from the rhizosphere sand were much larger than those from bare sand just above high-water mark.

(3) The organisms obtained by the usual methods of isolating the "rhizosphere" flora include both those from the root surface as well as of the rhizosphere proper, together referred to as the "root region" (Harley, *Biol. Rev.*, 23, 127, 1948). A technique was developed for separating these two floras. Using this technique, and calculating numbers of organisms per unit

weight of substratum, the numbers of organisms from the root surface of *Agropyron* and *Ammophila* were found to be much larger than those from the rhizosphere sand—indicating a denser flora on the root surface.

(4) Morphological investigation of isolates from these two sources (root surface and rhizosphere sand) indicate a high proportion of organisms having affinities with *Corynebacteria*, *Mycobacteria* and *Nocardia*. The flora from the root surface of *Ammophila* differed from that of *Agropyron* in that it carried a greater proportion of gram-negative non-sporing rods. Fungal floras were relatively uniform with a species of *Cephalosporium* predominant, especially in the case of *Ammophila*. A paper on this work has been accepted for publication[28].

General. Certain species of the genus Proactinomyces (=Nocardia, Bergey, 6th ed.) of the group of organisms found to be dominant in the rhizosphere micro-community are able to grow on a liquid paraffin and paraffin wax as sole source of carbon. A strain of one of these species *P. opacus* is being investigated in detail using the Warburg apparatus. A preliminary paper embodying some interesting results has been submitted for publication[29].

Mycology, The principal subject of interest has been the degradation of the lignin present in plant tissues. The first line of approach was the direct attack on wood meal by pure cultures of recognized "white rot" fungi. Extracts of the wood before and after attack were prepared by ethanolysis for spectrometric investigation. Pure cultures of timber-rotting fungi were supplied with polyphenolic compounds associated with the degradation of lignin. These substances tend to be toxic and the organisms used do not appear to be able to utilize them as the sole source of carbon. It seems that study of the polyphenol oxidase enzymes present in the white-rot fungi may prove fruitful. These enzyme systems, absent in the cellulose rots, have been found in a number of soil fungi not generally associated with timber decay. Several mucilages produced by hymenomycetous fungi are being examined for their carbohydrate constituents.

FORESTRY INVESTIGATIONS

A paper on work carried out on the Culbin Forest has been published,[13] and a similar paper on work in the Tentsmuir area has been accepted for publication[30].

Culbin Forest continues to be the main research area for the study of profile development in forest soils. The scope of the work, started in 1947, has been extended by the establishment of a number of new sample plots in the older plantations of Corsican pine, and on areas of dune bearing respectively Scots pine, birch and dry heath vegetation.

Samples have been taken from all these plots to a depth of 5 feet for chemical and mechanical analyses. Preliminary analyses of the total iron and aluminium content of some of these samples suggest that leaching is taking place to a considerably greater depth than would appear from the visual examination of the profiles. The degree of leaching varies considerably, depending on the vegetational cover. Since the silt and clay content of the Culbin sand is extremely small, it is possible that the usual grades of particle size are too wide to give a good indication of particle size distribution. For this reason mechanical analysis has so far been confined to the sub-division of the coarse and fine sand by dry sieving.

In order to investigate further the cyclic movement of available nutrients taking place in the planted areas, the litter fall on the sample plots is being collected at bi-monthly intervals and its nutrient content determined. An attempt is being made to obtain a more continuous record of moisture movements in the soil than is possible by periodic sampling. For this purpose a number of Bouyoucos gypsum moisture blocks have been constructed and buried in the plots. Preliminary readings show that the blocks are well suited to the range of moisture content involved. A parallel study of temperature fluctuations is being made using thermistor units adapted as soil thermometers.

At the request of the Forestry Commission and in collaboration with the Soil Survey Section, data were obtained regarding the soils of the Bowmont Norway spruce sample plots, and were discussed at the British Association field meeting at the Forest. Effects on the soil of different degrees of thinning are not yet generally apparent but considerable differences were found in the rates of nitrification in soils from the various plots. These data have been incorporated in a more general study of nitrogen transformations in forest soil using the percolation technique of Lees (*Plant and Soil*, **1**, 221-239, 1949).

PEAT INVESTIGATIONS

Pollen Analyses. These have been carried out on profiles from several mosses near Aberdeen and from Flanders Moss, and profiles sampled from a wider area in the north of Scotland. This work has not yet reached a stage at which generalizations can safely be made. Samples from some of these mosses have also been taken for the spectrochemical determination of trace constituents.

Routine Work. Routine work has continued in connection with the peat survey carried out by the Peat Division of the Department of Agriculture for Scotland. During the year 754 routine samples have been examined and analysed, in addition to some 100 samples submitted for special analysis. The vegetation of the mosses of Altnabreac and Badenloch has been examined and peat samples taken. The samples of ash obtained during analysis are being examined for radioactivity.

A small number of horticultural peats have been submitted for analysis and advice, and the usual number of queries have been answered.

FIELD AND GLASSHOUSE EXPERIMENTAL WORK

This has continued along the same lines as reported last year. More extended experiments involving the use of composts have been established in the field. These will be of a continuous character involving the characterization of the humus produced by the different organic treatments.

PLANT PHYSIOLOGY

The work of the Department has dealt mainly with the examination of ion relationships in nutrient absorption using soil, sand and water culture methods. Investigations have included studies on trace-element toxicities, magnesium-potassium antagonism, iron and manganese nutrition in water-culture, and soft-fruit nutrition. Chemical methods of analysis have also received attention.

Instruction in the methods used in the Department has been given to several visiting research workers, one of whom has collaborated in the research on nickel toxicity.

TRACE ELEMENT TOXICITIES

(*a*) *Nickel.* In localized areas of Aberdeenshire, the soils are derived from serpentine and contain relatively large amounts of extractable nickel and other trace elements. Under certain conditions, some crops grown in these areas are seriously affected, characteristic symptoms being developed. These symptoms are also produced in sand-culture when the nutrient solution contains 2.5 p.p.m. nickel as nickel sulphate; the soil toxicity, therefore, may reasonably be assumed to be due to nickel. In the oat, which is a convenient indicator plant, symptoms range from a slight chlorosis of the leaf to a prominent longitudinal striping in which extensive leaf areas are colourless.

Sand-culture has been used to examine (1) the effect of nickel on major-nutrient absorption and (2) the relationship between major-nutrient supply (both low and high level) and nickel absorption and toxicity; examination of the data is at present incomplete but indicates that deficiencies of nitrogen, potassium, calcium and magnesium intensify the toxic action of nickel whilst a high level of calcium reduces it. Nickel absorption is being studied at pH values ranging from 4.0 to 7.5 using water-culture. The effects of excessive amounts of other trace elements (aluminium, chromium, cobalt, copper, manganese, molybdenum and zinc) and their interaction with nickel are being examined and the work has shown that of these elements only cobalt produces symptoms similar to those of nickel. The relationship between nickel and iron in deficient and normal amounts is being investigated, results indicating that an adequate supply of iron prevents the development of chlorosis, but not of the more extreme symptoms produced by nickel. Field trials and pot experiments with soil, and sand-culture experiments, are being used to determine the relative susceptibility of common crops to damage by nickel and the most satisfactory soil corrective treatment; the experiments so far have shown cereals (especially oats) to be the most susceptible crops, and improvement of the soil nutrient status (particularly calcium) the most satisfactory remedy. Aberdeenshire and American serpentine soils are being compared from chemical and general fertility aspects and as the investigation proceeds, the number of soils of this type under examination is expected to increase. The effect of nickel on the carbohydrate content of oat plants has been investigated with the co-operation of the Department of Soil Organic Matter and found to be negligible. The nickel-nitrogen relationship is now being examined. The anatomical changes produced on oat plants by nickel have been studied and the investigation is being extended to a comparison of nickel and cobalt toxicities and iron deficiency; the Department of Botany, University of Aberdeen, is providing facilities for this aspect of the investigation.

(*b*) *Boron.* A limited investigation followed the occurrence in the field of an abnormally high phosphorus content in oat plants which had received excessive boron. Both soil and sand-culture experiments failed to relate phosphorus uptake to boron supply.

MAGNESIUM-POTASSIUM ANTAGONISM

A preliminary experiment using water-culture was set up to examine the effects of various levels of nitrate, phosphate, chloride and sulphate ions on the uptake of magnesium by tomatoes grown in solutions of equal osmotic pressure and constant potassium/magnesium ratio. The investigation is continuing.

IRON AND MANGANESE NUTRITION IN WATER-CULTURE

Iron as ferric citrate and ferric potassium ethylenediamine tetra-acetate (L. Jacobson; *Plant Physiol.*, **26**, 411, 1951) and manganese as manganese sulphate, were used in a series of nutrient solutions of varying iron and manganese concentration to investigate the effect of concentration and form of iron and concentration of manganese on growth of tomato plants in water-culture. 2.5—5 p.p.m. iron and 0.5—1 p.p.m. manganese gave excellent results when the source of iron was the tetra-acetate complex, the nutrient solution being renewed at intervals of 10 days.

SOFT-FRUIT NUTRITION

The first-year yield data for fruit-bud and fruit production in the raspberry and strawberry experiments have been examined statistically with no significant results. The results confirm that plot size and soil uniformity are adequate. Treatments included factorial combinations of nitrogenous, phosphatic and potassic fertilizers at two levels, the lower being applied in spring and the higher as complete dressings in spring and as split dressings in spring and late summer. The experiments were designed to correlate leaf composition with treatment and with vegetative, fruit-bud and fruit yields.

CHEMICAL METHODS OF ANALYSIS

The analytical technique for diagnosing the nutrient status of plants has been used extensively in the above investigations. Analytical methods have been kept under review; the method for determining potassium has been considerably improved and a rapid method developed for determining calcium which is more sensitive and less susceptible to error from iron, manganese and aluminium interference than the previous one.

RADIOACTIVE STUDIES

The radioactive-tracer investigations outlined in the previous report have been continued.

With the co-operation of the Department of Agriculture, University of Oxford, and the Atomic Energy Research Establishment, Harwell, a radio-autograph technique was applied to determine the distribution of nickel in oat and barley plants affected by nickel toxicity; the results were unsatisfactory, due to the short half-life and low activity of ^{65}Ni. Because of the similarity between nickel and cobalt toxicity symptoms, the investigation is being continued using ^{60}Co which is a convenient isotope for radioactive-tracer studies.

The study of phosphate fixation has been continued in collaboration with the Department of Soil Fertility. In laboratory experiments ^{32}P has been employed to follow the rate of reaction between phosphate and different soils and to study the nature of the reactions taking place. This method has also enabled the total readily exchangeable P in the soils to be measured as a criterion of their phosphate status. The ^{32}P tracer technique has been used in an extensive pot experiment to measure the uptake of applied phosphate by oats from four different soil types and to assess the amount of available phosphate. An attempt has been made to develop a photographic method suitable for following the diffusion of phosphate from fertilizer granules into soils.

Further samples of peat ash, obtained in the course of the Peat Survey of Scotland, have given negative results when tested to determine whether radioactive minerals occur in proximity to the peat moss.

SOIL FERTILITY—CHEMISTRY AND FIELD EXPERIMENTATION

The general object of the work of the Department continues to be the maintenance and improvement of soil fertility in its widest sense of improving both the yield and the feeding quality of crops. To this end experimental work has been continued both on problems with immediate practical implications and on those of the more fundamental type with no obvious immediate bearing on practical agriculture. Throughout these studies of the soil from numerous aspects the aim has been to maintain an appropriate balance between the fundamental and the applied sides. Detailed characterization of field behaviour under varying manuring, seasonal conditions, cropping and management is indispensible to the identification and assessment of the various factors determining the inherent fertility of different soil types. Such data are also necessary as a yardstick for assessing the results of pot experiments and laboratory studies; all three types of work have therefore been continued and extended.

Accounts of the work and reviews of the position to date have been given in the form of addresses to various bodies in different parts of the country and in four publications [14, 15, 16, 17]. A paper on the agricultural land resources of Scotland was read at the British Association meeting in Edinburgh.

FIELD EXPERIMENTS

In design these all conform to modern statistical requirements and, depending on the individual objectives, include randomized blocks, latin squares, split plot latin squares, factorial arrangements and lattice squares. The actual statistical work continues to be carried out in the Statistics Department in the University of Aberdeen and we are indebted to Mr M. H. Quenouille and his staff for facilities and willing collaboration. The experiments, which have been continued from previous years or commenced during the past year, are designed to investigate the following main points:

General manuring and liming problems.

Factorial experiments to determine the response of various crops to nitrogen, phosphate and potash in the presence and absence of dung have been continued and extended. Results to date for turnips, swedes and potatoes indicate that the application of dung does not materially reduce the need for nitrogen but it does reduce responses to both phosphate and potash. Experiments have been undertaken to obtain more information on the optimum time of application of nitrogen to cereals, and work is also in hand to find the cause of blind or empty ears in oats growing on certain moderately acid soils. The long-term liming experiments commenced in 1944 to measure the residual effects of various liming materials have been continued. On oats and potatoes in 1950 the differences between the various treatments were scarcely significant. A special study is being made of the effects of ordinary ground limestone and ground magnesian limestone on the composition of pasture throughout the growing season; the magnesian limestone has the effect of increasing appreciably the magnesium content of the herbage.

As emphasized in previous reports one of the major objects of the field experiment work is the characterization of the yielding capacity and nutrient status of the principal soil associations identified in the Soil Survey of Scotland. Most of the experiments make some contribution to this end and, in addition, a more specific contribution continues to be made by the soil substitution experiments at Craigiebuckler and by the corresponding set of experiments on farms from which the soils were taken. Both these sets of long-term experiments are now at the pasture stage in the first rotation.

Phosphate relationships of soils

(1) *Effectiveness and positional availability of phosphate residues.* New experiments on the Countesswells, Insch, Foudland and Stonehaven Soil Associations have been started. In these the residual effects of dressings of up to 960 lb. P_2O_5 per acre applied for oats in 1951 will be estimated in terms of fresh dressings applied to roots in 1952. The 1951 treatments include applications before and after ploughing to study the effect of the factor of positional availability on the effectiveness of the residues, and hence to clarify the relationship between field estimates of availability and laboratory measurements of solubility. The effect of lime on phosphate availability is also being tested in these experiments.

(2) *Time of application of phosphate.* The effect of varying periods of contact between superphosphate and bare soil under field conditions is being tested in a new series of experiments with particular reference to phosphate at low rates of application. This question is of considerable theoretical as well as practical importance, and to obtain adequate information experiments will have to be continued over a number of seasons.

(3) *Forms of phosphate.* Trials with dung-superphosphate mixtures and superphosphate of varying particle size have been continued and two co-operative experiments have been started to test the effectiveness of "Nitro-phosphate." This type of experiment is being continued with different crops over a number of seasons until adequate data are available.

(4) *Comparison of well-drained and poorly-drained soils.* Experiments involving lime, sulphur and phosphate treatments are in progress on corresponding well-drained and poorly-drained soils to investigate the significance of the marked contrasts in their phosphate relationships which are found in laboratory studies.

(5) *Penetration of phosphate in grassland.* The long-term experiment commenced two years ago is being continued.

A paper on the efficient utilization of phosphate fertilizers and summarizing the practical conclusions to be drawn from the work to-date has been accepted for publication[31]. The main topics dealt with are: amount, frequency, time and method of application, the effectiveness of different forms, and the effects of soil conditions. The broad conclusion is that each crop should receive a dressing according to its responsiveness and the degree of deficiency in the soil, and that no attempt should be made to build up large reserves quickly by the application of single heavy dressings. Suitable placement and adequate liming are also of prime importance. Under Scottish conditions citric-soluble forms of phosphate provide very effective alternatives to superphosphate.

Fertilizer Placement

The investigations on placing fertilizers for turnips and swedes grown in ridges referred to in previous reports have been continued, and a report on the 1950 experiments has been submitted to the Agricultural Research Council. So far, the results indicate that with superphosphate placement in a band 1½ to 2½ inches below the seed is likely to be more effective than either broadcast application or placement in bands in other positions relative to the seed. With sulphate of ammonia and muriate of potash there does not appear to be any particular advantage or disadvantage in band placement, but further work with individual fertilizers and with mixtures is required before definite conclusions can be drawn.

A general account of the results obtained and of their practical implications has been given in a paper dealing with factors affecting methods of applying fertilizers which has been accepted for publication[32]. The question of when, where and how fertilizers should be applied are discussed, and it is emphasized that in Scotland at present the case for placement hinges mainly on the cereal crop, with which the combine-drilling of superphosphate or mixtures containing phosphate gives better yields than customary broadcast application. A paper giving the results of earlier experiments, referred to in previous reports, has now been published[18].

POT EXPERIMENTS

An additional 130 pots of the Mitscherlich type have been obtained and pot experimental work has been continued and extended to supplement the field data and to investigate specific problems such as the effect of neutral salts on phosphate availability. An experiment covering three pairs of corresponding well-drained and poorly-drained soils and four sources of phosphate has been carried out to test the effect on availability to plants of phosphate left in contact with moist soil for six months. A parallel experiment with cropped and uncropped soils has also been started to give in 1952 a measure of the effect of one year's contact between phosphate and soil, and to study the influence of the roots of growing crops on the reactions between the added phosphate and the soil.

In collaboration with the section for Radioactive Studies, the ^{32}P tracer technique has been applied to estimate the uptake of added phosphate from different soil types, and to measure the amount of available phosphate in the soils for comparison with values obtained by chemical extraction.

LABORATORY WORK

Extensive analytical work has been continued on soil and produce samples from the various experiment areas in order to characterize the soils as fully as possible and to determine the effects of the experimental treatments on the mineral composition of the crops. Apart from this the laboratory work has been devoted mainly to various aspects of the phosphate relationships of the soils. The main subjects under investigation are:

Fractionation of phosphate

This covers such determinations as total phosphate, organic phosphate, alkali-soluble, fluoride-soluble and various categories of acid-soluble phosphate. Surface soils from experiment areas are being examined along these lines to study the relationships of the different catetories and their bearing on the field behaviour of the soils. Parallel studies are in progress on the distribution of phosphate in soil profiles. These include a series of profiles with contrasting drainage conditions, which are being examined in collaboration with the Soil Survey Section, and profiles corresponding to the soil substitution experiments, the latter forming a special subject of study for a higher degree by one of the Overseas Workers. To supplement these phosphate fractionations various categories of iron and aluminium compounds in the soils are being estimated.

Phosphate retention

Sorption curves obtained from systems of varying pH, dilution and salt concentration are being used to study the mechanism of phosphate retention in different soils. Instructive contrasts have been found between corresponding well-drained and poorly-drained soils, and there appear to be at least four factors involved, *viz.*: binding by iron, binding by aluminium, a Donnan effect of divalent calcium and, in some cases, precipitation of calcium phosphate. The sorption curves show characteristic variations in form depending on the relative contributions of these factors. It is hoped shortly to prepare an account of this work for publication.

Rate of phosphate fixation

This work is the counterpart of the field and pot experiments on the effect of different periods of contact between phosphates and soils. One approach involves solubility measurements on mixtures of soil and phosphate treated under different conditions in the laboratory and on phosphate residues in samples from field plots. The other main approach is by means of isotopic exchange experiments with ^{32}P in collaboration with the Section on Radioactive Studies.

During his stay at the Institute as a British Council Scholar, Mr Erik Eriksson collaborated in some of the work on phosphate, and prepared a theoretical paper on the significance of physico-chemical measurements in colloidal systems[19]. He also read a paper to the British Society of Soil Science on the physico-chemical behaviour of nutrients in soils. In this paper a series of relationships derived from existing data on pH, solubility products, dissociation constants, and oxidation-reduction potentials is presented. From these the probability of formation of various compounds and the order of magnitude of the equilibrium concentrations of different nutrients under varying soil conditions are assessed.

Another overseas worker who has also been collaborating in the phosphate retention studies is Dr L. H. P. Jones, a Nuffield Foundationer from Melbourne University. The latter is also extending his Australian investigations on *manganese* to Scottish soils, with particular reference to the laboratory assessment of manganese status and the ability of different soils to reduce added manganese oxides.

The paper on the effects of acid treatments on soil phosphate referred to in last year's report has now been published[20]. Further papers covering work in which Dr Williams took part when he was in Sweden have also now appeared [34, 35, 36, 37, 38].

ADVISORY AND OTHER *AD HOC* WORK

Advisory work on soils in co-operation with the North of Scotland College of Agriculture has been continued, and during the year over 8,000 samples of soil have been tested. Other work includes the determination of the agricultural value of various liming materials and industrial and other by-products. Advisory work on the maintenance and improvement of fertility in forest nursery soils has also been undertaken, mainly on behalf of the Forestry Commission.

The recording of analytical data and the grouping of advisory soil samples from Aberdeenshire and Kincardinshire on the basis of soil associations have also been continued. The main trend is towards deficiencies in lime and phosphate being less marked in the Stonehaven and Laurencekirk Associations and potash deficiency being less pronounced in these two and the Cruden Association than in the others. Although increased quantities of lime and fertilizers have been used in recent years, there are still widespread deficiencies in lime and phosphate and the majority of the soils are slightly low in potash.

Specialist advisory enquiries, with particular reference to the trace element contents of soil and produce in relation to animal health, are becoming steadily more numerous. In collaboration with the Department of Spectrochemistry many reports have been drawn up and, in doubtful cases, *ad hoc* trace element experiments arranged through the veterinary and other specialist services.

COLLABORATIVE WORK

A survey of agricultural, forestry and fishery products and their utilization in the United Kingdom has been carried out jointly with Dr F. N. Woodward and the late J. P. Maxton. A report has been prepared and presented to the Development Commission.

PUBLICATIONS

(A) *Published during the year—*

1. Recent advances in soil research at the Macaulay Institute. By D. N. McArthur. (*Proc. Roy. Philos. Soc., Glasgow*, **74**, 73-78, 1950).
2. The Macaulay Institute for Soil Research. By D. N. McArthur. (*Brit. Agric. Bull.*, **4**, No. 13, 3-6, 1951).
3. Vermiculite-organic complexes. By G. F. Walker. (*Nature*, **166**, 695, 1950).

   Organic complexes of vermiculite, like those of montmorillonite and halloysite, are found to be of two types. Complexes are formed with organic cations, such as codeine, where displacement of the vermiculite basal reflection depends on the concentration and the nature of the amine. Van der Waals adsorption complexes with substances such as glycerol are formed to a limited extent depending on the exchangeable inorganic cation present.
4. Vermiculites and some related mixed-layer minerals. By G. F. Walker. (*X-ray Identification and Crystal Structure of Clay Minerals*, Chap. VII. The Mineralogical Society, London, 1951).

   In a handbook on the identification of clay minerals this chapter defines the mineral vermiculite and discusses its chemical, structural, optical, thermal and dehydration criteria. Methods are given of distinguishing between vermiculite, chlorite and montmorillonite and between the pure mineral and the common mixed structures, mica-vermiculites and chlorite-vermiculites. The nature of the interlayer water and the properties which make this mineral important in soils, in structural investigations and, when exfoliated, in building and industry are fully discussed.
5. A micromethod for determination of cation-exchange capacity of clay. By R. C. Mackenzie. (*J. Coll. Sci.*, **6**, 219-222, 1951).

   A method is described for the determination of cation-exchange capacities of clays on samples of 10-50 mg. The method is discussed and the results obtained compared with those using the normal method employed here for samples of 0.2-1.0 g. clay.
6. Some notes on the hydration of montmorillonite. By R. C. Mackenzie. (*Clay Min. Bull.*, No. 4, 115-119, 1950).

   Present theories of the structure of intersheet water in montmorillonite are discussed and some criticisms presented. Calculations of hydration energies of cations for one or two shells of water molecules show good correlation with the temperature of the hygroscopic moisture peak on thermograms of montmorillonite saturated with these cations, thus indicating that hydration of the sorbed cation may be the most important factor—at least at low water contents.
7. The spectrographic determination of trace elements in rocks, minerals and soils. By R. L. Mitchell. (*Mikrochemie*, **36/37**, 1042-1047, 1951).

   The total content of trace elements in rocks, minerals and soils is determined by a semi-quantitative cathode layer arc spectrographic technique. For more accurate determinations a variable internal standard technique, in which the trace element contents are compared with that of iron, is employed. This method is combined with a chemical concentration for the analysis of extracts of soils and plant materials. The chemical concentration technique involves the use of 8-hydroxyquinoline, tannic acid and thionalide, and gives recovery of microgram quantities of most trace elements, rejecting at the same time the alkalis, alkaline earths and phosphate.
8. Leaf analysis: an authorized translation by R. L. Mitchell of " *Die Blattanalyse*" by H. Lundegårdh. (*Hilger & Watts*, 98 St. Pancras Way, London, N.W.1. Price: 22/6 plus postage 6d.).

   Describes practical results of using analysis of leaves as a method for the determination of manurial requirements of soil. Spectrographic methods were employed and an automatic, " Robot " equipment specially designed to deal with the vast number of solutions investigated, is described. Of interest to investigators in plant physiology or applied botany as well as practising spectroscopists.

9. The spectrographic analysis of plant ash in the carbon arc. By V. C. Farmer. (*Spectrochim. Acta*, **4**, 224-228, 1950).

A spectrographic method using the cathode layer arc technique for the determination of Cu, Fe, Mn, Sr, Ba, Na, Mg and Ca in plant ashes without chemical pre-treatment is reported. Potassium sulphate is used as a spectrographic buffer, while traces of Ag and Cr incorporated in the carbon powder provide internal standards for the elements determined. A method for preparing $CaCO_3$ free from Sr and Ba is reported.

10. The distribution of trace elements during strong fractionation of basic magma — a further study of the Skaergaard intrusion, East Greenland. By L. R. Wager (*University of Oxford*) and R. L. Mitchell. (*Geochim. Acta*, **1**, 129-208, 1951).

A number of trace elements have been determined spectrographically in the rocks and minerals of the Skaergaard intrusion, East Greenland. The original basic magma from which the varied rocks of the complex were developed is shown to have had a normal trace element composition. The sorting out of the trace elements into the various mineral series produced by strong fractional crystallization of the original basic magma is traced in detail by means of analyses of the separated minerals. Certain of the trace elements (Cr, Ni) are shown to be strongly concentrated in the early rocks so that later fractions have little or none of them; other elements (P, V, Cu, Sc, Mn, S) reach maximum values in the middle or late middle stages represented by certain olivine-free gabbros and ferrogabbros; other elements (Li, Zr, Y, La, Ba, Rb) tend to remain in the residual liquid during fractionation and are thus abundant in the latest granite fraction. Still other trace elements (Co, Sr, Ga, Mo) show only small changes in amount throughout the series. Of these Co is a little more abundant in the early and middle stages, Sr in the middle stages, Ga in the later stages and Mo in the early and later but not in the middle stages. The distribution of the trace elements in the rocks is considered in relation to the varying composition of the minerals produced by the fractional crystallization process and an attempt is made to discuss the mineral compositions in terms of crystal chemical concepts.

The Skaergaard sequence by differentiation from gabbros, through ferrogabbros, to granite is considered to be a common trend of fractionation of basic magma at high levels in the crust, and the observed changes in trace element composition of the intermediate Skaergaard differentiates is significantly different from that of diorites reported by other workers and suggests that diorites have had some other origin than by fractionation of basic magma. On the other hand the trace element composition of many granites resembles that of the granite fraction produced in the Skaergaard intrusion.

11. The trace constituents of the soil. By R. L. Mitchell. (*Trans. XI. Int. Cong.* (1947) *Pure and Appl. Chem.*, **3**, 157-164, 1951).

A lecture on the factors involved and their relation to uptake by the plant.

12. Peat and its uses in horticulture. By G. K. Fraser. (*J. Bd. Greenk. Res.*, **7**, 322-334, 1950).

The introductory Part I of this paper deals along conventional lines with the origin and formation of types of peat deposits and the distribution of these in this country. Part II covers the essentially practical side of the utilization of peat under the headings of peat harvesting, the chief types of peat and their uses (with special reference to horticulture) and the reclamation of peat for agriculture and horticulture. These subjects are dealt with in a semi-popular manner.

13. The afforestation of the Culbin Sands. By J. D. Ovington. (*J. Ecol.*, **38**, 303-319, 1950).

Discussion of the ecological changes resulting from the reclamation of the Culbin Sands by the Forestry Commission.

14. Fertilizer utilization with special reference to phosphates. By A. B. Stewart. (*Fert. Soc. Proc.* No. 12, 1950).

The problems of the efficient use of fertilizer phosphorus are discussed under the heads of land utilization and consumption of fertilizers in the U.K., the respective merits of mixtures and of straight fertilizers, general response to fertilizers, field, pot and laboratory studies of the phosphate relationships of soils with special reference to phosphate fixation, the relative effectiveness of phosphate in different forms, placement, liming and other means of increasing the effectiveness of applied phosphate.

15. Fertilizers and lime in Scotland. I. Fertilizers and crop production. By A. B. Stewart. (*Scot. Agric.*, **30**, 107-111, 1950).

A brief review of the principal scientific and technical factors affecting the use of fertilizers, with particular reference to:—land utilization and fertilizer consumption in Scotland, factors affecting the response to fertilizer and estimated annual fertilizer requirements of arable and grassland in Scotland.

16. Fertilizers and lime in Scotland. II. Lime and soil fertility. By A. B. Stewart. (*Scot. Agric.*, **30**, 149-153, 1951).

A stocktaking of the position regarding the use of lime in Scotland, with special reference to:—forms of lime available, tonnage of lime consumed in Scotland during the period 1937-1949, need for more liming and for using supplies to the best advantage, rates and time of application, dangers of over-liming.

17. Fertilizers and crop production. By A. B. Stewart. (*Dept. Agric. Scot. Advis. Leafl.* No. 18, n.s., 1951).

The principal scientific and technical factors affecting the use of fertilizers are discussed under the heads of:—land utilization, fertilizer units and valuation of fertilizers, consumption of fertilizers in Scotland, factors affecting response to fertilizers, profitability, and estimated annual fertilizer requirements of land under crops and grass in Scotland.

Supplies are still quite inadequate to meet all possible demands, and the case is argued for meeting the fertilizer requirements of arable land, permanent grassland, and other land, in that order of precedence.

18. Placement of mineral nutrients in soils. By A. B. Stewart. (*Trans. XI. Int. Cong.* (1947) *Pure and Appl. Chem.*, **3**, 301-307, 1951).

An account of the results obtained in the earlier experiments on placement of fertilizers.

19. The significance of pH, ion activities and membrane potentials in colloidal systems. By E. Eriksson. (*Science*, **113**, 418-420, 1951).

Different theories for explaining the potential which arises across an electrically charged colloidal membrane separating two solutions of different salt activities are discussed and compared.

20. Effects of acid treatment of soils on phosphate availability and solubility. By E. G. Williams. (*J. Soil Sci.*, **21**, 110-117, 1951).

Pot tests with oats showed that extraction of soils with 2.5 per cent. (by vol.) acetic acid and 0.007N sulphuric acid, respectively, followed by restoration of the cation content and pH, increased greatly the availability of the remaining phosphate. This more than compensated for the readily soluble phosphate removed, and the treated soils gave much higher yields and P_2O_5 uptakes than the untreated soils. On three of the four soils used, treatment with acetic acid resulted in a considerably greater increase than treatment with sulphuric acid. Solubility measurements in water and in a solution of salts, simulating the basal dressings used in the pot tests, also gave higher values for the treated soils.

The solubility increases run parallel to, and are probably sufficient to account for, the increase in availability. The nature of the effect is discussed and it is attributed to a combination of factors, such as: deactivation of fixing agents, partial hydrolysis of difficultly soluble inorganic and organic phosphates, and redistribution of phosphate in the soils. One of the treated soils showed a marked increase in adsorbed phosphate.

(*B*) *Submitted for publication—*

21. Effect of grinding on micas. By R. C. Mackenzie and A. A. Milne. (To appear in *Clay Min. Bull.*).

22. Unidimensional Fourier synthesis of vermiculite. By G. F. Walker and A. A. Milne. (To appear in *Clay Min. Bull.*).

23. Differentialthermoanalyse und ihre Anwendung auf technische Stäube. By R. C. Mackenzie. (To appear in *Tonindust. Zeit.*).

24. The trace elements in sea-water and the brown marine algae common to Scotland. By W. A. P. Black (Institute of Seaweed Research) and R. L. Mitchell. (To appear in *J. Mar. Biol. Ass. U.K.*).

25. The administration of cobalt by different routes to lambs maintained on a low cobalt diet. By A. T. Phillipson (Rowett Research Institute) and R. L. Mitchell. (To appear in *Brit. J. Nut.*).

26. Electrode clamps for spectrochemical analysis. By R. O. Scott and A. M. Fraser. (To appear in *Spectrochim. Acta.*).

27. Naturally occurring L-pipecolinic acid. By R. I. Morrison. (To appear in *Proc. Biochem. Soc.* (Biochem. J.))

28. Development of a soil microflora in relation to plant succession of sand dunes, including the "rhizosphere" flora associated with colonizing species. By D. M. Webley, D. J. Eastwood and C. H. Gimingham (University of Aberdeen). (To appear in *J. Ecol.*).

29. The metabolism of some saturated aliphatic hydrocarbons, alcohols and fatty acids by *Proactinomyces opacus* (*Jensen*) = *Nocardia opaca* (Waxman and Hendrick, Bergey, 6th ed.). By D. M. Webley and P. C. de Kock (University of Aberdeen). (To appear in *Biochem. J.*).

30. Afforestation of Tentsmuir. By J. D. Ovington. (To appear in *J. Ecol.*).

31. Making the best use of phosphate fertilizers. By E. G. Williams. (*Scot. Agric.*, **31**, 68-72, 1951).

32. Factors affecting the methods of applying fertilizers. By J. W. S. Reith. (*Scot. Agric.*, **31**, 104-109, 1951).

33. Soil Survey maps (1 inch to 1 mile) based on Ordnance Survey Sheets 86 and 96 (3rd ed.), and descriptive memoir.

(*C*) *Collaborative Work* (*Foreign*)

34. Phosphate relationships of soil and plant. II. Soil—soil solution equilibria and phosphate solubility. By S. Mattson, E. G. Williams, E. Eriksson and K. Vahtras. (*Ann. Roy. Agric. Coll. Sweden*, **17**, 65-91, 1950).

35. Phosphate relationships of soil and plant. III. Forms of P in the Brannalt limed and unlimed podzol series. By S. Mattson, E. G. Williams and E. Barkoff. (*Ann. Roy. Agric. Coll. Sweden*, **17**, 107-120, 1950).

36. Phosphate relationships of soil and plant. IV. Forms of P in the hydrologic soil series of the Dala Brown Earth and the Unden podzol. By S. Mattson, E. Barkoff and E. G. Williams. (*Ann. Roy. Agric. Coll. Sweden*, **17**, 121-129, 1950).

37. Phosphate relationships of soil and plant. V. Forms of P in the Lanna soil. By S. Mattson, E. G. Williams, E. Koutler-Andersson and E. Barkoff. (*Ann. Roy. Agric. Coll. Sweden*, **17**, 130-140, 1950).

38. Boden-Bodenlösunggleichgewichte und Phosphatloslichkeit. By S. Mattson, E. G. Williams, E. Eriksson and K. Vahtras. (*Z. PflErnahr. Dung.*, **50(95)**, 39-59, 1950).

APPENDIX

The following are more detailed descriptions of the soils found in the survey areas.

NORTH-EAST SCOTLAND

Morayshire (*Geological Survey Sheet* 95)

ASSOCIATIONS

Foudland Association

Distribution . . The higher ground south of Buckie, around Tarrymount.

Parent Material . Till derived from fine-grained flag-stones of the Highland Schists.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Grey-brown, fine sandy loam; crumb structure. Sharp change into
B_2	10-18 in.	Yellow-orange, fine sandy loam; soft and mellow; weakly cloddy. Sharp change into
B_3	18-24 in.	Grey-yellow, sandy loam; indurated. Merging into
C	28 in. +	Yellow, stony fine sandy loam till.

The topography is hilly.

Boyndie Association

Distribution . . Over practically the whole area bounded by a line Portgordon - Fochabers - Elgin - Lossiemouth, except for the Corby and Links areas listed below, and where cut across by the alluvium of the Spey and the Lossie.

Parent Material . Fluvio-glacial sand.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Grey-brown, loamy sand; soft cloddy structure. Merging into
A_1	10-16 in.	Transitional; grey-brown sand merging downwards to yellow-brown sand; soft and loose.
B_2	16-22 in.	Bright yellow-brown sand; single grain structure. Sharp change into
C	22-44 in.	Light-brown sand; single grain structure; moderately compact.

The topography is undulating to hummocky.

Strichen Association

Distribution . . On top of Hillhead Wood and south from Bridge of Shougle.

Parent Material . Till derived from quartz schist and mica schist.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Grey-brown sandy loam; crumb structure. Relatively sharp change into
B_2	10-18 in.	Yellow sandy loam; soft cloddy structure. Sharp change into
B_3	18-24 in.	Yellow-grey loamy sand; strongly indurated. Merging into
C	24 in. +	Pale yellow, stony sandy loam till.

The topography is hilly.

Corby Association

Distribution . . An irregular area west of the Spey between Mosstodloch and Upper Ashfield (a high terrace); in Threapland Wood; in isolated patches throughout the area of the Boyndie Association.

Parent Material . Water-sorted and morainic gravel.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
A_0F	0-3 in.	Dark brown, partially decomposed fibrous organic matter. Sharp change into
A_2	3-8 in.	Grey gravel with grey-brown interstitial coarse sand. Sharp change into
B_2	8-11 in.	Orange-brown sandy gravel; compact. Merging with decreasing compaction into
B_3	11-20 in.	Yellow-brown gravel. Merging into
C	20-40 in.	Pale yellow-brown gravel; tending to single grain structure.

The topography of the larger area is flat; elsewhere it is moundy.

Tynet Association

Distribution . . An irregular strip 1½ to 2 miles wide, from Fochabers to Inchgower.

Parent Material . Till derived from sandstone and conglomerate of the Middle Old Red Sandstone.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-7 in.	Medium brown loam; weak cloddy to crumb structure. Sharp change into
B_2	7-14 in.	Bright orange-red gravelly sandy clay loam; crumb structure. Sharp change into

B_3	14-20 in.	Red gravelly clay loam; strongly indurated. Merging into
C	20-40 in.	Red gravelly clay loam till; cloddy structure; compaction decreasing with depth.

The topography is undulating.

LINKS

Distribution . . In the raised beach strip from Spey Mouth east to Portgordon, and in parts of the corresponding strip westwards from Kingston to Lossiemouth.

The soil is mainly freely drained and has 4-6 inches of dark brown loamy sand with soft cloddy structure over light yellow-brown sand with single grain structure.

The topography is generally flat.

UNDIFFERENTIATED ALLUVIUM

Distribution . . Wide spreads bordering the Rivers Spey and Lossie, notably at Dipple, Manbeen, Calcots and Barmuckity.

All textural grades from coarse sand to silt are found in the alluvium and drainage is dominantly poor.

SKELETAL SOILS

Dune Sands

Distribution . . A relatively narrow strip extending eastwards along the coast from Lossiemouth for about four miles.

Parent Material . Blown sand.

The area is mainly bare of vegetation and no profile has developed.

Storm Beach Shingle

Distribution . . A $\frac{1}{4}$ to $\frac{1}{2}$ mile wide strip along the coast from Lossiemouth to Garmouth, behind the sand-dunes where they exist.

Parent Material . Shingle of storm beaches of 25 foot raised beach.

Dominant Series . Excessively freely drained.

Profile

Horizon	*Depth*	
A_0F	0-1 in.	Very thin layer of felty, partially decomposed organic matter.
C		Grey, well-rounded stones, 1 to 4 inches in diameter, mostly of quartzite and quartz schist; loose.

The topography consists of long, narrow ridges from 4 to 10 feet high with wet spots and small lochans between.

Most of this area has been planted with Scots pine.

Aberdeenshire and Kincardine (*Geological Survey Sheet* 66)

ASSOCIATIONS

Countesswells Association

Distribution . .	An area north of the Dee valley between the eastern edge of the Moor of Dinnet and Hirn; the hill country south of the Dee from the west boundary to Finzean; and area south of the Dee extending eastwards from Slewdrum to Banchory.
Parent Material .	Till derived from granite and granitic gneiss; sometimes rather water-sorted, as in the area north of the Dee.
Dominant Series .	Freely drained.

Profile

Horizon	*Depth*	
A_0F	0-6 in.	Black raw humus. Sharp change into
A_2	6-9 in.	Grey organic sandy-loam; white bleached quartz grains and granite fragments; structureless. Sharp change into
B_2	9-17 in.	Bright orange-brown sandy-loam; crumb structure; some darker brown patches of humus staining. Merging into
B_3	17-24 in.	Pale grey-brown, gritty, stony, loamy sand drift; indurated; induration decreasing with depth.
	24 in.+	Pink weathered granite.

The profile is often shallower on hill slopes.
The topography is generally hilly to mountainous.

Corby Association

Distribution . .	The Moor of Dinnet; gravel terraces and morainic mounds lining the Dee valley and its larger tributaries; remnants of end moraines at valley mouths; in Feughside where the Water of Aven joins the Water of Feugh.
Parent Material .	Fluvio-glacial gravels.
Dominant Series .	Freely drained.

Profile

Horizon	*Depth*	
A_1	0-2 in.	Mull humus. (Vegetation—larch wood).
A_2	2-4 in.	Bleached greyish coarse sand; single grain structure. Merging into
B_2	4-15 in.	Pale brown, gravelly coarse sand with darker brown patches of organic staining. Merging into
B_3	15-23 in.	Darker brown loamy sand; rather indurated. Merging into.
C	23 in. +	Brownish gravelly coarse sand; single grain structure.

The topogrpahy consists of river terraces and areas of moundy moraine.

Deecastle Association

Distribution . .	Patches along the south side of the Dee valley from Glentanar to Feughside between the river gravels and the granitic till on the hills.
Parent Material .	Till derived from calc-silicate rocks and schists with a variable proportion of granite and granitic gneiss.
Dominant Series .	Freely drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Dark medium brown loam; soft cloddy structure. Sharp change into
B_2	10-16 in.	Yellow-brown, stony fine sandy-loam; soft cloddy structure. Sharp change into
B_3	16-25 in.	Yellowish-grey, gritty sandy-loam; indurated.
	25 in. +	Induration decreases with depth.

These soils are found on the lower hill slopes south of the Dee.

SKELETAL SOILS

Granite

Distribution . .	Extensive areas of high ground throughout the hill country south of the Dee valley.
Parent Material .	Weathered granite.

Profile

Horizon	*Depth*	
A	0/6 in. (variable)	Black raw humus; very gritty; speckled with white quartz.
	6/20 in. (variable or absent)	A scree of coarse granite boulders up to 3 feet in diameter. Interstices filled with organic stained granite gravel.
		Weathered granite.

The topography is mountainous.

HILL PEAT

Limited amounts of saddle peat are found in the same area as the skeletal soils.

EAST SCOTLAND

Angus (Geological Survey Sheet 57)

ASSOCIATIONS

Corby Association

Distribution . .	Morainic mounds scattered throughout the arable area. Some patches of river terrace along Noran Water.
Parent Material .	Fluvio-glacial gravel.
Dominant Series .	Freely drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Dark brown sandy loam; cloddy crumb structure; many well-rounded stones. Fairly sharp change into
B_2	10-18 in.	Bright brown, gravelly, gritty loamy-sand; loose, weak crumb structure. Merging into
B_3	18-26 in.	Dull brownish, gritty, gravelly loamy coarse-sand; strongly indurated. Merging into
C	26 in. +	Brown, gritty, gravelly coarse-sand; single grain structure.

The topography is moundy or flat.

Strichen Association

Distribution . . A triangular area of hill country between Glenquiech, Glen Lethnot and Toardyhill.

Parent Material . Fine sandy-loam till derived from flaggy quartzite and quartz mica-schist.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
A_0L	0-½ in.	Calluna-moss litter.
A_1	½-1 in.	Dark greyish-brown, organic loam; white specks of quartz.
A_2	1-2 in.	Light greyish-brown, fine sandy-loam; crumb structure; occasional small stones. Merging into
S	2-9 in.	Medium brown, fine sandy-loam; crumb structure; moderate stone content of medium and small stones. Merging into
B_2	9-19 in.	Brighter orange-brown, stony, fine sandy-loam with patches of darker brown organic staining; crumb structure; large and small subangular stones. Merging into
B_3	19-36 in.	Pale brown, fine sandy loam; indurated platy to cloddy structure. Merging into
C	36 in. +	Greyish-yellow, stony, fine sandy-loam till.

Profile quoted is an old arable soil now under calluna, at an altitude of c.1200 feet above OD, showing horizons of incipient repodzolisation.

The topography consists of steep elongated ridges, hilly to mountainous.

Stonehaven Association

Distribution . . One small area immediately south of Shandford Hill.

Parent Material . Sandy clay loam till derived from Old Red Sandstone sandstones and conglomerate beds.

Dominant Series . Poorly drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Dark brown loam; cloddy structure; moderate stone content. Fairly sharp change into
G	10-36 in.	Reddish-brown sandy clay loam; cloddy prismatic structure; considerable grey and rusty mottling. Merging into
C	36 in. +	Red-brown, stony, sandy clay loam till.

The topography is gently sloping.

Strathfinella Association

Distribution . . The Caterthuns, Ledmore Hill, Shandford Hill and a small area at Noranside.

Parent Material . Loam to sandy loam till derived from sandstone and conglomerate beds of Old Red Sandstone age with metamorphic erratics.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-6 in.	Brown sandy-loam; crumb structure. Sharp change into
B_1	6-9 in.	Pale reddish-brown sandy-loam; crumb structure. Merging into
B_2	9-14 in.	Bright brownish-red sandy-loam; crumb structure. Merging into
B_3	14-27 in.	Pale reddish-brown loam to sandy-loam; strongly indurated; compact cloddy structure. Merging into
C	27 in. +	Light brownish-red, loam till.

The topography is hilly.

Auchinblae Association

Distribution . . An area of about half a square mile around Cairndrum Farm; an area of extensive separate mounds covering about a square mile south of Kirkton of Menmuir; additional scattered mounds occur throughout the arable area.

Parent Material . Red fluvio-glacial sand and gravel.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Medium brown, coarse, sandy-loam; crumb structure; many rounded stones. Sharp change into
B_2	8-16 in.	Bright reddish-brown, coarse sandy gravel; loose single grain structure. Merging into
B_3	16-22 in.	Pale reddish-brown, coarse sandy gravel; rather indurated. Merging into

C	22 in. +	Reddish-brown, coarse sandy gravel; single grain structure.

The topography is moundy.

Craigo Association

Distribution . . The Blair Muir area; a small area north of Little Brechin; an area round Duns Wood.

Parent Material . Red water-sorted deposits overlying red, sandy clay-loam till of Stonehaven or similar type.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Dark brown loam; crumb structure. Merging into
B_2-G	10-14 in.	Pale pinkish-brown, stony sandy-loam; crumb structure; fairly strong rusty mottling. Merging into
C	14-21 in.	Pale, reddish-brown, stony sandy-loam; cloddy structure; faint rusty mottling near top of horizon. Clear change into
	21 in. +	Red-brown, sandy clay-loam till; cloddy structure.

The topography is gently sloping.

Balrownie Association

Distribution . . Occurs generally throughout the arable area south of the Caterthuns, Ledmore Hill and Standford Hill; it extends eastwards as far as Trinity, and to the west and south is bounded by present survey limits. There are some areas of the Craigo Association within this extent.

Parent Material . Red, water worked deposits and till material of loam to sandy-loam texture, with lenses of heavier and lighter textured material.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Medium brown loam; crumb structure; no mottling. Sharp change into
B_2-G	9-17 in.	Pale reddish-brown sandy-loam, with greyish patches and rusty mottling; cloddy crumb structure above, cloddy and slightly indurated below. Merging into
B_3	17-25 in.	Dull red-brown loam; with some roughly vertical grey streaking; rather compact, cloddy structure. Merging into
C	25 in. +	Dull brownish-red loam till, cloddy to cloddy laminar structure.

The topography is gently undulating with low east to west ridges. The general slope falls gradually from north to south.

UNDIFFERENTIATED ALLUVIUM

Distribution . .	Small areas restricted to drainage channels and river courses through the area. Texture and drainage are very variable.

SKELETAL SOILS

Flaggy Quartzite

Distribution . .	Hill tops and upper slopes throughout the area north of the Highland Boundary Fault.
Profile . . .	Generally thin raw humus over somewhat shattered rock rubble.

HILL PEAT

Limited areas of hill peat are found throughout the same area as the skeletal soils.

SOUTH-EAST SCOTLAND

Roxburghshire (*Geological Survey Sheet* 17)

ASSOCIATIONS

Bowmont Association

Distribution . .	Eastern part of the area.
Parent Material .	Till derived from Upper Old Red Sandstone formation, overlying solid.
Dominant Series .	Freely drained.

Profile

Horizon	*Depth*	
A_0L	0-$\frac{1}{4}$ in.	Moss and free litter.
A_0F	Trace	Partly decomposed plant material.
A_0H	Trace	Humus.
A_1	$\frac{1}{4}$-8 in.	Reddish-brown sandy-loam; soft cloddy to crumb; uniform colour. Merging into
B	8-10 in.	Light reddish-brown sandy-loam; soft cloddy to crumb; uniform colour.
C	10-16 in.	Reddish-brown, sandy clay-loam till; cloddy; uniform colour.
	16-43 in.	Rotten Old Red Sandstone sediments.

The topography is broadly rolling.

Hindhope Association

Distribution . .	Western part of the area.
Parent Material .	Till derived from rocks of Silurian formation.
Dominant Series .	Poorly drained.

Profile

Horizon	*Depth*	
A_0L	Trace	Plant material.
A_0F	0-½ in.	Partly decomposed plant material.
A_0H	½-3 in.	Black greasy humus becoming brown towards base. Merging into
A-G	3-7 in.	Light brown grey loam; cloddy; humus staining associated with plant roots. Sharp change into
G	7-12 in.	Light grey clay-loam; prismatic; ochreous mottling associated with root channels. Sharp change into
G	12-24 in.	Yellow clay-loam; cloddy to prismatic; strong, bright orange mottling; grey, round stones. Merging into
G-C	24-42 in.	Pale yellow clay; cloddy; grey mottling on structural faces and round stones.

The topography is hilly with south-west-north-east ridges clearly defined on the hill slopes.

Minto Association

Distribution . . A strip between the Bowmont and Hindhope Associations.

Parent Material . Mixed till derived from Old Red Sandstone and Silurian formations.

Dominant Series . Poorly drained.

Profile

Horizon	*Depth*	
S	0-11 in.	Brown, fine-sandy, silty clay-loam; strong cloddy structure; no mottling. Sharp change into
G	11-20 in.	Light yellowish brown, fine sandy clay; strong prismatic structure; grey-coated faces to structural units; prominent black manganese stains; moderate ochreous mottling. Merging into
G-C	20-44 in.	Reddish-brown sandy clay; weak prismatic to massive structure; slight ochreous and grey mottling.

The topography is broadly rolling.

Hawick Association

Distribution . . Alluvium of River Teviot from Denholm to Hawick; alluvium of other smaller rivers; lacustrine alluvium within the area of the Hindhope Association.

Parent Material . Alluvium of Silurian origin.

Dominant Series . Poorly drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Brown, fine sandy, silty loam; strong, cloddy; uniform colour. Sharp change into
G-C	10-42 in.	Light yellowish-brown, fine sandy, heavy-loam; prismatic; uniform colour.

The topography is flat.

Jedburgh Association

Distribution . . Alluvium of Rivers Jed and Rule and other smaller rivers.
Parent Material . Alluvium of Old Red Sandstone origin.
Dominant Series . Poorly drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Reddish-brown loam; cloddy; uniform colour. Sharp change into
G-C	8-26 in.	Reddish brown loam; very strong columnar structure; uniform colour. Merging into
	26-36 in.	Light reddish-brown sand; single-grained structure; uniform colour. Sharp change into
	36-42 in.	Gravel; single-grain structure.

The topography is flat.

Denholm Association

Distribution . . Alluvium of River Teviot from Jedfoot to Denholm.
Parent Material . Alluvium of Old Red Sandstone and Silurian origin.
Dominant Series . Poorly drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Light brown to brown; very fine sandy, silty loam; strong cloddy structure; uniform colour. Merging into.
G-C	10-32 in.	Light brown to brown; very fine sandy, silty loam; strong prismatic structure; dull colour on structural faces, otherwise uniform colour. Sharp change into
	32-40 in.	Brown sandy gravel; single-grained structure; uniform colour.

SKELETAL SOILS

Silurian Sediments

Distribution . . Throughout the area of the Hindhope Association where rock is close to the surface.
Parent Material . Weathered Silurian rocks.

Profile

Horizon	*Depth*	
A_0L	Trace	Undecomposed litter.
A_0F	0-½ in.	Partially decomposed litter.
A_0H	Trace	Humus.
A_1	0-6 in.	Very strong brown loam; crumb structure; uniform colour. Merging into
	6 in. +	Shattered rock.

The topography is hilly.

SOUTH-WEST SCOTLAND

Ayrshire (*Geological Survey Sheet* 22)

Northern Region

ASSOCIATIONS

Ashgrove Association

Distribution . . In a strip four miles broad running north-east-south-west from Auchentiber to Barrmill, west of Lugton Water.

Parent Material . Mixed till of sedimentary rocks, mainly sandstones, together with shale and limestone of Carboniferous formation.

Dominant Soil . . Poorly drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Brown, heavy clay loam; strong cloddy structure; moderate rust staining; faces of structural units dull. Relatively sharp change into
G	8-25 in.	Yellow and grey brown clay; prismatic structure; strong ochreous and grey mottling. Merging into
G-C	25-45 in.	Dark grey brown clay; massive structure; many heavily gleyed decomposed stones.

The topography is undulating.

Darleith Association

Distribution . . On major part of high ground, bounded by a line joining Dunlop, Longloch and Glenouther Moor in the south, and in the north by a line running just south of Neilston, Balgray Reservoir and Newton Mearns; Lochliboside Hills; high ground north of Beith.

Parent Material . Thin till on basic and intermediate lavas.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
A_0L	0-2 in.	Undecomposed grass litter.
A	2-10 in.	Brown loam; nutty structure; stony. Sharp change into
B_2-G		Red-brown, heavy loam; amorphous; very stony, slight ochreous staining. Merging into weathering and shattered rock.

The topography is hilly with many rock outcrops.

Kilmarnock Association

Distribution . . Small area south-east of Beith, extending to Barrmill; in the vicinity of Symington (southern region); ½-1 mile broad strip south of River Irvine from Hurlford to a little west of Fairlie House.

Parent Material . Mixed till derived mainly from lavas with varying sedimentary rock content of sandstone and shale.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Strong brown heavy loam; cloddy structure. Sharp change into
B	8-30 in.	Red-brown clay loam; prismatic structure; moderate ochreous mottling. Merging into
G-C	30-45 in.	Dark brown, clay loam to clay; weakly laminated structure; slight gleying.

The topography is rolling in the Beith and Symington areas and undulating in the Hurlford area.

Glenmount Association

Distribution . . In localised pockets throughout the Ashgrove Association.

Parent Material . Mixed till, derived mainly from shales, with other sediments of Carboniferous formation.

Dominant Series . Poorly drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Dark brown, heavy loam; strong cloddy structure. Sharp change into
G	9-27 in.	Bluish-grey clay; prismatic structure with moderate grey and ochreous mottling. Merging into
G-C	27-40 in.	Dark brown clay; massive structure; strong grey gleying; high content of weathered shale chips.

The topography is undulating.

ANLAIRD ASSOCIATION

Distribution . .	In a broad belt between the Darleith Association in the north and the Kilmarnock Association in the south.
Parent Material .	Heavy till derived from basic and intermediate lavas.
Dominant Series .	Poorly drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Dark grey brown heavy loam; cloddy. Moderately sharp change into
G	8-17 in.	Yellowish brown clay; cloddy to prismatic structure; strong gleying and iron staining. Moderately sharp change into
G	17-32 in.	Brown clay loam; weak prismatic structure; heavy iron staining and gleying. Sharp change into
G-C	32-43 in.	Reddish-brown clay; massive structure; moderate gleying; many weathered lava stones.

The topography varies between hilly and broadly rolling.

Southern Region

ASSOCIATIONS

DREGHORN ASSOCIATION

Distribution . .	A broad flat area south of the River Irvine, narrowing at the southern tip of Shewalton Moss to form a coastal strip approximately one mile wide.
Parent Material .	Raised beach sand.
Dominant Series .	Freely drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Dark brown, loamy sand; weak cloddy structure. Sharp change into
B-C	8-42 in.	Reddish-brown sand; single grain structure.

The topography varies between flat and gently undulating.

There are many examples of subsidence due to coal mining in the area. As the permanent water table is high, drainage of these depressions presents great difficulties.

ROWANHILL ASSOCIATION

Distribution . .	Inland from the coastal sands with the Inchgotrick Fault forming the eastern boundary.
Parent Material .	Carboniferous sediments with a high proportion of shales and coal.
Dominant Series .	Poorly drained.

Profile

Horizon	*Depth*	
S	0-7 in.	Brown, heavy loam; strong cloddy structure. Sharp change into
G	8-18 in.	Light yellowish-brown clay; well defined columnar structure; strongly mottled with ochre and slightly grey gleyed. Merging into
G	18-26 in.	Brown clay; prismatic structure; marked grey gleying. Merging into
G-C	26-40 in.	Brown clay; platy structure; decrease in grey gleying.

The topography is undulating.

Dundonald Association

Distribution . . High ground in the vicinity of Dundonald and Craigie.

Parent Material . Teschenite and olivine dolerite lavas.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Yellowish-brown loam; cloddy structure. Sharp change into
B_2-G	9-16 in.	Yellowish-brown clay-loam; prismatic structure; slight ochreous mottling. Merging into
B_2-G	16-28 in.	Brown clay loam; ill-defined prismatic structure; moderate ochreous mottling; several large weathering dolerite stones. Sharp change into
C	28-40 in.	Fine sandy clay-loam, composed essentially of weathering dolerite; markedly iron stained.

The hilly region covered by this soil association is deeply gullied and is studded with rock outcrops.

Bargour Association

Distribution . . South of Glaston and around the lower reaches of the River Cessnock.

Parent Material . Mixed till derived mainly from rocks of Upper Old Red Sandstone formation, with slight carboniferous sandstone and lava admixture.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Brown loam; cloddy structure. Sharp change into
A	9-14 in.	Strong brown, heavy-loam; prismatic structure. Merging into

B_2-G	14-24 in.	Yellowish-red, sandy clay-loam; well-defined prismatic structure; marked ochreous mottling and slight grey gleying. Merging into
C	24-42 in.	Reddish-brown, sandy clay-loam; weak prismatic structure.

The topography is rolling.

LINKS

Distribution . . Narrow coastal strip from Irvine to Troon and in a number of small areas near Shewalton Moss.

The soil is free to excessively freely drained and has about two feet of light brown sand overlying iron stained yellow-brown sand; buried dark brown humus A horizons are common. Podzolisation with accompanying Fe pan occurs in some parts.

The topography is undulating.

ALLUVIUM

Flat spreads of alluvium are found along every stream, especially the Irvine, Lugton and Cessnock Rivers. Numerous lake deposits have also been mapped, the more important being around Loch Libo, Riccarton Moss, near Inchbean and north of Newfield House. A layer of organic accumulation is often found in these water-laid deposits at from 18-24 inches.

HILL AND BASIN PEAT

Hill and basin peat is scattered throughout the area surveyed, the former being confined to the northern portion as at Glenouther and Moyne Moors and the latter to the southern part in Shewalton and Riccarton Moss.

SOIL HORIZON SYMBOLS USED BY THE SOIL SURVEY OF SCOTLAND (1951)

ELUVIAL HORIZONS

A undifferentiated

Subdivisions of Eluvial Horizons

A_0L undecomposed plant remains.

A_0F partially decomposed organic matter.

A_0H well decomposed organic matter

A_1 intimate mixture organic and mineral matter.

A_2 grey silicious.

GLEYED ELUVIAL HORIZONS

A-G gleyed A.

Subdivisions of Gleyed Eluvial Horizons

A_2-G gleyed A_2.

ILLUVIAL HORIZONS

B undifferentiated.

Subdivisions of Illuvial Horizons

B_1 iron pan, or humus concentration or both.

B_2 diffuse deposition of sesquioxides or humus or both.

B_3 indurated or compacted.

GLEYED ILLUVIAL HORIZONS

B-G gleyed B.

Subdivisions of Gleyed Illuvial Horizons

B_2-G gleyed B_2.

PARENT MATERIAL

C undifferentiated.

GLEYED PARENT MATERIAL

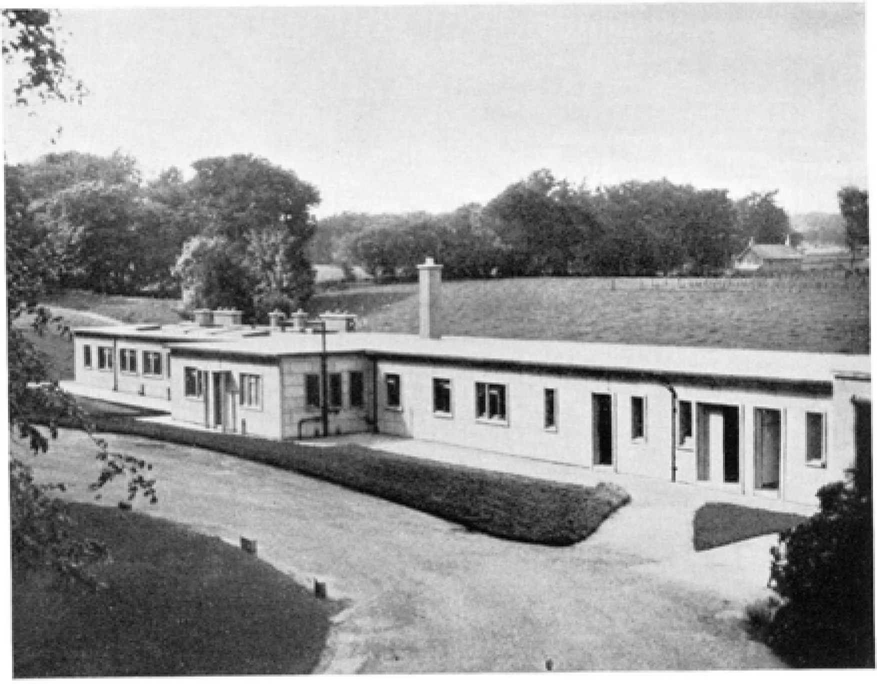
G-C gleyed C.

GLEY HORIZONS

G undifferentiated.

CULTIVATED HORIZONS

S undifferentiated.



DEPARTMENT OF SOIL FERTILITY

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