THE MACAULAY INSTITUTE FOR SOIL RESEARCH

FOUNDED 1930

ANNUAL REPORT 1953-1954

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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CRAIGIEBUCKLER, ABERDEEN
(Founded 1930)

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1953-1954

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*Appointed 1954 †Resigned 1954 ‡Retired 1954

POST-GRADUATE RESEARCH WORKERS

J. Adrien (Department of Agriculture, Port-au-Prince, Haiti, West Indies).

R. du T. Burger (Stellenbosch-Elsenburg College of Agriculture, Stellenbosch, South Africa).

J. D. Colwell (Department of Agriculture, Sydney, New South Wales, Australia).

D. J. Greenland (Agricultural Research Council Training Grant).

F. Gülcür (Orman Fakültesi, Istanbul Üniversitesi, Büyükdere, Istanbul, Turkey).

K. Kristjansdóttir (Department of Agriculture, University of Reykjavik, Iceland).

S. Larsen (Blangstedgaard Experimental Station, Denmark).

D. M. McAleese (Agricultural Chemistry Department, The Queen's University, Belfast, Northern Ireland).

I. R. MacDonald (Agricultural Research Council Training Grant).

S. A. Radwanski (Department of Soil and Land-Use Surveys, Kumasi, Gold Coast).

B. Ramamoorthy (Indian Agricultural Research Institute, New Delhi).

R. K. Richardson (Department of Agriculture, Hope, Kingston, Jamaica, West Indies).

E. L. Strmecki (Faculty of Agriculture and Forestry, University of Ljubljana, Yugoslavia).

CONTENTS

INTRODUCTION

The aim of the Institute is to advance the fundamental study of the soil in all its aspects and this report indicates the lines along which the research programme has developed and the scope of the work in progress. In the investigation of a wide variety of problems close collaboration is maintained with other research organizations, the Colleges of Agriculture in Scotland, the Forestry Commission, and the Department of Agriculture for Scotland. The Institute is a recognized centre of study for higher degrees of the University of Aberdeen, and facilities are also provided for the training of research workers in the various branches of soil science.

The success of the work is largely dependent on the generous financial support given by the Department of Agriculture for Scotland, the Agricultural Research Council, and the Forestry Commission, and grateful acknowledgement is again made to these bodies and to other benefactors.

COUNCIL

Mr William Hunter was nominated by the North of Scotland College of Agriculture to fill the vacancy caused by the death of Major James Keith.

STAFF

The Council of Management learned with much pleasure of the appointment of Dr A. B. Stewart, Deputy Director of the Institute, to the Strathcona-Fordyce Chair of Agriculture in the University of Aberdeen. Dr Stewart was appointed to the staff of the Institute in 1932 to take charge of the Department of Soil Fertility, and since his appointment as Deputy Director in 1945 has represented the Institute on many technical committees. The Council wish to record their appreciation of the services which Dr Stewart has rendered to the Institute and to express their good wishes for his future welfare.

(*a*) *Retirement*:

Department of Soil Fertility—

Miss A. J. Preddy, M.A.

(*b*) *Appointments*:

Department of Pedology—

Mr B. M. Shipley, B.Sc. (Soil Survey Section).

Miss W. W. Smith, B.Sc. (X-ray Section).

Department of Soil Fertility—

Mr W. E. Simpson, B.Sc.

Members of the Institute staff have taken part in several conferences during the year. Dr E. G. Williams went to Denmark to attend the O.E.E.C. Conference on the Effective Use of Lime and Fertilizers to which he contributed a paper on fertilizers and lime in Scotland, with reference to the general position in Great Britain. Dr R. Glentworth was the delegate of the Soil Survey of Scotland at the Ghent meeting of the F.A.O. Subgroup for Soil Classification and Survey in Europe. The Institute was represented at the International Peat Symposium held in Dublin in July; Dr G. K. Fraser contributed a paper on the classification and nomenclature of peat, and Dr R. L. Mitchell dealt with trace elements in Scottish peats in a paper read by Dr D. J. Swaine who acted as his representative at the meeting. Messrs R. Grant and J. C. C. Romans attended the Wye meeting of the British Society of Soil Science and Mr E. L. Birse and Mr S. E. Durno were present at the meeting of the British Ecological Society in Cambridge. Dr R. L. Mitchell and Mr R. A. Robertson went to the VIIIth International Botanical Congress in Paris, and Dr Mitchell presented a paper to the Colloquium on Plant Analysis Dr R. L. Mitchell discussed recent advances in spectrochemical analysis in a paper to the International Symposium on Analytical Chemistry held in Birmingham, and at a meeting of the Midland Association for Analytical Chemistry Dr R. O. Scott read a paper on the porous cup technique. Mr W. A. Mitchell contributed a paper on the occurrence of saponite in vesicular lava to the Third International Congress of the Union of Crystallography in Paris. A paper on soil moisture determination by neutron scattering, written in collaboration with Dr T. W. Wright, was read at the Second Radioisotope Conference in Oxford by Mr A. H. Knight. Miss M. E. K. Henderson attended the Reading meeting of the Society for General Microbiology and presented a paper on a method for studying the metabolism of fungi in the Warburg apparatus using spore suspension.

HIGHER DEGREES

Mr A. M. Ure was awarded a Ph.D. degree by the University of Aberdeen for a thesis entitled *The application of electronics to spectrochemistry.*

PUBLICATIONS

Fourteen publications were issued during the year and are summarized in this report.

VISITORS

As in previous years, valuable opportunities for discussion and interchange of ideas were provided by visits from individual research workers and organized parties. Amongst the many overseas visitors welcomed to the Institute were scientists from Argentina, Australia, Belgian Congo, Canada, Ceylon, Finland, Germany, Holland, India, Iran, Israel, Jamaica, New Zealand, Norway, South Africa, Sudan, U.S.A., and Yugoslavia.

POST-GRADUATE RESEARCH WORKERS

During the year the following research workers were associated in the work of the Institute:

Department of Pedology:

Soil Survey—

F. Gülcür (Orman Fakültesi, Istanbul Universitesi, Büyükdere, Instanbul, Turkey).

S. A. Radwanski (Department of Soil and Land-Use Surveys, Kumasi, Gold Coast).

X-ray—

D. J. Greenland (Agricultural Research Council Training Grant).

D. M. McAleese (Agricultural Chemistry Department, The Queen's University, Belfast, N. Ireland).

Department of Plant Physiology:

I. R. MacDonald (Agricultural Research Council Training Grant).

E. L. Strmecki (Faculty of Agriculture and Forestry, University of Ljubljana, Yugoslavia).

Department of Soil Fertility:

J. Adrien (Department of Agriculture, Port-au-Prince, Haiti, West Indies).

R. du T. Burger (Stellenbosch-Elsenburg College of Agriculture, Stellenbosch, South Africa).

J. D. Colwell (Department of Agriculture, Sydney, New South Wales, Australia).

K. Kristjansdöttir (Department of Agriculture, University of Reykjavik, Iceland).

S. Larsen (Blangstedgaard Experimental Station, Denmark).

Department of Spectrochemistry:

B. Ramamoorthy (Indian Agricultural Research Institute, New Delhi).

R. K. Richardson (Department of Agriculture, Hope, Kingston, Jamaica, British West Indies).

Other workers who spent short periods studying the methods in use at the Institute were—

Mohamed Abdel Aal (Ministry of Agriculture, Sudan).

J. N. Benjaminsen (State Laboratory of Plant Culture, Lyngby, Denmark).

R. Ho (University of Malaya, Singapore).

J. D. Martin (Chester Beatty Research Institute, London).

G. L. Mason (Rio Tinto Co. Ltd., Broken Hill, N. Rhodesia).

K. D. Nicolls (C.S.I.R.O. Division of Soils, Hobart, Tasmania).

M. Pinta (Institut d'Enseignement et de Recherches tropicales, Bondy, Seine, France).

U. Schwertmann (Institut für Bodenkunde, Hanover, Germany).

J. Spector (Imperial College of Tropical Agriculture, Trinidad, British West Indies).

R. S. Subrahmanya (Indian Institute of Science, Bangalore, South India).

REPRESENTATION ON COMMITTEES

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

(1) *Secretary of State for Scotland*:

(*a*) The Scottish Standing Committee for the Calculation of Residual Manurial Values of Fertilizers and Feeding Stuffs.

(*b*) The Scottish Peat Committee and the Sub-Committee on the Survey of Peat Deposits in Scotland.

(*c*) The Nature Conservancy (Scottish Committee).

(*d*) The Standing Advisory Committee, Fertilizers and Feeding Stuffs Act, 1926.

(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) *Agricultural Research Council*:

(*a*) Conference on Fertilizers.

(*b*) Conference on Mineral Deficiencies in Agricultural and Horticultural Crops.

(*c*) Group for Mineral Deficiencies and Excesses in Animals.

(*d*) Land Drainage Conference.

(*e*) Soil Survey Research Board.

(4) *Forestry Commission*:

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

(5) *Colonial Office*:

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

PEDOLOGY

SOIL SURVEY (SCOTLAND)

Despite bad weather, 260 square miles have been mapped on the systematic survey on a scale of 2·5 inches to 1 mile. Field work has continued on Sheet 57 (Forfar) and has been commenced on Sheets 25 (Kelso), 26 (Berwick-upon-Tweed) and 14 (Ayr). Extensive revision and checking has been done on Sheet 22 (Kilmarnock—393 square miles) on which field work has now been completed. A re-examination of association boundaries and the definition of series boundaries and drainage classes within associations have been undertaken on two Aberdeenshire sheets—76 (Lumphanan) and 87 (Peterhead)—of which some 270 square miles have been revised.

This year a policy was adopted of exchanging the junior surveyors attached to teams in order that they might gain experience of the soils in the various survey areas.

A joint field meeting of the Soil Survey of England and Wales and the Soil Survey of Scotland was held at Ayr. The soils of Sheet 22 (Kilmarnock) were inspected.

Overseas visitors from Australia, Canada, Haiti, India, Sudan and Turkey, have spent varying periods with the field survey teams.

NORTH-EAST SCOTLAND

Aberdeenshire (Geological Survey Sheet 76)

Revision has been carried out over approximately 170 square miles of this sheet in the following areas:

(1) In the south-east corner of the sheet, an area bounded in the north by a line running east-west through Lyne of Skene and on the west by a line through Kinnernie, Barmekin Hill and Meikle Tap to the southern edge of the sheet.

In this area the underlying rock is mainly granite, giving rise to granitic till and the lighter-textured coarse sandy loam soils of the Countesswells Association. There are several areas of peat, as at Moss of Air, Leuchar Moss, Quartains Moss and Red Moss The topography is undulating to moderately hilly. Occasional mounds of fluvio-glacial sand and gravel occur, particularly in the vicinity of Roadside of Garlogie and Garlogie village The soil drainage is free to imperfect, except in the area immediately north of the Loch of Skene where it is mainly poor.

(2) In the west, an area bounded on the north by a line through Clova to Lumsden and on the east by an irregular line from Lumsden through Invermossat, Leochel-Cushnie and Coull to the southern edge of the sheet.

From the vicinity of Lumsden, rocks of the Old Red Sandstone Age extend southwards to Kildrummy Castle, but, except in a few isolated areas, the sandstone is overlain by a mixed till or mounds of morainic sands and gravels; consequently it appears to have little influence on the soil profiles except in these isolated areas. Where the sandstone is near the surface, red or red-brown soils are found with textures varying from clay loam to sandy clay. These soils have been provisionally named the Mossat Association. The soils developed on the mixed till, which is derived from acid and basic igneous and metamorphic rocks, have been included in the Tarves Association. The topography of the Mossat and Tarves Associations is gently to moderately rolling. Further west, towards the edge of the sheet, the topography becomes strongly rolling to hilly, and soils developed mainly on andalusite-schist and knotted schist till have been included in the Foudland Association. Southwards from the alluvium of the River Don there is a mixed drift cover and soils of the Tarves Association predominate, except in an area immediately south-east of Migvie where till derived mainly from basic-igneous rocks gives rise to soils of the Insch Association.

In the south-west corner of the sheet there are numerous sand and gravel mounds with either peat or alluvium in the hollows.

Soils with free drainage predominate in this area.

(3) In the central part of the sheet, an area stretching southwards from Leslie through the Howe of Alford to the vicinity of Lumphanan.

Serpentine rock in the vicinity of Leslie gives rise to soils of the Leslie Association. Passing southwards, a narrow belt of basic igneous material occurs on which the Insch Association is developed. The Foudland Association occupies most of the high, uncultivated, rising ground which reaches 1,350 feet in Knock Saul about 1 mile to the south and falls gradually to the valley of the River Don. A little north of a line through Tullynessle and Forbes, the till becomes more mixed, giving rise to arable soils of the Tarves Association. This Association continues on the south side of the Don Valley to north of the main Aberdeen-Tarland road where it merges into the Countesswells Association which dominates the Lumphanan area. The ground here is hilly and undulating, rising to 1,400 feet in Corse Hill.

(4) An area stretching south-west from Lumphanan through Mortlich Hill to the edge of the sheet and eastwards towards the lower slopes of the Hill of Fare.

The underlying rock in this area is granite and the Countesswells Association predominates, except for some small spreads of alluvium and the reclaimed Loch of Auchlossan which is mainly peat. The topography is hilly becoming more rolling towards the east between Lumphanan and the lower slopes of the Hill of Fare. The soils are mainly freely drained with imperfectly and poorly drained areas in the hollows.

Parts of these areas, originally mapped as *Sand and Gravel* and generalized under the name of Corby Association, have now been divided into the Corby and Boyndie Associations, the former being developed on water-sorted and morainic gravel and the latter on fluvio-glacial sand.

Mixed farming with emphasis on beef cattle production is carried out throughout the areas mapped, except on parts of the higher ground which are given over to sheep grazing and afforestation. Oats, turnips, potatoes, and, to a lesser extent, barley, are among the crops regularly grown.

A more detailed account of the topography, geology and agriculture of the area has already been given in the Annual Report for 1945-1946.

The following soils are found in these areas and are described in the appendix. Descriptions of the soil series of these associations are given in a memoir of the Soil Survey of Great Britain (Scotland)[1].

Associations

1. Countesswells	*see* Annual Reports 1943-44 and 1950-51.
2. Tarves	*see* Annual Reports 1945-46 and 1949-50.
3. Foudland	*see* Annual Reports 1940-41 and 1945-46.
4. Insch	*see* Annual Reports 1939-40 and 1945-46.
5. Leslie	*see* Annual Reports 1945-46 and 1949-50.
6. Boyndie	*see* Annual Report 1942-43.
7. Corby	*see* Annual Reports 1944-45 and 1945-46.
8. Mossat	New Association.

Alluvium

Basin Peat

EAST SCOTLAND

Angus (Geological Survey Sheet 57)

Approximately 90 square miles of Sheet 57 have been surveyed during this season.

The main area of about 55 square miles is a strip of country 4 to 5 miles wide lying along the southern margin of the sheet between the Brechin-Arbroath road in the east and the lowest slopes of Hayston Hill in the west. Additional areas have been surveyed between Brechin, Letham and Friockheim.

The characteristic topography of the main area is intermediate between hill and basin and ridge and valley. It is most intensely developed in the west, where Fothringham Hill and Bractullo Moor rise to approximately 800 feet and 750 feet respectively. There is a gradual falling away towards the east through lower hills with gentler slopes towards the low-lying glacial overflow channel running between Friockheim and Arbroath.

The underlying Lower Old Red Sandstone rocks consist of rather flaggy or more massively bedded sandstones (the extensive, but now disused, Carmyllie quarries lie within the area) with occasional conglomerates and locally extensive patches of contemporaneous and generally rather basic lavas. Superficial deposits are mainly reddish tills or fluvioglacially modified till material with lacustrine alluvium and/or patches of peat in some of the more basin-like valleys. Alluvium, gravels, and light-textured moraines are found along the valleys of the South Esk and the Lunan Water.

The soils developed are generally of light or medium texture throughout the profile, and are predominantly imperfectly drained. Freely drained soils occur on the steeper hills and ridges and in gravel areas, whilst poorly drained or peaty hollows are quite often encountered but are never extensive.

Arable farming is generally practised below 600 feet; the limited areas above this altitude are either woodland or moor. Scattered small plantations or estate policy woods are a noticeable feature of the lower ground.

The following soils are found in the areas surveyed and are referred to in the appendix.

Associations

1. Auchinblae *see* Annual Report 1950-51.
2. Corby *see* Annual Report 1950-51.
3. Balrownie *see* Annual Report 1950-51.
4. Turin *see* Annual Report 1952-53.
5. Drumgley *see* Annual Report 1952-53.
6. Dean *see* Annual Report 1952-53.

Alluvium (undifferentiated)

Lacustrine Alluvium

Basin Peat

SOUTH-EAST SCOTLAND

Berwickshire, Midlothian, Peeblesshire, Roxburghshire and Selkirkshire (Geological Survey Sheets 25 and 26)

Approximately 120 square miles have been surveyed on the two sheets. A third of this area lies north of the Tweed, extending from Kelso in the west through the Merse of Berwickshire to the coast at Berwick-upon-Tweed. This area is reputed to be some of the finest arable land in Scotland. Its soils are derived from a very heterogeneous till (Whitsome Association) which, though not uniform in composition, develops almost exclusively an imperfectly drained soil. There is a unique topography of long interdigitating drumlins aligned by ice movement in a south-west to north-east direction. These drumlins average about one mile long, 300 yards wide and 20 feet high from trough to cap. Their transverse section is dome-like and longitudinal section shows a "crag and tail" form. They are uniform in composition, but in the troughs between them deep colluvial soils develop; these are sometimes poorly drained. Unfortunately survey of this area was restricted to early summer, due to the high proportion of cereals which form the main arable crop.

Most of the remaining 80 square miles lie south of the Tweed between Kelso and Clovenfords, and two new soil parent materials have been found there. The first has been named the Yarrow Association, developed on fluvio-glacial gravel terraces of the Tweed and the Ettrick and Yarrow Waters, and composed dominantly of Silurian greywacke. The second new parent material is a till derived from red Silurian greywackes and shales; soils developed on it near Bowden, Melrose, and between Galashiels and Earlston all have a red or reddish brown colour. The mineralogy of this greywacke differs little from the parent rock of the Ettrick (formerly Hindhope) Association, except in its high haematite content. It is suspected that the red greywacke is formed by low grade thermal metamorphism, as it has only been found in abundance in the vicinity of the trachytic and allied igneous plugs and sheets at Darnick and the Eildon Hills, and similar intrusions near Earlston. Until further information is available this association will be considered a variant of the Ettrick Association.

The Ettrick Association has been encountered only in the south-west of Sheet 25, and on the lower ground soils are identical with those previously described for Sheet 17, except that the till contains more greywacke. On the higher ground however, there is a podzolic soil that differs from the peaty podzol with thin iron pan which commonly occurs further south. This new podzolic series has a similar B_2 horizon, but has a diffuse humus-iron B_1 horizon. It is commonly developed where *Calluna vulgaris* is dominant rather than under a *Molinetum* where thin iron pan soils are found.

Twenty-nine profiles have been sampled this season; nine of these, however, were taken from areas on Sheets 17 and 18 to enable analytical records to be completed.

Since the completion of Sheets 17 and 18 certain changes in Association nomenclature have been considered necessary. Details of these changes will be found in the appendix.

The following soils are found in the area surveyed this year and are described in the appendix.

Associations

1. Ettrick	*see* Annual Reports 1949-50 and 1952-53.
2. Hobkirk	*see* Annual Reports 1948-49 and 1951-52.
3. Whitsome	*see* Annual Report 1948-49.
4. Yarrow	New Association.

Alluvium

SOUTH-WEST SCOTLAND

Ayrshire (Geological Survey Sheet 14)

The survey of south-west Scotland has been continued into central Ayrshire where some 50 square miles have been mapped. This area lies south of a line from Ayr to Coylton and includes most of the land between the Coylton-Maybole road and the coast.

The outstanding topographical feature of the area is the extensive outcrop of volcanic rocks which forms the Carrick Hills. These lavas are mainly basalts and andesites of Lower Old Red Sandstone age. The hills rise steeply from the shore to a height of over 900 feet, with smooth slopes to the north and west. The underlying Lower Old Red Sandstone sediments occupy a broad belt of rolling country southwards to beyond Maybole. The rocks are micaceous and felspathic sandstones with occasional conglomerate and thin marl bands. Fairly easily eroded sedimentary rocks of the Upper Old Red Sandstone and Carboniferous Ages form the lower ground in the north-east. Lime-rich cornstones and cementstones occur quite frequently in these formations. The prominent landmarks of Mochrum Hill, west of Maybole, and the Heads of Ayr are formed of volcanic vent agglomerate.

Glaciation has considerably modified the landscape, rounding the outlines and leaving a mantle of till of varying thickness over most of the area. Minor topographical features due to glaciation include drumlins, which are locally well developed as around Kirkmichael, mounds of moraine and fluvio-glacial sands and gravels, which are widespread in the Maybole district, and alluvial flats such as those near Coylton and Dalrymple.

The River Doon with its tributaries the Castleton and Culney Burns drains most of the area to the east. Of the many small streams draining westwards the Rancleugh Burn is the most important.

Gley soils predominate on the heavy textured till of the north-east part of the area, and here dairy farming is the chief agricultural practice. Lighter textured, freely drained soils occur in the coastal strip north of the Carrick Hills and on the drift deposits derived from the Old Red Sandstone formation in the south. Dairying is still the main activity, but potatoes are an important crop, particularly near the coast. The soils of the lava hills form a complex pattern, being thin, often skeletal, and weakly podzolized on the mounds and ridges, with peaty gleys on pockets of till in the poorly drained hollows. They provide some useful grazing for both sheep and cattle.

The following soils have been distinguished in the area and are described in the appendix.

1. Darleith	*see* Annual Report 1950-51.
2. Dreghorn	*see* Annual Report 1950-51.
3. Darvel	*see* Annual Report 1951-52.
4. Glenalmond	New Association.
5. Maybole	New Association.
Links	*see* Annual Report 1950-51.
Alluvium	
Peat	

In addition, small areas of other soils have been mapped. These appear to be southward extensions of associations recognized in North Ayrshire and this should be confirmed as the survey proceeds.

Ayrshire (*Geological Survey Sheet 22*)

The revision of Sheet 22 (393 square miles) has been completed. Associations have been re-examined and in some cases boundaries defined in greater detail. The continuity of the drainage classes within and between associations has been checked.

As a result of this and from discussions at the Ayrshire Soil Survey Field Meeting in April, several associations have been combined. Soils of the Dundonald and Distinkhorn Associations developed on teschenite, olivine diorite, and granodiorite, respectively, are now included in the Darleith Association which is developed on a thin till derived from basic and intermediate lavas, mainly of Calciferous Sandstone age. The Glen Mount soils have been incorporated in the Ashgrove Association, but the heavy-textured, dominantly poorly drained soils covering the lower ground between Neilston and Carmunnock, mapped originally as Ashgrove, have been grouped into a new association, the Giffnock. Although these soils, like those of the Ashgrove Association, are developed on a heavy textured till derived essentially from sandstone and shales of the Carboniferous Limestone Series, they do not show the customary increase in exchangeable calcium and pH down the profile. This chemical divergence is considered to warrant their separation.

On the higher ground, where topography and climate favour the accumulation of organic matter, the areas of organo-mineral soils have been revised in some detail. These soils have been assigned to the appropriate genetic soil group and, further, on a basis of similar parent material, they have been grouped with the corresponding mineral soil associations.

The modifications carried out this season are now being incorporated in the 1 inch to 1 mile base map and the production of a fair copy of this will shortly be undertaken.

The soil associations distinguished this year have all, apart from the Giffnock, been described previously (Annual Reports 1949-50-1952-53).

SPECIAL SURVEYS

Detailed surveys have been made of the following farms:

1. The Tillycorthie Estate, Aberdeenshire, of the University of Aberdeen, comprising the farms of Tillycorthie, Hillbrae and Thistleyhill (540 acres). The soils were mapped on a scale of 25 inches to 1 mile.
2. The North of Scotland College of Agriculture Demonstration Farm at Aldroughty, near Elgin (100 acres), on a scale of 25 inches to 1 mile.
3. The North of Scotland College of Agriculture Farm at Achany, near Lairg, Sutherlandshire (4500 acres) on a scale of 6 inches to 1 mile.
4. Restored open-cast coal sites in Fife, inspected at the request of the Department of Agriculture for Scotland.

HEATHER SURVEY

The survey of conditions and practices on upland grazings with special regard to heather management has been continued. Areas have been visited in the counties of Argyll, Lanark, Ayr, Kirkcudbright and Wigtown where the present vegetation has been examined and data systematically acquired regarding vegetational changes and stocking history. As recommended in the Hill Farming Research Committee Report (1951), particular attention has been paid to regeneration of heather after burning by different methods, at different ages, in different associations with other plants, and on different soils. It is hoped that in the near future an area may be acquired where a properly controlled long term experiment on heather burning can be conducted. In the meantime, observations on plots laid out on areas burned in normal routine management have been continued. The vegetational succession, yield of herbage, and the chemical analysis of the heather are being recorded at regular intervals.

The general ecological studies at Glensaugh and Lephinmore Research Farms have been continued. A paper on the ecology of the hill pastures at the former station is being prepared for publication. At Lephinmore a botanical survey is to be carried out to supplement the recently completed soil survey.

The experiment designed to test the effect of light applications of lime and phosphate on various types of hill pastures is still in progress. Soil and herbage samples have been taken from the four centres in the north of Scotland. The work of co-ordinating these trials has been continued and an inspection of the plots at the fifteen centres in Scotland, England and Wales has been completed. This work is being carried out in collaboration with the Hill Farm Research Organization.

Co-operation with other departments and Research Institutes has been maintained. For example, in a heather grazing experiment initiated by the Rowett Research Institute, detailed botanical records are being kept of the effect of grazing on an enclosed heather sward.

Botanical analyses have also been undertaken on behalf of the Department of Soil Fertility on a grassland manurial experiment.

The herbarium has been expanded. Collection and identification this year has been concerned mainly in building up the *Bryophyte* section.

MAPS AND REPORTS

The first memoir of the Soil Survey of Great Britain (Scotland) dealing with the soils of the country round Banff, Huntly and Turriff, with accompanying maps (Sheets 86 and 96), was published by Her Majesty's Stationery Office on 19th July, 1954[1].

Fair copies of Sheets 17 (Jedburgh) and 18 (Morebattle) have been lodged with the Ordnance Survey for printing. Work on the accompanying memoir is well advanced.

A fair copy of Sheet 22 (Kilmarnock) is in course of preparation, and work on the memoir for this Sheet has commenced. The chemical analytical data relevant to Sheets 17, 18 and 22 has been completed.

A paper[15] describing the main soil types in an area of south-east Scotland and assessing the relative importance of the various soil-forming factors, has been accepted for publication.

LABORATORY INVESTIGATIONS AND COLLABORATIVE WORK

The extension of the surveys has entailed more work for the senior surveyors in compiling information which will be of use in future memoirs and less time has been available for chemical studies. Work continued, however, on samples for air-space determinations. Some of the junior surveyors assisted in the laboratory with the routine analysis of soil profiles.

Photographic records have been made for use in subsequent memoirs, and as it is hoped that a number of profiles in colour may also be included, colour transparencies of certain profiles have been procured.

The herbarium which now contains approximately 450 specimens has been checked for species identification, and the geological collection has been augmented.

Selected soil samples have been submitted for investigation of the clay fraction by X-ray and differential thermal analyses, and selected profiles have also been taken for spectrographic analysis. Assistance has been given in the selection of sites for field trials conducted by the Institute and by the Scottish Colleges of Agriculture. Joint investigations with various departments of the Scottish Universities have continued.

SOIL GEOLOGY AND MINERALOGY

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

The field examination of hill farms in connection with the sheep pining investigation was continued in Selkirkshire. The main areas visited lie in the upper valley of the Yarrow and neighbouring waters.

A number of samples were examined from glacial drifts, mainly derived from shales and greywackes of Silurian age in Selkirkshire. A marked feature of the fine sand fractions in both the soils and drifts was the presence of large amounts of rock fragments. These fragments are derived from the fine grained shales and would seem to indicate that the weathering processes have not gone so far in these soils as is generally the case.

In samples from an area of glacial drift, derived from sedimentary rocks, mainly shales and sandstones of Old Red Sandstone age, in Berwickshire the low content (about 2·6 per cent.) of ferromagnesian silicate minerals and the high content (about 96 per cent.) of quartz was marked.

X-RAY

Quantitative Analysis

In the development of internal standard methods for quantitative analysis by X-ray powder diffraction the effect of X-ray absorption on the intensity of the lines has been studied. Amorphous diluents and short wavelength X-rays have been used to reduce the absorption in the specimens.

Soil Clays

Routine mineralogical analysis of Scottish soil clays has been continued and a paper[16] based on the relative abundance of the various clay minerals in different soil types is in the press.

The examination of the clay fractions of Turkish forest soils has been completed in collaboration with the Department of Forestry of the University of Istanbul and a joint paper is in preparation. Other soil clays studied included samples from Australia, Malaya, Norway, Italy, Spain and North Africa.

Northern Ireland Basalts

Co-operating with the Department of Geology of the University of St. Andrews, a study has been made of the Interbasaltic laterites, and a section on the clay mineralogy was written for a paper[17] which has been accepted for publication.

Following a request from the Department of Agricultural Chemistry of The Queens University of Belfast, an examination of a number of soil profiles developed on the Antrim basalts has commenced, in an attempt to explain the very high cation exchange capacity.

A detailed study of the particle-size distribution of the minerals in one basaltic soil profile has been started.

Montmorillonite-Organic Complexes

The study of the nature of the forces involved in the formation of complexes between montmorillonite and organic molecules and ions has been continued.

Granulated Fertilizers

An investigation by X-ray diffraction and optical methods has been made of granulated compound fertilizers supplied by a number of manufacturers. A paper[3] on this subject has been published in which the interactions occurring between the ingredients during manufacture and their influence on caking of the granules during storage are discussed.

Apparatus

A three-layer X-ray diffraction camera designed for work with clay minerals has been constructed. It records simultaneously the diffraction pattern from three different specimens.

PHYSICAL CHEMISTRY

Differential Thermal Analysis

In soil clays from Aberdeenshire, Ayrshire, Kincardineshire and Roxburghshire examined during the year by differential thermal analysis, the usual suite of clay minerals was observed. Hydrous mica was again normally predominant, although higher kaolin contents were noted in some Ayrshire clays—presumably where the parent sediments contained kaolin. Sets of soil clays from Ireland, Italy, Malaya and the Sahara were also examined and the clay mineralogy of rendzinas is receiving further attention.

Continuing the study of the decomposition products of rocks, samples of fresh and decomposed rocks (where possible the complete series from the fresh rock through various stages of weathering to the soil clay) were examined. The results obtained from greywacke and mudstone, nepheline basanite, Old Red Sandstone basalt, and some Carboniferous rocks, were reported in a paper read before the Clay Minerals Group of the Mineralogical Society in November, 1953.

Oxides of aluminium and iron precipitated and aged under controlled conditions of temperature and pH were examined by differential thermal analysis and a few preliminary experiments were also carried out upon manganese oxide precipitates. Synthetic samples of hydrous oxide minerals were also examined.

Among minerals investigated during the year were allophane, antigorite, bauxites, bayerite, diaspore, hydrous micas, montmorillonoids, pyrophyllite, saponites, talc, vermiculites, and manganese oxide minerals. The use of piperidine-treated samples for distinguishing allophane and montmorillonite is being checked and the thermal behaviour of some clay-organic complexes has been investigated.

A note upon the comparative performance of nickel and porous alumina specimen holders of identical dimensions has been accepted for publication[19]. The prototype of a simplified temperature controller for differential thermal analysis has been constructed and is ready for testing.

The papers on the mineralogy of kaolin clays from Pugu, Tanganyika[4] and the standardization of differential thermal analysis technique[5] and the paper summarizing the lectures delivered in Madrid in 1952[6] have now appeared.

Chemical Studies

Considerable use has been made of semi-micro methods of silicate analysis in the investigation of pure clays—for example, saponite and vermiculite—and the products of grinding micas. Attention has been paid to the use and/or development of more convenient methods and a versenate method for calcium determinations has been adopted as a standard.

The papers on the removal of free iron oxides from soils[7] and clays[8] have now been published.

SOIL ANALYSIS

Routine analyses have been completed on the samples taken by the Soil Survey officers during 1952 (410 samples representing 93 profiles). During 1953, 650 samples (131 profiles) were taken and routine analyses have been completed on about 90 per cent. of these. Ultimate analyses of 7 selected profiles (36 samples) from Roxburghshire have been completed.

Numerous analyses were made at the request of the various departments of the Institute.

SPECTROCHEMISTRY

The principal lines of research in which the Department of Spectrochemistry is engaged are the study of the interrelationship of the trace elements in rocks, soils, plants and animals, the development of new spectrochemical and allied techniques, and the application of ultraviolet, visible and infrared absorption methods of the study of soil organic matter. In addition, specialized analytical facilities are provided for other departments within the Institute and collaborative work is in progress with outside institutions. The demands for analytical determinations are increasing considerably; in consequence there is on occasion some delay before results are available, particularly if the determinations required involve modification of the procedures normally used. The chief types of analyses made by emission methods include determinations of alkali and alkaline earth metals by flame methods and of trace elements in soils and plant materials by arc techniques.

The Grubb Parsons S4 double beam infrared spectrometer has been brought into operation in the course of the year, having been set up initially as a single beam unit. This instrument should supplement the facilities for the study of organic materials already provided by the ultraviolet and visible spectrophotometers, on which collaboration with the Departments of Soil Organic Matter and Plant Physiology is already in progress.

The problem of accommodation remains a major factor in restricting output and the development of techniques. The most serious bottle-neck is in chemical pretreatment, chemical laboratory accommodation being particularly restricted. Overcrowding is however general and leads to difficulties, especially in the introduction of new methods. One or two methods have been developed to the stage of routine application but full advantage cannot be taken of them until further accommodation is available.

Collaboration on a research basis has continued with numerous outside institutions and university departments. Numerous workers from Britain and overseas have been given tuition in the methods developed in the Department. Among those spending an appreciable period were Mr R. K. Richardson, Department of Agriculture, Jamaica, Mr J. Spector, Imperial College of Tropical Agriculture, Trinidad, Mr J. B. Martin, Chester Beatty Research Institute, London, Mr J. Benjaminsen, State Laboratory for Plant Culture, Lyngby, Denmark, Dr M. Pinta, Institut d'Enseignementet de Recherches tropicales, Bondy (Seine), France, Dr B. Ramamoorthy, Indian Agricultural Research Institute, New Delhi, Mr R. S. Subramanya, Indian Institute of Science, Bangalore, and Mr G. L. Mason, Rio Tinto Co. Ltd., Broken Hill, Northern Rhodesia.

Members of the staff of the Department have attended meetings of the Consultative Committee for the Development of Spectrographic Work, the

Interservices-D.S.I.R. Panel on Emission Spectroscopy, the Agricultural Research Council Group on Mineral Deficiencies and Excesses in Animals, the Glasgow Spectrographic Discussion Group and the Infra Red Discussion Group. Papers were presented to the Colloquium on Plant Analysis at the VIIIth International Botanical Congress in Paris (on spectrochemical methods of analysis), to the International Symposium on Analytical Chemistry in Birmingham (a review of recent advances in spectrochemistry), to the International Peat Symposium in Dublin (on trace elements in peats), and to the Midland Association for Analytical Chemistry (the porous cup technique). Several other short papers and contributions to discussions were presented at the meetings mentioned above. A comprehensive bibliography of references to trace elements in soils has been submitted for publication as a Technical Communication of the Commonwealth Bureau of Soil Science[24].

The punched card filing system for the recording of analytical determinations of trace elements in all types of materials investigated has been in operation throughout the year, and is being extended to include determinations made in previous years. Results will be included from the analytical spectrochemical units established at the Edinburgh and East of Scotland College of Agriculture and the West of Scotland Agricultural College, where methods developed in the Department are being employed.

SPECTROCHEMICAL METHODS OF ANALYSIS

(*a*) *Flame Emission*

The flame methods in use are essentially routine analytical tools for the determination of alkali and alkaline earth metals in soil and plant extracts. For potassium, sodium and calcium, flame photometry is often more satisfactory than a spectrographic method and gives results more quickly; when other elements are required the Lundegardh technique is used. During the year a total of some 15,000 samples have been examined by flame methods, chiefly on behalf of the Department of Soil Fertility.

An integrating flame photometer for potassium determination is in process of development: until further trials have been carried out, the success of the design cannot be assessed.

(*b*) *Arc Emission*

There is little change to report in the spectrochemical techniques employed for arc emission trace element determination. Minor modification of the chemical concentration technique involves an acid extraction of plant ash prior to sodium carbonate fusion in order to avoid reducing conditions in the platinum crucibles. An experimental hotplate made of MG5 aluminium alloy has been constructed in an attempt to avoid the contamination resulting from corrosion of the common type of iron hotplate. These changes refer to pretreatment conditions rather than to the spectrochemical techniques employed for the bulk of the trace element work.

The method used for the direct determination of Cu, Mn, Ba, and Sr in plant ash is being extended to include Al, which occurs in appreciable but variable amount in all plants.

(*c*) *Spark Emission*

The porous cup solution spark technique is being used on a routine scale for the determination of Mg, Cu and Zn in soil extracts, Mg being determined in a proportion of the advisory soil extracts by this method.

The application of the method to the determination of Cu, Mn, Mg, Fe and P in plant materials is being studied. Problems arising from variation in Ca content of the extracts and the possibility of the production of colloidal precipitates which do not pass through the electrode base require to be solved before the method can be applied on a routine scale.

(*d*) *Photometry*

The stabilized power pack for the Hilger Microphotometer mentioned in last year's report has been in use throughout the year. A batch of four have been built in the Department and are proving very satisfactory in operation. As now arranged, their adjustment is not difficult and the stability more than adequate. The design, which will be published in due course, is based on a circuit using a saturated diode, requiring only a standard and readily available radio components, as is not the case with, for instance, stabilizers based on a saturable reactor.

Development of the display microphotometer with electronic scanning has continued. A suitable plate carriage has been constructed in the Instrument Workshop and satisfactory displays have been obtained on a twelve inch cathode-ray tube.

TRACE ELEMENTS IN SOIL, PLANTS AND BIOLOGICAL MATERIALS

(*a*) *Soils and Soil Parent Materials*

Study of the distribution of trace elements in soil profiles has been continued along the lines previously reported, having been extended to soils of different associations developed on types of parent material not previously investigated. In general the findings have been in line with those previously reported.

A concise statement on the current views on the distribution and occurrence of trace elements in soils has been prepared for publication in an American Chemical Society Monograph on the chemistry of soils[21].

In collaboration with Professor L. R. Wager (University of Oxford) a study of trace element status of granitic gneisses and related rocks is being carried out on samples from Scotland and elsewhere.

The survey of the cobalt status of the soils of South Scotland has continued, some 200 having been examined for acetic acid soluble cobalt. A considerable number of soils from the North of Scotland area have been tested for acetic soluble cobalt on an advisory basis. The study of methods of assessing available copper in soils has been extended to include further extractants.

The examination of soil samples on an *ad hoc* basis for trace elements has continued, numerous samples from Britain and overseas where crop or stock problems arise having been examined for such trace elements as Co, Ni, Mo, Pb, Sn, Zn, V, Ti, Cr, Ag, Au, Ga, Mn and Cu. Instances of high contents of toxic elements such as Mo, Ni and Zn have been observed. On behalf of Dr W. J. Rees of the University of Birmingham, analyses are being made for trace elements in power station ash used as a soil additive, and of soils and crops so treated.

(*b*) *Plant Materials*

Analyses of plant samples from variously treated experimental plots have continued in order to establish the effects of liming and manuring on trace element uptake. This type of work is of a long term nature and only after general trends have been established and confirmed would it be justifiable to state definite conclusions: at present certain effects appear contradictory in different samples, and further investigation is required.

Among samples examined for advisory purposes, apart from numerous samples for Co, Mo and Cu where stock disorders occur, may be mentioned a number of instances of cereals with low Mn contents, pointing to the continued occurrence of occasional instances of manganese deficiency in the soils of west and north-east Scotland.

(*c*) *Other Types of Sample*

The investigation of water samples from mains water supplies and other sources, has continued. One investigation in collaboration with Dr J. M. Sutherland (Raigmore Hospital, Inverness) deals with the possible correlation of trace element status of water to the incidence of disseminated sclerosis in Orkney and Shetland.

A joint study with Dr T. Moore (Dunn Nutritional Laboratory, Cambridge) of the discoloration of rats teeth in relation to manganese and iron contents, has been completed and the findings have been submitted for publication[23].

Numerous samples of livers, received from various sources, mostly through the Animal Diseases Research Association, have been examined for trace constituents. Materials analysed on behalf of the Rowett Research Institute have included milk products, feeding stuffs, distillery by-products and sheep livers. Other miscellaneous samples examined for trace element contents have included sheep's horns, seaweed meals, streptomycin broths, and various fertilizers.

ABSORPTION SPECTROMETRY OF SOIL ORGANIC MATTER

As already mentioned, a Grubb Parsons S4 double beam infrared spectrometer has been installed during the year. This apparatus finds its principal use as a research tool in the characterization and identification of organic compounds: it is especially useful when these are only available in milligram quantities. As an example may be quoted a ketone isolated in the Department of Soil Organic Matter from the products of alkali-nitrobenzene oxidation of phragmites peat, which has been positively identified. Such small quantities are most easily handled when incorporated in potassium bromide powder, the whole being pressed to form a clear transparent disk. A press and mould have been constructed for this purpose. The mould is of an improved design, in which the potassium bromide disk is formed within a short jig liner bush. The disk is removed from the mould and inserted in the infrared beam still mounted inside the cylindrical steel bush. With many previous designs of mould, the disk was liable to fracture on extraction from the body of the mould, but with the simple modification described above opportunity for fracture does not occur. Initial trials have been made on the use of this technique for the identification of carbohydrates when available only in the small quantities that can be isolated by chromatography.

Ultraviolet absorption studies have proved useful for following the metabolism of aromatic compounds by microorganisms, in co-operative work with the Microbiological Section of the Department of Soil Organic Matter.

In a study of the action of over seventy soil micro-fungi on aromatic compounds akin to lignin, it has been established that the majority can oxidize vanillin and ferulic acid to vanillic acid, and syringaldehyde to syringic acid. A considerable number can also destroy the benzene ring in vanillic and syringic acids, so that these only appear as intermediates. A joint paper[25] describing this work has been accepted for publication.

An absorptiometric method for the determination of total haematin in plant leaves has been developed. A study of the haematin level in certain cases of chlorosis under investigation by the Department of Plant Physiology has shown a direct relationship between the concentration of haematin and chlorophyll, in the plants so far investigated.

SOIL ORGANIC MATTER

A feature of the work this year has been the development of combined effort within the department. This has arisen fundamentally from the present organization of the department. The Microbiological and Chemical Sections have been working essentially on the same general problem of the metabolism of the larger groups of organic matter in soil, namely carbohydrates, protein, "lignin derivatives," and, to a lesser degree, waxes; in the first instance these groups are studied both chemically and microbiologically from the aspect which seems likely to be most productive at the hands of the individual worker concerned, but it is expected that converging interests will lead to combined effort in dealing with results or problems which arise from the work of either section. The value of this essential unity of organization was first shown in the collaborative work of Forsyth and Webley on bacterial polysaccharides which had its origin in chemical studies, and it is fully demonstrated in the present report. For instance, microbiological work on the metabolism of lipids by *Nocardia* has led to joint chemical and microbiological investigation of the physiology of the organism, including not only lipid but also carbohydrate synthesis; an earlier conclusion that the thermophil *Micromonospora vulgaris* is of importance in the breakdown of protein in compost has resulted in a joint study of its physiology which shows promise of yielding results of general importance and interest; and in the study of the phenyl decomposing activities of soil fungi the necessity for combined chemical and mycological work has already become apparent.

At the invitation of Dr Firman E. Bear, a chapter on soil organic matter has been written for the American Chemical Society monograph on the chemistry of soils[28].

CHEMISTRY

Carbohydrates

(*a*) *Soluble Polysaccharides from Soil and Peat*

Efforts are being made to build up a stock of the purified polysaccharide complex for further investigation. Two of the three unknown *O*-methyl sugars which form a small proportion of the units of the above polysaccharides have been partly identified in that products obtained by periodate oxidation and by sodium borohydride reduction followed by periodate oxidation (Lemieux & Bauer, *Canad. J. Chem.*, **31**, 814, 1953) appear, on the paper chromatogram, to be identical with products obtained similarly from 2-*O*-methyl aldose sugars (that is probably methoxymalonaldehyde and 2-*O*-methyl-D-glyceraldehyde respectively).

The inference is that the soil sugars are 2-*O*-methyl aldoses although they differ from any known 2-*O*-methyl aldoses, and the occurrence of products additional to those obtained from a 2-*O*-methylaldohexose during the oxidation suggests that they are heptose sugars. Comparable sugars isolated from natural sources have been 3-*O*-methyl sugars (for example, digitalose and 3-*O*-methyl D galactose) or ketoheptose (sedoheptulose). It would probably be necessary to isolate the soil sugars in relatively large quantities to confirm these deductions.

(*b*) *Fungus Cellulose*

The "fungus cellulose" isolated from *Polyporus betulinus* has been named *betulan*, following the use of the name *nigeran* for a similar glucose polymer isolated from *Aspergillus niger*. (Barker *et al.*, *Chem. and Ind.*, 756, 1952). Work is being continued with a view to confirming the structure indicated by previous work (Duff, *J. Chem. Soc.*, 2592, 1952).

(*c*) *Investigation on the "Total Carbohydrate" of Soil and Peat*

The term "total carbohydrate" includes soluble carbohydrate (simple sugars and water soluble polysaccharides) and insoluble carbohydrate (cellulose, chitin, glucosans from fungi, etc.). Information on these fractions had previously been obtained by the method of Waksman. With the recent development of sensitive reagents such as anthrone-sulphuric acid, capable of estimating small amounts of total carbohydrate with speed and accuracy, it was hoped that the reagent could be used directly on a sample of soil, thereby avoiding inaccuracies of extraction procedures. For example, a soil from the Craibstone lysimeters containing about 5 per cent. total organic matter gave 1·2 per cent. total carbohydrate (expressed as glucose). However, when the conditions of the estimation and the previous treatment of the soil samples were altered the values obtained varied widely. Values obtained by the Waksman procedure were much lower than the above and a similar relationship was found when other soils were used. Although admittedly unsatisfactory, the above experiments suggest that the proportion of carbohydrate in soil organic matter may be higher than hitherto indicated. It is hoped to resume work on these lines when rather more is known about the reagent; at present attention is being directed to the parallel problem in peat where the methods used for investigations on plants can be applied without interference from the soluble and colloidal inorganic matter present in soil. Attention has been concentrated principally on the phragmites section of a peat deposit, samples being taken at intervals of 6 to 9 inches to a total depth of 13 feet.

A method using hydrolysis with 72 per cent. sulphuric acid at 30°C., which has been found satisfactory with cellulosic materials, gave very low results with the phragmites peat (8 to 13 per cent. carbohydrate as glucose over the profile), a commercial sphagnum peat (16 per cent.), a commercial eriophorum peat (13 per cent.) and Lewis peat (12 per cent.). It seemed probable that more useful results would be obtained from investigations involving removal of lignin with sodium chlorite and subsequent extraction of hemicelluloses from the residual holocellulose. Lignin, ash, water soluble material, benzene-ethanol soluble material, and moisture were determined separately. The phragmites peat contained about 30 per cent. holocellulose with no significant variation over the profile. The sums of the above determinations for the various samples were consistently in the range 109-115 per cent., probably because high results were given by the method used to determine lignin (66-74 per cent. found).

Subsequently hemicelluloses will be extracted from the holocellulose prepared as above. Preliminary work has shown that this can be done almost quantitatively.

Other methods of "holocellulose" determination which have been investigated and found unsatisfactory in this case involve delignification with gaseous chlorine or with ethanolamine. With both methods the "holocellulose" content obtained was higher than that indicated by the 72 per cent. sulphuric acid hydrolysis previously mentioned.

Nitrogenous Compounds: the Humus Complex

Work has continued in an effort to isolate protein material from soil. Walters (*J. Ind. Eng. Chem.*, **7**, 861, 1915) described the isolation, by precipitation with phosphotungstic acid, of a fraction from the acid-soluble portion of an alkaline extract of soil, which from its properties he concluded was a mixture of various proteoses and peptones resulting from the hydrolysis of proteins. By the use of Walter's method, a fraction having similar properties has now been obtained from a woodland soil (Dunnottar Woods, 4-8 inches) and examined by the use of more recent techniques. The results indicate that the material is a heterogeneous complex containing both amino-acid and sugar residues, and having a nitrogen content of about 5 per cent. Acid hydrolysis yields a mixture of the amino-acids normally found in proteins, together with a mixture of monosaccharides including glucose, arabinose, mannose, xylose, fucose, and rhamnose, corresponding to a total carbohydrate content of about 25 per cent. The material may be further fractionated by precipitation with ammonium sulphate, ethanol, etc., but there is no evidence that these further fractions are homogeneous. It is adsorbed from aqueous solutions at pH 2-3 by activated charcoal, and, by successive elutions with distilled water and dilute alkali, two fractions may be obtained, each with a somewhat lower nitrogen content than the original material. Although the original material gives a distinct positive biuret reaction, indicating the presence of peptide linkages, both fractions from the charcoal are negative in this respect. These and other similar fractions obtained by various methods are being further investigated.

The examination of the products of alkali-nitrobenzene oxidation of the organic matter of soils and peats has been continued, and refinements in technique have led to improved yields and to better separation of the products on paper chromatograms. An unidentified product, already reported, from the oxidation samples of phragmites peat has now been isolated and identified as *p*-hydroxyacetophenone by comparison of its melting point and (with the assistance of the Department of Spectrochemistry) of its ultraviolet absorption spectrum with those of an authentic sample. This substance has so far been obtained in relatively large quantities only from phragmites peat, but smaller amounts have been detected in the oxidation products from other samples of soil organic matter; it has not been obtained from phragmites plants. In most cases, the main products of the oxidation are the phenolic aldehydes, syringaldehyde, vanillin, and *p*-hydroxybenzaldehyde; relatively high yields of these are obtained from peats and from the F-layer of forest soils, much lower yields from the H-layer of forest soils, and lowest from the humic acid extracted by alkali from mineral soils. This suggests that during the normal process of humus formation there is a progressive alteration in the part of the lignin molecule from which the aldehyde group is derived, and, as might be expected, the indications are that the process is one of oxidation, since the alteration is less in peats, where oxidising conditions do not obtain.

Joint work involving absorption studies has been done on the exhaustive methylation of sphagnum in the search for a method of stabilizing the lignin molecule, and thus permitting of its isolation in a relatively unchanged condition. Repeated methylation of sphagnum with diazomethane in ether has yielded a product containing 11·6 per cent. of methoxyl, and by subsequent repeated methylation with dimethyl sulphate the methoxyl content has been raised to a maximum of 35·7 per cent. This completely methylated product has unfortunately not proved amenable to dilute acid hydrolysis, for in the presence of acid it forms compounds even more strongly coloured than those from the original sphagnum. It has been confirmed that the diazomethane-methylated sphagnum on oxidation with neutral permanganate yields *p*-methoxybenzoic acid (anisic acid); a somewhat higher yield (4 per cent.) has been obtained than previously reported, probably because a more completely methylated sphagnum was used, and only very minor quantities of other (unidentified) aromatic acids have been detected.

MICROBIOLOGY

Paraffin and Fat Decomposing Soil Nocardias

Little is known regarding the transformation of fatty materials in the soil or of their nature; particular attention has been devoted to a soil actinomycete, *Nocardia opaca*, which takes part in this transformation.

A paper[30] on the growth and morphology of *Nocardia opaca* Waksman & Henrici (*Proactinomyces opacus* Jensen) when grown on hydrocarbons, vegetable oils, fatty acids, and related substances, has been accepted for publication. It has been shown that this organism can use certain long chain saturated aliphatic hydrocarbons and many vegetable oils as sole carbon and energy source. Long chain saturated aliphatic acids (for example, myristic, palmitic, stearic) can similarly be used. The ability of these partially acid-fast nocardias to grow on liquid paraffin or paraffin wax is well known (Erikson, *J. gen. Microbiol.*, **3**, 361, 1949). Also the proportion of this type or organism among soil nocardias is quite considerable. Thus out of 300 soil strains studied by Erikson, 30 per cent. were partially acid-fast. The finding that *N. opaca* can grow on vegetable oils and also utilize long chain fatty acids indicates that this group of organisms is of some importance in the breakdown of lipid material in soil.

Attempts are being made to follow the intermediate metabolism of fatty acids, etc., using *N. opaca*. A study of the biosynthesis of lipids and polysaccharides by this organism is also being carried out. A convenient shaking machine for the production of uniform cell material for this work has been constructed and installed in the constant temperature room. A modification of a recently described method for the microestimation of lipid has been evolved for use with this organism. Determinations of sugars and the identification of some aromatic acids on the paper chromatogram have been made. Preliminary results have shown that while the lipid content remains reasonably constant the polysaccharide content varies considerably depending on the carbon source.

Thermophilic Actinomycetes from Composts

The inhibitory effect of oxygen on the respiration of the aerial mycelium of the aerobic thermophil *Micromonospora vulgaris* was confirmed by growth experiments. In the presence of pure oxygen at one atmosphere it was found that *M. vulgaris* was unable to form in liquid medium a surface pellicle of growth bearing aerial mycelium. The production of bottom growth was either unaffected or stimulated under these conditions. A paper on the effect of oxygen on the growth metabolism of *M. vulgaris* has been published[9].

Work on the physiology of this organism with the object of determining its role in the breakdown of organic matter in composts during the high temperature phase of composting has been started. A considerable amount of chemical work has been required and has involved the separation and identification by means of paper chromatography of the amino-acids in cultures of the organism grown on various liquid media.

Growth experiments have shown that *M. vulgaris* will grow in the presence of certain proteins. During growth amino-acids are liberated into the medium. Examination of metabolic solutions from cultures of the organism grown on complex media containing amino-acids has shown that there is a very distinct selective utilization of amino-acids by the organism: certain amino-acids, notably lysine, tyrosine, phenylalanine and glycine, are never appreciably attacked; leucine, valine, and alanine are strongly attacked and usually completely removed from the medium; other amino-acids, such as arginine, glutamic acid, aspartic acid, serine, threonine, and proline are also subject to attack but to a variable degree, and they are not usually completely removed from the medium. The organism has been found to possess strong proteolytic activity and can hydrolyse casein, egg albumen, and edestin with the utilization of certain amino-acids and the accumulation of others in the metabolic solution. In addition growth will take place on a mixture of amino-acids (for example, digest of casein), certain amino-acids being utilized more readily than others. Growth will not take place in a vitamin free amino-acid mixture (for example, in Difco vitamin free casamino-acids) unless yeast extract is present.

From this information attempts are being made to establish a synthetic medium for the growth of this morphologically complex thermophil.

In the expectation of more precise quantitative experiments on the utilization of amino-acids by *Micromonospora*, the potentialities of a method of determination of amino-acids as their dinitrophenyl derivatives (Levy, *Nature*, **174**, 126, 1954) is being examined. The results so far obtained have been more reliable and consistent than those obtained by other available methods, and it is hoped that the method will prove valuable in this and other fields where the determination of individual amino-acids is required.

Mycological Studies

(a) Lignin Decomposition

The investigations into the decomposition of aromatic compounds related to lignin have been continued. About sixty fungi isolated from soils under several vegetational types were grown on media containing either *p*-hydroxybenzaldehyde, ferulic acid, syringaldehyde or vanillin as sole sources of carbon. Following the growth period, analysis by absorption spectrometry (in collaboration with the Department of Spectrochemistry) revealed that a number of fungi had removed all traces of aromatic compounds from the media, while others left varying amounts. It was possible to identify syringic acid, formed as an intermediate product in the utilization of syringaldehyde, and vanillic acid, formed from ferulic acid and vanillin. The production of these intermediates was confirmed by paper chromatography. A paper on the utilization by soil fungi of *p*-hydroxybenzaldehyde, ferulic acid, syringaldehyde, and vanillin has been accepted for publication[25].

(b) Warburg Studies

The use of the Warburg apparatus for the study of fungal metabolism is limited on account of the high rate of endogenous respiration shown by fungi and the difficulty of obtaining uniform suspensions. A technique to overcome this has been developed and an outline of the method was given in a paper entitled *A method for studying the metabolism of fungi in the Warburg apparatus using spore suspensions*, which was presented at the meeting of the Society for General Microbiology in Reading in September. In the case of fungi with non-wettable spores, suspensions can be prepared by treating the spores with a surface active agent. The spores are incubated overnight prior to addition of substrates. This method possesses three important characteristics—the rate of endogenous respiration is low, good uniformity is obtained between different flasks, and it is superior to methods which employ mycelial suspensions in that the whole organism is being studied.

PEAT

A paper giving a tentative classification of peat deposits in Scotland and making some suggestions with reference to the need for more uniform system of peat nomenclature, was presented at the International Peat Symposium in Dublin[27].

Routine Work

The bulk of this work continues to be carried out in conjunction with the Department of Agriculture for Scotland (Peat Division).

During the year 1,271 samples for routine analysis have been received from the following sources:

Moss	*Location*	*No. of samples*
Strathy-Halladale	Sutherland	333
Gardrum	Stirlingshire	360
Darnrigg	Stirlingshire	312
Blairderry	Wigtownshire	266

Additional samples from each moss have been received for estimation of fibre content.

Contact with the Department of Agriculture for Scotland (Peat Division) Field Survey team was made during visits to the Gardrum-Darnrigg area and the Wigtownshire mosses.

Further samples for trace element analysis have been taken and submitted to the Department of Spectrochemistry.

Pollen Analysis

A paper covering some earlier pollen analyses of Scottish peat deposits has been submitted for publication[26].

During the year the completed pollen analysis diagrams from 13 deposits in different parts of Scotland were sent to Dr H. Godwin, F.R.S., of the Botany School, University of Cambridge, to whom acknowledgement is made for help and advice received.

The initial aim of this work has been to produce pollen analysis diagrams (based on the identification of pollen from tree species and the main groups of non-tree species) from peat deposits in every part of Scotland. Sampling has continued with this end in view and during the year profiles have been taken from the following mosses:

Darnrigg, Stirlingshire.
Forrestburn, Lanarkshire.
Fannyside, East Dunbartonshire.
Slidderies Burn, Angus.
Blairderry Moss, Wigtownshire.
Moss of Cree, Wigtownshire.
Loch Neldricken, Kirkcudbrightshire.

It is hoped to carry out pollen analysis on these samples which now make a comprehensive series covering peat from most parts of Scotland. The opportunity was taken of sampling a buried peat uncovered during excavations prior to the reconstruction of a school in Nelson Street, Aberdeen.

FOREST SOILS

A paper describing the work on soil profile development at Culbin Forest has been submitted for publication[31]. The periodic analyses of foliage samples have been continued, and samples from a stand of Corsican Pine at Monaughty Forest, ten miles east of Culbin, have been included as representing trees growing on a more normal soil.

In order to determine the effect of phosphate manuring on the growth of young Corsican Pine at Culbin, plots of trees four years of age have been treated with ground mineral phosphate at the rate of two ounces per square yard (corresponding approximately to the standard Forestry Commission dressing of two ounces per tree at the time of planting), and the response is being measured by leaf analysis and measurement of the leading shoots. The plots are sufficiently large to allow work to be continued over several growing seasons.

The development of the experimental apparatus for the measurement of soil moisture by neutron scattering, jointly with the Department of Plant Physiology (Radioactive Studies), has been described in a joint paper[32] presented at the Second Radioisotope Conference (Oxford, 1954). The method appears to be applicable to a wide range of soils, and further development is being directed towards more sensitive methods of measuring the slow neutron flux and the production of a portable meter to enable the method to be used in routine field determinations.

The examination of soils from forest nurseries in Scotland, hitherto conducted by the Department of Soil Fertility, has been transferred to this section. The object of this work is to assist the Research Branch of the Forestry Commission in problems of forest nursery nutrition, and also to advise both Conservancy and private nurseries on suitable manurial treatments. Advice on treatment for forest soils has also been given to the Forestry Commission and to private woodland owners in connection with special projects.

PLANT PHYSIOLOGY

Investigations so far conducted on the mineral nutrition of plants have emphasized the need for elucidating the problems of cell metabolism, employing modern techniques using paper chromatography, radioisotopes and enzyme methods on micro or semi-micro scale.

Phosphate Absorption

A study of the physiology of starving sugar beet disks had shown the nature and extent of the changes in sugar content which take place with time. Increased absorption of phosphate can be related to the concentration of reducing sugar existing in the cell. Some details of the protein and amino-acid metabolism have also been worked out. Final studies are now being made on organic phosphates and acids to obtain a clearer picture of phosphorus metabolism. This work is being prepared for publication.

An investigation into the growth promoting effect of a lignite has been published[10]. Several important concepts in the iron metabolism of plants have emerged from this study. The ratio of the phosphorus to iron in leaves gives a clearer presentation of the iron status of plants than does a consideration of the phosphorus or iron contents individually, high ratios being characteristic of iron chlorotic plants. The high phosphorus-iron ratio appears to be applicable to most forms of chlorosis, whether due to deficiency or excess of elements, or to virological or genetical causes.

Humic acid, moreover, maintains iron in a form available to the plant in the presence of high phosphorus. From evidence obtained by split root experiments with tomatoes in which iron and phosphorus were supplied together in one compartment and humic acid (synthetic or peat-extracted) in another, it would appear that humic acid or some simpler substance is able to enter the plant root and make iron available to the leaves.

Further experiments on the effect of chelating agents on iron nutrition have been conducted and a paper has been accepted for publication[34]. Autoradiographs using radio-iron and radio-phosphorus have been made of leaves and roots of mustard and tomato plants.

The interaction between iron, potassium and calcium is being investigated, and an investigation into the effect of heavy metal toxicity on iron metabolism is being completed.

Sterile Culture of Roots

The technique of the culture of tomato roots under sterile conditions has been studied over the past year and is now being used to elucidate the metabolism of roots. An effect of molybdenum on growth of mustard roots in solution culture has been confirmed in sterile culture. The micronutrient status of such sterile roots is now being investigated.

Nickel Toxicity

Further studies have been carried out on various aspects of nickel toxicity in plants. The results of a factorial sand-culture experiment confirmed field observations that the severity of toxic symptoms was reduced by liming and increased by phosphorus applications. An interesting but as yet unexplained, feature of this work is the highly significant increase in calcium absorption in the presence of nickel. A paper which embodies the results of investigations into the relationship between nickel toxicity and the supply of major nutrients has been accepted for publication[33].

The study of the relationship between nickel toxicity and iron supply continues, and a paper covering the first stage of the investigation has been published[11]. Further experiments have examined the effect of substrate nickel-iron ratios on the toxic symptoms produced. While high values of the ratio are associated with severe symptoms and *vice versa*, the absolute concentration of nickel in the nutrient solution still has to be taken into consideration. A high level iron supply prevents the appearance of necrosis in oat plants, although the level of nickel found in the plants on analysis is quite high. Root analyses of oat plants grown in solution culture have confirmed the suspicion that nickel reduced the translocation of iron by immobilizing it in the roots. Analyses of healthy oat plants showed that the concentration of iron in the tops remained remarkably constant for a tenfold increase in the level of iron supplied, although the increase in the level of iron supply was reflected in the iron content of the roots. From these results it became evident that nickel was not primarily responsible for the high levels of iron found in the roots of nickel-toxic plants, although some slight increase was caused.

In the course of this investigation it had been noted that while necrotic symptoms, which affected mainly basal and intermediate leaves of oat plants, varied little in intensity, chlorotic symptoms varied with age of the plant. In the growing plant, young leaves were severely chlorotic and young leaves which unfolded subsequently were also chlorotic, whereas those which emerged after 40 to 50 days were normal in appearance. This suggested some change in the rate of absorption of nickel or some other factor associated with the production of chlorosis. Analyses of plant samples at regular intervals during growth showed that the concentration of nickel in the plant increased rapidly and reached a maximum after about 30 days, thereafter decreasing slowly. Iron, on the other hand, was highest in the very young plants and decreased slowly with time. When the nickel-iron ratio in the plant is plotted against time, a point of inflexion is found at about 40 days which agrees well with the change in chlorotic symptoms observed at that time.

A short note has been published on the effect of the nickel chelate of E.D.T.A. (ethylenediamine tetra-acetic acid) on oat plants[12]. In contrast to the ferric chelate, the iron of which is freely available to plants, no nickel from the chelate source was found in the plants on analysis. The mechanism by which a plant obtains iron from the iron chelate is still not fully understood but work in this department and elsewhere indicates that the whole molecule is probably absorbed and then split up in the plant. Results obtained here show that this does not happen with nickel, nor is there any indication that nickel is being removed from the ligand at the root surface, the mechanism first suggested to explain the availability of the iron chelate. In the initial experiment the nickel chelate was supplied at a level equivalent to 2·5 ppm. ionic nickel in the nutrient solution. It was later shown that this level could be increased tenfold without any appreciable amount of nickel appearing in the plants.

The paper dealing with the effects of various heavy metals on iron absorption and metabolism has now been published[13]. The effects of the individual metals on nickel toxicity and uptake have also been studied.

Collaborative

Work in collaboration with the North of Scotland College of Agriculture has continued, and samples of plants suffering from major nutrient deficiencies have been examined.

Chemical Methods of Analysis

Techniques for colorimetric analysis of copper by *bis*-cyclohexanone-oxalyl dihydrazone and boron by 1–1 dianthrimide have been explored. The copper analyses have been found to agree very well with results obtained by the Department of Spectrochemistry. A method for the determination of calcium and magnesium by ethylenediamine tetra-acetic acid is being investigated.

RADIOACTIVE STUDIES

The value of the radioactive method in estimating plant available phosphate has been tested in a series of pot experiments, and analytical methods involved in the estimation of the radioactive content of the plant material have been further investigated.

Radioactive isotopes have been used in several investigations to show the distribution in detail of nutrients within plants.

The electrodeposition method for counting radio iron has been investigated for application to tracer studies in plants and soil.

A method for the determination of soil moisture by neutron scattering was described to the Second Radioisotope Conference[32], being an account of the joint investigation with the Department of Soil Organic Matter.

The activated metal foil method for detection of slow neutrons has been found adequate but relatively insensitive when compared with detection by boron trifluoride counters, which have recently become available in the United Kingdom. The possibility of improving the efficiency and portability of the equipment by employing such counters is being studied.

Co-operation with the new Scottish Horticultural Research Institute, Invergowrie, has been established in a study of the use of radioactive technique in special problems.

SOIL FERTILITY—CHEMISTRY AND FIELD EXPERIMENTATION

The basic policy of the work on soil fertility continues to be parallel development and integration of field, pot and laboratory studies directed towards the broad objectives of: (a) improving fertilizer practice, (b) clarifying the significance of soil properties and pedological and environmental factors in relation to crop production, and (c) developing methods for evaluating the nutrient status and requirements of soils for advisory purposes. To these ends, experimental work has been continued and extended along the lines given below, while contact with other research organizations and technical bodies has been maintained. Advisory work in association with the North of Scotland College of Agriculture has continued. The practical implications of recent work have been discussed in addresses given to various agricultural and technical groups.

An account[14] of recent results on the placement of fertilizers for swedes and turnips has been published. Papers covering the determination of total organic phosphorus in soils[37], the effects of calcic and magnesium liming materials on the composition of crops[36], and the fertilizer responses of cereals[35] have also been accepted for publication. In the last paper, the need for nitrogen, phosphorus and potassium under Scottish conditions and the increases in yield of grain that can be expected from normal fertilizer dressings are discussed in the light of field experiment results.

The department was represented at the recent O.E.E.C. Conference on the effective use of lime and fertilizers, held in Denmark. An account of the present position in Scotland was presented at the meeting, and reports covering the discussion and summarizing observations concerning the storage and utilization of liquid manure have been submitted to the Department of Agriculture for Scotland.

FIELD EXPERIMENTS

Characterization of the field behaviour of different soil types is a basic objective in all the field experiments. Practically all the experimental centres are therefore on commercial farms and the sites are chosen in consultation with members of the Soil Survey Section. During the past season data have been obtained from over 50 experiments involving about 800 plots with cereals, 800 with grass and hay, 300 with potatoes, and 1500 with swedes and turnips. In addition to investigations on phosphate and on methods of applying fertilizers, the main points covered during the year were: the effects of various liming materials; the responses of different crops to and the interactions of nitrogen, phosphorus and potassium; the effects of time of application of nitrogen; and responses to trace elements. In one experiment on the occurrence of blind ears in oats the application of copper sulphate doubled the yield of grain and increased its volume weight by 50 per cent. Further work has been done on the effects of copper, molybdenum, and zinc on the growth and composition of mixed herbage and on the effects of manganese treatments on oats.

An account of the work with magnesium liming materials has been accepted for publication[36]. Materials rich in magnesium produce quite large increases in the percentages of this nutrient in the tops of mangolds, fodder beet, sugar beet, and turnips, in the leaves of kale and in cereal straw and hay. But the magnesium contents of roots, stems, and grain are practically unaffected by the type of liming material used. With mixed herbage cut at regular intervals of two to four weeks throughout the growing season, there is a 60 to 100 per cent. variation in the percentages of calcium and magnesium. The values are relatively low during April, May, and early June and gradually increase until August after which they remain fairly constant. Compared with no lime or ground limestone, magnesian limestone produced an average increase of 55 per cent. in the magnesium content of the herbage over a three year period.

Phosphate Relationships of Soils

Apart from short-term NPK experiments on different soils and crops, the work on phosphate covered the following main points: measurements of residual effects, interactions of lime and phosphate, comparisons of autumn and spring applications, and the effectiveness of different forms of phosphate. Experiments on all these subjects have been continued and extended. The measurements of residual effects are being combined with examination of the effect of lime and comparisons of phosphate applied before and after ploughing. As mentioned in last year's report, one of the designs being used permits of continued evaluation of phosphate residues in terms of fresh dressings. The comparisons of ploughed-down and surface applications of phosphate are intended to clarify the significance of ploughing and cultivations in relation to the positional availability of phosphate residues, and are also included in the series of experiments on autumn and spring applications of phosphate. Earlier experiments on the latter question showed no appreciable difference between spring and autumn dressings, but subsequent work indicated that the rate of application of about 1 cwt P_2O_5 per acre was rather high for sensitive comparisons to be obtained. Since the question is of importance in relation to the occurrence, rate, and significance of phosphate fixation, the present series of experiments including a range of dressings was started. The results are not yet complete but it is noteworthy that in several instances autumn application has resulted in an appreciable fall in effectiveness.

Methods of Fertilizer Application

Special attention continues to be given to the effectiveness of different methods and times of applying fertilizers. A paper[14] dealing with the results obtained with swedes and turnips up to the end of 1952 was read to the

Agriculture Group of the Society of Chemical Industry and has since been published. The main conclusions are that placing superphosphate directly below the seed at a depth of about 3 to 3·5 inches from the soil surface has consistently given higher yields of roots than placing it in other positions or broadcasting. There is no advantage in placing sulphate of ammonia, and placing it directly below the seed may be harmful to early growth. There is neither benefit nor any great disadvantage from placing muriate of potash (60 per cent. K_2O), but with 40 per cent. potash salts broadcasting is likely to be superior to placing directly below the seed. With NPK fertilizer mixtures there does not appear to be any benefit from placing. It seems that the positive effect from placing phosphate is counterbalanced by the negative effect from placing a mixture of nitrogen and potash. The results for the 1953 root experiments are in general agreement with these conclusions and a report on them has been submitted to the Agricultural Research Council. A further series of eight experiments was laid down in 1954 in order to obtain more data under varying seasonal conditions.

Experiments on the time of application of nitrogen to oats have been continued. The results to date do not show any advantages of late or split dressings over seed time applications of nitro chalk. Experiments have also been laid down to study the effectiveness of broadcasting superphosphate and muriate of potash either before or after sowing oats compared with combine drilling these two fertilizers.

POT EXPERIMENTS

A major part of the work has been devoted to collaborative experiments with the Section for Radioactive Studies on the use of P^{32} to evaluate the phosphorus status of soils. A selection of 40 soils representing the four main soil associations in north-east Scotland is being studied, using two rates of labelled KH_2PO_4 solution and oats as indicator crop. In some instances parallel experiments using soil diluted with sand have also been carried out. Data are being obtained for samples taken at an intermediate stage of growth as well as for the mature crop. Estimates of plant available phosphate are also being obtained from the response curves and by various laboratory extraction methods, and from the results it is hoped to be able to assess the general validity, usefulness and range of application o fthe P^{32} technique.

In another series of experiments a range of 15 phosphate compounds has been tested in sand and soil-sand media. These include superphosphate, dicalcium phosphate, three finenesses of each of Gafsa, Nauru and Morocco phosphate, iron and aluminium phosphates, and two organic forms, phytin and nucleic acid phosphate. Several of these compounds are also being tested in the field. Other subjects which have been covered are: (a) the effects of oven-drying treatments on the availability of native and applied phosphate, (b) the residual effects of one year old phosphate residues in a series of Australian Krasnozem soils, (c) measurements of potassium responses, the availability of fixed potassium, and the removal of potassium by continuous cropping, (d) effects of copper on the yield of oats on a selection of soils including cases of suspected copper deficiency, and (e) the effects of various trace elements, including molybdenum, copper, zinc and boron, on the growth of clover on a soil from a problem area.

LABORATORY WORK

Characterization of soils and analyses of produce samples from field and pot experiments, and attendant developments of analytical procedures, continue to form a major part of the work. In addition, investigations on the following main subjects have been continued and extended.

Phosphate Investigations

Increasing attention has been paid to the organic phosphorus fraction and further work has been done on the determination of total organic phosphorus in soils. A paper[37] on this subject has been accepted for publication. This investigation arose from the finding that an ignition -0·2N H_2SO_4 extraction method (Mattson, Williams & Barkoff, *Ann. Roy. Agric. Coll. Sweden*, **17**, 107, 1950) gave values two or four times higher than those obtained by hot 0·5N ammonia extraction following pretreatments with 0·1N HCl (Pearson, *Ind. Eng. Chem.* (*Anal ed.*), **12**, 198, 1940). To test the validity of the methods, the effects of varying the experimental conditions were examined and parallel determinations carried out using 0·1N NaOH as extracting agent. The results show that, on Scottish soils at least, hot ammonia has very definite limitations as an extractant for organic phosphorus and gives values which are much too low. Sodium hydroxide is much superior, and on 20 out of 23 samples examined a procedure using a double extraction with cold 0·1N NaOH following pretreatment with hot 0·1N HCl gives results very similar to those obtained by the ignition -0·2N H_2SO_4 extraction method. The general tendency, however, is for the values obtained by the ignition method to be slightly higher and in the case of three samples from a well drained profile derived from slaty till the NaOH values are clearly lower. With the ignition method, the values are very little affected by varying the ignition temperature between 450°C. and 650°C., the concentration of acid between 0·2 and 4N, and period of extraction between 2 and 16 hours. The most likely explanation for differences between the two methods is that the NaOH values are liable to be somewhat low due to incomplete extraction and/or hydrolysis of organic phosphorus. But both methods give the same general picture of the distribution of organic phosphorus in the soils, and the results by the NaOH method can be regarded as minimum values. The results point very strongly to the conclusion that the ignition method, which is very simple and rapid to carry out, gives valid results.

The conflicting requirements and numerous sources of error involved in organic phosphorus estimations make it very difficult to prove conclusively that the values are correct. Without adequate knowledge of the nature and properties of the individual compounds present, it is hardly possible to be certain of the validity and significance of estimations by different methods. Such information is also important for assessing the significance of the organic phosphorus fraction in relation to crop nutrition. Much importance is therefore being attached to developing work on the detailed qualitative examination of phosphate esters in soils. Chromatographic techniques are proving very useful for this purpose and positive identifications of certain esters in the phytate group have been obtained. Evidence of the presence of nucleic acids has also been obtained, and analytical procedures for quantitative estimation of specific forms are being studied. Investigations on inorganic phosphorus have also been continued. The Section of the Department of Plant Physiology for Radioactive Studies has assisted in the estimation of exchangeable phosphate and in further work on the factors governing the solubility and retention of phosphate in different soil types, including a series of Krasnozem soil profiles from Eastern Australia.

Potassium Studies

Good progress has been made in an investigation of the potassium relationships of a selection of Scottish and South African soils. The laboratory work on this subject is being carried out in conjunction with pot experiments and covers (a) the distribution of various categories of potassium in soil profiles, surface soils and mechanical fractions, (b) the solubility and release of native fixed potassium, and (c) the conversion of added potassium into non-exchangeable forms. A selection of the soils has been examined by the Section for X-ray Studies with a view to relating their behaviour to the clay minerals present. The results in general show several marked contrasts depending on the soil parent material, particularly in relation to the extent of fixation of added potassium and the conditions under which it occurs. But the evidence at present available does not suggest that potassium fixation is likely to be of much practical importance in any of the soils which have been examined.

Manganese

Cases of manganese deficiency in oats continue to appear in the advisory work and some comparisons of laboratory extraction methods have been made. Except possibly for quinol treatment followed by calcium nitrate extraction, the relatively simple determination of exchangeable manganese by means of ammonium acetate appears to give at least as useful results as the more elaborate methods such as ammonium acetate and hydrosulphite or ammonium acetate and quinol.

STATISTICAL WORK

All the field experiments are designed according to modern statistical requirements and the results are evaluated by statistical methods. Increasing use of the statistical approach is also being made to correlate the results of field, pot and laboratory work. The analyses carried out during the year include an examination of the results of the co-operative grassland experiments organized by the Grassland Sub-Committee of the Scottish Agricultural Improvement Council.

ADVISORY WORK

Over 10,000 soil samples, most of which were received through the staff of the North of Scotland College of Agriculture, have been tested during the year. As in the past, special problems concerning crop growth and animal health have been dealt with in collaboration with the Departments of Spectrochemistry and Plant Physiology. Numerous samples of calcareous sands, limestones, and other materials of potential agricultural value, have also been examined, and analyses of soil samples from forest nurseries have been continued.

The results recorded for advisory soil samples continue to emphasize the widespread need for lime and fertilizers on agricultural land. Samples from gardens and intensively cultivated horticultural areas, on the other hand, are generally well supplied with lime, phosphate and potash; indeed the contents, particularly in the case of lime, are often unnecessarily high. Detailed grouping of results for agricultural land in Aberdeenshire and Kincardineshire according to soil associations confirms the trends noted in last year's report, namely, lime and phosphate deficiencies are less pronounced in the Stonehaven and Laurencekirk Associations than on the others, while shortage of potash is least pronounced in these two and in the Cruden Association.

PUBLICATIONS

(A) *Published during the year*—

1. The soils of the country round Banff, Huntly and Turriff (Sheets 86 and 96). By R. Glentworth. (*Memoirs of the Soil Survey of Great Britain*: *Scotland*. 1954. pp. 169. With Soil Maps of Sheets 86 and 96. H.M.S.O., 17/6).

   The report deals with an area of 560 square miles in north-east Scotland, in which the soil series of 16 soil associations are described. A comprehensive account is given of the system of classification used and the morphology and genesis of the soils, together with an extensive section on the discussion of the chemical properties of the soils. Some of the topics dealt with are physical features, climate and post-glacial climate, vegetation, geology (solid and glacial), soil survey methods and definitions, horizon nomenclature, mechanical composition and soil textural classes, topographical classes, agriculture and rating of the soils for agricultural use, forestry. An appendix contains reference to analytical methods, chemical analyses and clay mineral composition of representative soil profiles. A glossary and index of place names is given.

2. Oriented aggregate specimens of clay for X-ray analysis made by pressure. By W. A. Mitchell. (*Clay Min. Bull.*, **2**, 76-78, 1953).

   The preparation of oriented aggregates of clay for X-ray analysis has in the past been carried out by evaporating a suspension of the clay in water. This causes the plate-shaped crystals to settle horizontally. Similar orientation can be produced by squeezing dry clay between two flat polished surfaces. This greatly reduces the time necessary for specimen preparation, and good orientation of the clay minerals is obtained even in the presence of considerable quantities of non-platy minerals such as quartz or felspar.

3. An investigation into the caking of granular fertilizers. By W. A. Mitchell. (*J. Sci. Fd. Agric.*, **5**, 455-456, 1954).

   Compound granular fertilizers frequently cake during storage, making even distribution difficult. An investigation into this problem by X-ray, crystallographic, and optical methods showed that interaction occurred between the ingredients during manufacture, with the formation of ammonium chloride from ammonium sulphate and potassium chloride. During drying, the ammonium chloride is concentrated at the surface of the granules by sublimation. Small needle-shaped crystals of ammonium chloride grow outwards from the granules in the presence of moisture, and this crystallization is the cause of caking. To prevent caking, thorough drying is necessary, but high temperatures should be avoided as they would increase the surface concentration of ammonium chloride by sublimation.

4. Mineralogy of kaolin clays from Pugu, Tanganyika. By R. H. S. Robertson (Glasgow), G. W. Brindley (Pennsylvania State College) and R. C. Mackenzie. (*Amer. Min.*, **39**, 118-139, 1954).

   Kaolin clays from Pugu, Tanganyika, have been studied by X-ray, thermal, chemical, and electron-optical methods. They included deposits of well-crystallized kaolinite and also of the *b*-axis disordered kaolin mineral. The latter give exceptionally clear X-ray diagrams which have been studied in greater detail than has previously been possible. The differential thermal analysis curves of all samples were also analysed in detail. Morphologically the disordered kaolin shows small but well-formed hexagonal plates. The cation-exchange capacities have been measured and appear to be related to substitutions in both tetrahedral and octahedral positions. The main chemical difference between the ordered and disordered clays appears to lie in the amount of tetrahedral substitution.

5. Standardisation of differential thermal analysis technique. By R. C. Mackenzie and K. R. Farquharson. (*C.R. XIX Session Congr. Geol. Int., Alger, 1952*, **18**, 183-200, 1953).

Samples of "standard" minerals were distributed under the auspices of the International D.T.A. Sub-Committee of C.I.P.E.A. to various laboratories all over the world, with the request that curves for these should be returned for correlation. A considerable number of results are now available and a partial correlation has become possible. The magnitude of the variations in peak temperatures, the effect of correction of the peak temperature to the temperature of the sample at the peak, and various other related factors are discussed and some suggestions are made for standardization.

6. Los minerales de la arcilla: su identificacion y relaciones con la ciencia del suelo. By R. C. Mackenzie. (*An. Edafol. Fis. veg.*, **13**, 111-139, 1954).

This paper contains the substance of three lectures delivered at the Consejo Superior de Investigaciones Cientificas, Madrid, in September 1952. In the first part, a brief general description is given of the mineralogy of clays; in the second, the minerals which may occur in clays are discussed, special attention being paid to the classification and nomenclature of the mica group; in the third, clay mineralogy is discussed in relationship to soil science, with special reference to the use of differential thermal analysis and its application to the study of Scottish soil clays.

7. Free iron-oxide removal from soils. By R. C. Mackenzie. (*J. Soil Sci.*, **5**, 167-172, 1954).

A completely inorganic technique very convenient for routine determinations of the amount of free iron oxide in soils is described. Two modifications of the method were tested, and that eventually chosen is compared with other available methods, especially as regards its efficiency in removing both Fe_2O_3 and Al_2O_3.

8 The removal of free iron oxide from clays. By B. D. Mitchell and R. C. Mackenzie. (*Soil Sci.*, **77**, 173-184, 1954).

The sodium hydrosulphite ($Na_2S_2O_4$) method of bleaching clays has been adapted to give a completely inorganic procedure (using a centrifuge technique), for removing free iron oxides from soil clays. Details of the method are given, and the effects of various factors, such as pH and temperature, on the efficiency of iron removal and on the crystal lattice of the clay minerals are reported upon. The method is compared with others, and various aspects of the technique are discussed.

9. The effect of oxygen on the growth and metabolism of the aerobic thermophilic actinomycete *Micromonospora vulgaris*. By D. M. Webley. (*J. gen. Microbiol.*, **11**, 114-122, 1954).

In the presence of pure oxygen at one atmosphere pressure *Micromonospora vulgaris* is unable to form in liquid media a surface pellicle of growth-bearing aerial mycelium. The production of bottom growth is either unaffected or stimulated by oxygen. Vegetative mycelium which develops from spores in Warburg vessels has an oxygen uptake that is similar in the presence of air or oxygen. Aerial mycelium, harvested from growths in air, shows marked differences as regards oxygen uptake in the presence of air or oxygen; oxygen is inhibitory. Some evidence is presented to show that the effect of oxygen may be connected with the inactivation of essential –SH groups of thiol enzymes.

10. An investigation into the growth promoting effects of a lignite. By P. C. de Kock and E. L. Strmecki. (*Physiol. Plant.*, **7**, 503-512, 1954).

It is shown that mustard grown in water culture responds markedly to small additions of lignite. Lignite was fractionated into substances soluble in 3 per cent. hydrochloric acid and organic residues soluble in sodium oxalate and precipitated by acid (humic acids). While neither fraction had a marked effect alone, the two together stimulated growth of mustard in water culture very markedly. Stimulation was considered to be due to the complexing action of the humic acid on the iron in solution rather than to any trace elements contained in the lignite. A comparison is made between the growth promoting action of humic acids (natural and synthetic) and ethylene diamine tetra-acetic acid. The ability to form a metallo-organic complex, probably rendering the iron in the nutrient medium more available, appears to determine the growth promoting response. From the results it would appear that the relative amounts of iron and phosphorus absorbed by the plant determine whether the plant will show chlorotic symptoms or appear healthy.

11. The relationship between nickel toxicity and iron supply. By W. M. Crooke, J. G. Hunter and O. Vergnano. (*Ann. appl. Biol.*, **41**, 311-324, 1954).

The influence of varying levels of iron and substrate pH on the uptake of nickel and the intensity of toxicity symptoms in oat plants have been investigated using sand- and water-culture techniques. Nickel toxicity symptoms are less severe when the concentration of iron in the nutrient solution is high. Reduction in degree of necrosis is related to a reduced content of nickel in the leaf blades and of chlorosis to the Ni/Fe ratio in the leaf blades—an internal antagonism being indicated in the latter case. A reciprocal relationship exists between nickel and iron contents of the leaf blades; the nickel content is materially reduced by high concentrations of iron in the nutrient solution, and the iron content by nickel. the former being the more pronounced effect. Uptake of nickel increases with increasing pH for a constant iron level in the substrate, although the degree of necrotic symptoms is similar over pH range 4-7. Iron uptake is reduced by both nickel and increasing pH and results in chlorosis at pH values of 5.5 and above. For a constant level of iron supply, the phosphate content of the stem extracts is higher the greater the degree of nickel toxicity; the phosphorus status of the plant may be a factor in producing nickel toxicity but if so, it has to be considered in relation to other factors.

12. The effect of nickel versenate on oat plants. By W. M. Crooke. (*Nature*, **173**, 403, 1954).

Iron complexed by ethylenediamine tetra-acetic acid is still freely available to plants but it is found that nickel so complexed no longer exerts its toxic action when supplied to oat plants in sand culture. Analysis shows that their nickel content does not significantly differ from that of the control plants. It would appear that the complex molecule is not absorbed by the plant nor can the plant remove nickel from the complex at the roof surface.

13. Trace element toxicities in oat plants. By J. G. Hunter and O. Vergnano. (*Ann. appl. Biol.*, **40**, 761-777, 1953).

Excessive amounts of nickel, cobalt, chromium, copper, zinc, manganese, molybdenum and aluminium in nutrient solutions supplied to oat plants in sand culture produce (a) chlorosis and (b) other symptoms specific to the elements involved. The specific symptoms are distinct for each metal, although those of cobalt and nickel might be confused. The toxic effects of Ni, Co, Cu, Zn, Mn and Mo are associated with high concentrations of the element in the leaf tissue, but this is not always so with Cr and Al. The toxic effects of Ni, Cr, Cu and Mo are associated with a reduced nitrogen content of the plant. Ni, Co, Cr, Zn and Mn increase the concentration of phosphorus in the tissue whilst Al decreases it, probably to a deficiency level. Al reduces the intensity of toxic symptoms produced by Ni—probably by reducing the uptake of nickel and phosphorus. Cu effectively reduces the leaf necrosis produced by Ni, but not the Ni content of the leaf tissue; it is suggested that one factor in nickel toxicity may be inhibition of one or more functions of copper. The other elements slightly increase chlorosis and some increase necrosis. The order of activity of the elements in producing chlorosis is found to be Ni>Cu>Co>Cr>Zn>Mo>Mn. This order, which is related to that giving yield reduction and is similar to the order of stability of metal complexes, is discussed in relation to induced iron deficiency.

14. Recent advances in fertilizer placement. I. Fertilizer placement for swedes and turnips in Scotland. By J. W. S. Reith. (*J. Sci. Fd. Agric.*, **5**, 421-428, 1954).

During 1947-52 over 40 field experiments were carried out to compare broadcast and band applications of sulphate of ammonia, superphosphate, muriate of potash, 40 per cent. potash salts and two granular NPK fertilizers. Placement positions at distances up to 3 inches to the side of the row and up to 3·5 inches below the soil surface were examined by using a special drill machine developed by the National Institute of Agricultural Engineering. Placing superphosphate directly below the seed at a depth of about 3-3·5 inches from the soil surface has consistently given higher yields than placing it in other positions or broadcasting. The results show that there is no advantage in placing sulphate of ammonia, and that placing it directly below the seed may be harmful to early growth. There is no benefit or disadvantage from placing muriate of potash (60 per cent. of K_2O), but with 40 per cent. potash salts broadcasting is likely to be better than placing below the seed. With NPK fertilizer mixtures there does not appear to be any benefit from placing, but this seems to be due to the positive effect from superphosphate being counterbalanced by the negative effect from a mixture of nitrogen and potash.

(*B*) *Submitted for publication*—

15. The effect of soil-forming factors over an area in the south of Scotland. By J. W. Muir. (To appear in *J. Soil Sci.*).

16. A review of the mineralogy of Scottish soil clays. By W. A. Mitchell. (To appear in *J. Soil Sci.*).

17. (Section on clay mineralogy). By W. A. Mitchell. (To appear in *Proc. Roy. Irish Acad.* in a paper by E. M. Patterson (University of St. Andrews) on the tertiary lava succession in the northern part of the Antrim plateau).

18. Study of the more important soils of the Zanzibar protectorate. By G. F. Walker and W. E. Calton. (To appear in *J. Soil Sci.*).

19. Comparative study of nickel and porous alumina specimen holders for thermal analysis. By R. C. Mackenzie. (To appear in *Nature*).

20. Spectrochemical analysis of plant material. By R. L. Mitchell. (To appear in *Proc. VIII Int. Congr. Botany, Paris*, 1954: *Symposium on Plant Analysis*).

21. Trace elements. By R. L. Mitchell. (To appear in *American Chemical Society Monograph*: *The Chemistry of Soils*).

22. Trace elements in Scottish peats. By R. L. Mitchell. (To appear in *Proc. Int. Peat Symposium, Dublin*, 1954).

23. Dental depigmentation and lowered iron in the incisor teeth of rats deficient in vitamin A or E. By T. Moore (University of Cambridge) and R. L. Mitchell. (To appear in *Brit. J. Nutr.*).

24. The trace element content of soils. By D. J. Swaine. (To appear as *Technical Communication, Commonwealth Bureau of Soil Science*).

25. The utilization of p-hydroxybenzaldehyde, ferulic acid, syringaldehyde and vanillin by soil fungi. By M. E. K. Henderson and V. C. Farmer. (To appear in *J. gen. Microbiol*).

26. Data for the study of post-glacial history of Scottish peats. Pt. I. By S. E. Durno. (To appear in *New Phytol.*).

27. Classification and nomenclature of peat and peat deposits. By G. K. Fraser. (To appear in *Proc. Int. Peat Symposium, Dublin*, 1954).

28. Soil humus. By G. K. Fraser. (To appear in *American Chemical Society Monograph*: *The Chemistry of Soils*).

29. Data for the study of post-glacial history of Scottish peats. By G. K. Fraser and H. Godwin (University of Cambridge). (To appear in *New Phytol.*).

30. Morphology of *Nocardia opaca*. By D. M. Webley. (To appear in *J. gen. Microbiol.*).

31. Profile development in the sand dunes of the Culbin Forest, Morayshire. By T. W. Wright. (To appear in *J. Soil Sci.*).

32. Soil moisture determination by neutron scattering. By A. H. Knight and T. W. Wright. (To appear in *Proc. II. Radioisotope Conf., Oxford*, 1954).

33. Relationship between nickel toxicity and major nutrient supply. By W. M. Crooke and R. H. E. Inkson. (To appear in *Plant and Soil*).

34. Iron nutrition of plants at high pH. By P. C. de Kock. (To appear in *Soil Sci.*).

35. Cereal responses to fertilizers. By J. W. S. Reith. (To appear in *Scot. Agric.*).

36. Effects of calcic and magnesium liming materials on the calcium and magnesium contents of crops. By J. W. S. Reith. (To appear in *Emp. J. exp. Agric.*).

37. Observations on the determination of total organic phosphorus in soils. By W. M. H. Saunders and E. G. Williams. (To appear in *J. Soil Sci.*).

APPENDIX

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

NORTH-EAST SCOTLAND

Aberdeenshire (Geological Survey Sheet 76)

ASSOCIATIONS

COUNTESSWELLS ASSOCIATION

Distribution . .	The general area stretching westwards from the Loch of Skene through Lumphanan to Coull.
Parent Material . .	Granitic and gneissic boulder clay.
Dominant Series .	Freely drained.

Profile

As described in Annual Report 1950-51

Topography . .	Gently rolling to hilly.

TARVES ASSOCIATION

Distribution . .	The general area stretching northwards from Corse Hill through the Howe of Alford to the Tulynessle-Forbes area and an area stretching southwards from the vicinity of Glaschul Hill.
Parent Material . .	Boulder clay derived from acid and basic-igneous and metamorphic rocks.
Dominant Series .	Imperfectly to poorly drained.

Profile

As described in Annual Report 1949-50

Topography . .	Gently rolling to hilly.

FOUDLAND ASSOCIATION

Distribution . .	The high ground west of a general line from Clova to Towie and the high ground between Tullynessle and Leslie.
Parent Material . .	Till derived mainly from andalusite schist and schistose grits.
Dominant Series .	Freely drained.

Profile

As described in Annual Report 1950-51

Topography . .	Hilly.

Insch Association

Distribution . . Small isolated areas on the south-east side and on the west side of Migvie; a narrow strip following the line of the Gadie Burn on the west side of Leslie village.

Parent Material . . Till derived from basic igneous rocks.

Dominant Series . Free to imperfectly drained.

Profile

As described in Annual Report 1949-50.

Topography . . Gently sloping to undulating.

Leslie Association

Distribution . . A strip running westwards from the vicinity of Leslie village to Drumgowan Farm; small isolated patches in the Leslie area.

Parent Material . . Till derived mainly from serpentine rock.

Dominant Series . Free to imperfectly drained.

Profile

As described in Annual Report 1949-50

Topography . . Gently to moderately rolling.

Boyndie Association

Distribution . . Isolated small areas around the Loch of Skene and in the south-west by Black Moss.

Parent Material . . Fluvioglacial sand.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1949-50

Topography . . Flat to very gently sloping.

Corby Association

Distribution . . Fairly extensive spreads surrounding and to the north of Loch Davan; an area to the south-west of Lumsden.

Parent Material . . Water-sorted and morainic gravel.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1949-50

Topography . . Moundy.

Mossat Association

Distribution . . Isolated patches in the Lumsden-Kildrummy area. A small area on the south side of Towie.

Parent Material . . Till derived mainly from Sandstone and conglomerate of Old Red Sandstone age.

Dominant Series . Freely to imperfectly drained.

Profile

Horizon	*Depth*	
S	0-7 in.	Brown heavy loam; good crumb structure; moist with no mottling. Merges over 2 inches into
B_2	7-17 in.	Red-brown sandy clay loam; cloddy crumb structure; moist; faint rusty mottling towards bottom of the horizon. Fairly sharp change into
C	17-32 in.	Pale red-brown loamy coarse sand; single grain structure; moist with some grey and rusty mottling.

Topography . . Gently to moderately rolling.

ALLUVIUM

Distribution . . Along the line of the River Don in the vicinity of Alford, along the Tarland Burn between Tarland and Coull and along the Kinnernie Burn from Burnseat Farm to Dunecht. Also in the basin of the Gormack Burn, south of Garlogie.

BASIN PEAT

Distribution . . At the Moss of Air, Leuchar Moss and Quartains Moss on the south side of the Loch of Skene, and in the reclaimed Loch of Auchlossan, south of Lumphanan.

EAST SCOTLAND

Angus (Geological Survey Sheet 57)

ASSOCIATIONS

AUCHINBLAE ASSOCIATION

Distribution . . Occasional mounds along the southern margin of Sheet 57, between Dilty Moss and Haystoun Hill.

Parent Material . . Red fluvioglacial sand and gravel.

Dominant Series . Freely and imperfectly drained.

Profile

As described in Annual Report 1950-51

Topography . . Moundy.

CORBY ASSOCIATION

Distribution . . A narrow strip about three miles long between Balgavie Loch and Friockheim. Limited areas on the north and south banks of the river South Esk just west of Brechin. A small area adjoining the north-west outskirts of Arbroath.

Parent Material . . Fluvioglacial gravels.
Dominant Series . Freely drained.

Profile

As described in Annual Report 1950-51

Topography . . Moundy and gently sloping.

BALROWNIE ASSOCIATION

Distribution . . Occurs generally throughout the areas mapped where other associations have not been delineated.

Parent Material . . Red fluvioglacially modified till material or till of sandy loam to loam texture.

Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1950-51

Topography . . Either gently undulating or irregular hilly country with generally low angle slopes.

TURIN ASSOCIATION

Distribution . . Limited areas on Bractullo Moor and Fotheringham Hill.

Parent Material . . Till derived mainly from flaggy and shaly beds of Lower Old Red Sandstone age.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1952-53

Topography . . Hilly.

DRUMGLEY ASSOCIATION

Distribution . . A fair number of localised patches scattered throughout the area. Individually they do not usually exceed one square mile in extent.

Parent Material . . Light textured fluvioglacially modified red till material; rather variable.

Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1952-53

Topography . . Gently sloping.

DEAN ASSOCIATION

Distribution . . A small area adjoining the Corby Association west of Friockheim.

Parent Material . . Light textured morainic material of mixed origin.
Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1952-53

Topography . . Moundy or gently sloping.

ALLUVIUM

Distribution . . The lower terraces of the River South Esk west of Brechin, and about the upper reaches of the Lunan Water and its tributaries between Letham and Friockheim. Scattered patches of lacustrine alluvium occur throughout the areas mapped.

PEAT

Distribution . . The largest individual occurrence of basin peat is that of Dilty Moss; there are a number of other minor patches, some associated with areas of lacustrine alluvium.

SOUTH-EAST SCOTLAND

Berwickshire, Midlothian, Peeblesshire, Roxburghshire and Selkirkshire
(Geological Survey Sheets 25 and 26)

ASSOCIATIONS

The following changes have been made in association nomenclature.

New Association Name	*Old Association Name*
Carter	Martinlee
Darleith*	Windburgh
Ettrick	Hindhope
Hobkirk	Bowmont

**This is identical with the Darleith Association of south-west Scotland*

Ettrick Association

(*a*)

Distribution . . South of a line from Yarrow, through Galashiels and Melrose, to St. Boswells.

Parent Material . . Till derived from Silurian greywackes and shales.

Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1951-52 (Hindhope)

Topography . . Hilly.

(*b*)

Distribution . . Within the quadrilateral area between Galashiels, Lindean, Bowden and Earlston.

Parent Material . . Till derived from Silurian red greywackes and red shales.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
A_0L	½ in.	Grass litter.
A_1	0-10 in.	Red clay loam; nutty. Merging into
B_2	10-20 in.	Dark red clay loam; nutty; abundant angular dark red greywacke stones. Merging quickly into
C	20 in. +	Purplish red very stony rubble.

Topography . . Rolling to hilly.

HOBKIRK ASSOCIATION

Distribution . . South of the Tweed between Maxton and Roxburgh.

Parent Material . . Till derived from Upper Old Red Sandstone marls and sandstones.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1950-51 (Bowmont)

Topography . . Broadly rolling.

WHITSOME ASSOCIATION

Distribution . . Between the Tweed and the Kelso-Berwick road and around Whitsome, Hutton and Paxton.

Parent Material . . Till derived from a mixture of Lower Carboniferous sandstones and shales, and basaltic lavas, Upper Old Red Sandstone marls and sandstones, and Silurian greywacke.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Dark brown clay loam; crumby. Sharp change into
B_2-G	9-18 in.	Reddish brown clay; cloddy; becoming redder with depth; faint ochreous mottling. Merging into
C-G	18 in. +	Reddish brown clay; cloddy; abundant rounded and sub-rounded stones; faint ochreous mottling and some very fine black mottles.

Topography . . Rolling.

ALLUVIUM

Distribution . . Spreads of recent alluvium occur along the River Tweed and its tributaries. Up to three alluvial terraces are found adjacent to the Tweed between Leaderfoot and St. Boswells; the highest terrace shows the most mature profile and is generally more stony than the lower ones. Scattered patches of lacustrine alluvium also occur throughout the area mapped.

SOUTH-WEST SCOTLAND

Ayrshire (Geological Survey Sheet 14)

ASSOCIATIONS

DARLEITH ASSOCIATION

Distribution . . The Carrick Hills and small areas at Greenan, Heads of Ayr, and Mochrum Hill.
Parent Material . . Thin till derived from mainly basic lavas.
Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Brown loam to silt loam: crumb structure; stony. Merging into
A_1	8-14 in.	Lighter brown, gritty loam; very stony. Merging into
C		Weathering and shattered basalt.

Topography . . Hilly, with frequent irregular outcrops.

DREGHORN ASSOCIATION

Distribution . . A small area between Doonfoot and Heads of Ayr.
Parent Material . . Raised beach deposits.
Dominant Series . Freely drained.

Profile

As described in Annual Report 1950-51

Topography . . Flat to gently undulating.

DARVEL ASSOCIATION

Distribution . . Scattered small areas in the vicinity of Maybole.
Parent Material . . Fluvioglacial sands and gravels.
Dominant Series . Freely drained.

Profile

As described in Annual Report 1951-52

Topography . . Hummocky.

GLENALMOND ASSOCIATION

Distribution . . A wide area south and east of the Carrick Hills to beyond Maybole.
Parent Material . . Till derived from sandstones of Lower Old Red Sandstone age.
Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Brown sandy loam to loam; weak cloddy structure; sharp change into

B_2	10-16 in.	Reddish brown loam; weak cloddy; slightly stony. Merging into
C	16-36 in.	Red loam to sandy clay loam till; compact; sandstone fragments common.

Topography . . . Undulating to moderately rolling.

MAYBOLE ASSOCIATION

Distribution . . . In the Maybole district and extending south-westward to Kirkoswald.

Parent Material . . . Moraine deposits, mainly of Old Red Sandstone origin.

Dominant Series . . . Freely drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Dark reddish brown loam; small cloddy to crumb structure. Fairly sharp change into
B_2	9-17 in.	Reddish brown gritty heavy loam; abundant platy, angular fragments and blocks of sandstone. Merging into
C	17-36 in.	Reddish brown heavy loam; abundant stones as above; loose; some manganese staining in upper part of the horizon.

Topography . . . Moundy.

LINKS

Distribution . . . A small area west of Greenan.

Profile

As described in Annual Report 1950-51

Topography . . . Gently undulating.

ALLUVIUM

Small spreads of recent alluvium occur throughout the area. Certain alluvial flats between Maybole, Dalrymple and Coylton appear to be related to the morainic deposits and are probably of late glacial origin.

PEAT

A few small areas of peat have been mapped in the Carrick Hills, the only one of note being at Red Moss.

SOIL HORIZON SYMBOLS USED BY THE SOIL SURVEY OF SCOTLAND

ELUVIAL HORIZONS		GLEYED ELUVIAL HORIZONS	
A	undifferentiated	A-G	gleyed A.
Subdivisions of Eluvial Horizons		*Subdivisions of Gleyed 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.	A_2-G	gleyed A_2.

ILLUVIAL HORIZONS		GLEYED ILLUVIAL HORIZONS	
B	undifferentiated	B-G	gleyed B.
Subdivisions of Illuvial Horizons		*Subdivisions of Gleyed Illuvial Horizons*	
B_1	iron pan, or humus concentration or both.		
B_2	diffuse deposition of sesquioxides or humus or both.	B_2-G	gleyed B_2.
B_3	indurated or compacted.	B_3-G	gleyed B_3.

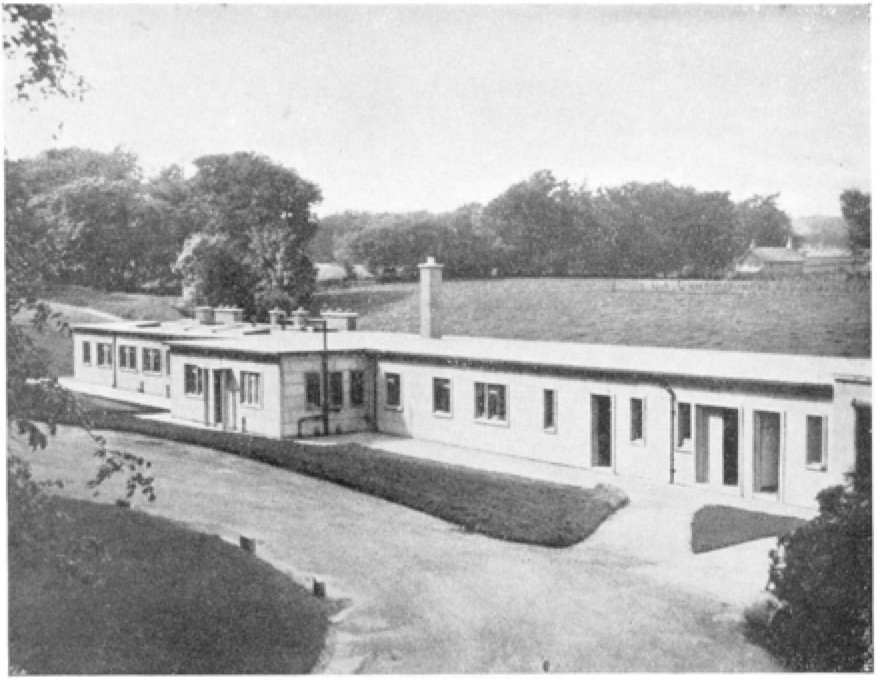
PARENT MATERIAL		GLEYED PARENT MATERIAL	
C	undifferentiated	C-G	gleyed C.

GLEY HORIZONS

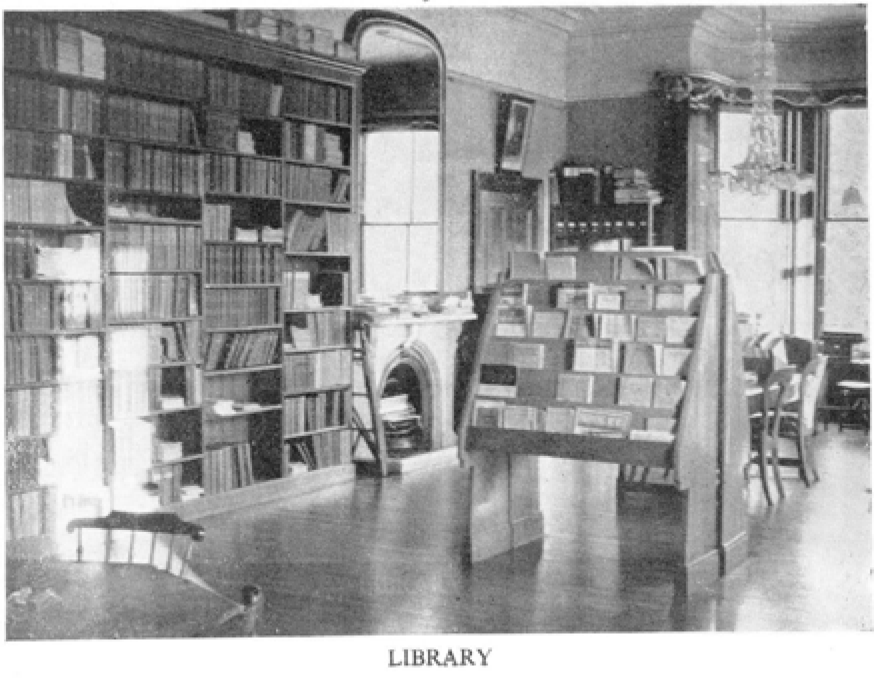
G undifferentiated

CULTIVATED HORIZONS

S undifferentiated



DEPARTMENT OF SOIL FERTILITY



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