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THE MACAULAY INSTITUTE FOR SOIL RESEARCH

FOUNDED 1930

ANNUAL REPORT 1951-1952

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THE MACAULAY INSTITUTE FOR SOIL RESEARCH

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CRAIGIEBUCKLER, ABERDEEN
(Founded 1930)

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*Appointed 1952 †Resigned 1952

POST-GRADUATE RESEARCH WORKERS

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

J. K. Coulter (Department of Agriculture, Kuala Lumpur, Malaya).

G. Fleming (Ministry of Agriculture, Johnstown Castle Soil Laboratory, Wexford, Ireland).

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

J. McAndrew (University of Melbourne, Australia).

C. W. Montgomery (Department of Soil and Land Use Survey, Aburi, Gold Coast).

R. P. Moss (Colonial Office, London).

J. Ramirez Muñoz (University of Madrid, Spain).

C. S. Read (McGill University, Montreal, Canada).

D. H. Romney (Colonial Office, London).

Susana M. de Salas (University of Buenos Aires, Argentina).

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

A. J. Smyth (Colonial Office, London).

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

Ornella Vergnano (University of Florence, Italy).

CONTENTS

INTRODUCTION

The maintenance and improvement of soil fertility continues to be the main objective of the work of the Institute. Collaboration is maintained with sister Research Institutes, the Colleges of Agriculture in Scotland, the Forestry Commission, and the Department of Agriculture for Scotland, and the Institute is widely recognized as a centre for post-graduate training in the various branches of soil research.

The Council of Management makes grateful acknowledgement to the Department of Agriculture for Scotland, to the Agricultural Research Council, and to the Forestry Commission for grants in aid of the work, and to other benefactors for generous support.

COUNCIL

It is with deep regret that the Council of Management records the death of Lt.-Col. Sir Garden B. Duff, Bart., D.S.O., which occurred at his home, Hatton Castle, Turriff, on 6th September, 1952. Sir Garden was appointed to the Council in 1948, as a representative of the North of Scotland College of Agriculture. He served on the Forest Soil and Finance Committees, and took a very real interest in the work and development of the Institute.

STAFF

(*a*) *Resignations*:

Department of Pedology—

Mr D. T. Davies, B.Sc. (Soil Survey Section), on appointment to the staff of the Hannah Dairy Research Institute.

Department of Spectrochemistry—

Dr I. W. M. A. Black.

Department of Soil Organic Matter—

Mr T. M. Forrester, B.Sc. (Microbiology Section).

Department of Plant Physiology—

Dr J. G. Hunter, on appointment as Director of Trelawney Tobacco Research Station, Southern Rhodesia.

(*b*) *Appointments*:

Department of Pedology—

Mr R. A. Jarvis, B.Sc. (Soil Survey Section).

Department of Spectrochemistry—

Dr D. J. Swaine.

Department of Soil Organic Matter—
Miss M. E. K. Henderson, B.Sc. (Microbiology Section).

Department of Plant Physiology—
Dr P. C. de Kock.

Department of Soil Fertility—
Dr G. Anderson.

At a meeting of the Biochemical Society held in London in October 1951, Dr R. I. Morrison read a paper reporting the isolation of L-pipecolinic acid from clover. Dr R. B. Duff presented a paper at an informal conference on carbohydrate chemistry held at Galway University College, Eire, in April 1952.

Dr R. C. Mackenzie visited Germany in October 1951 and April 1952 to read papers at the Goslar and Wiesbaden meetings of the Fachausschuss für Staubtechnick im Verein deutscher Ingenieure. In September 1952, he attended the XIX Session of the International Geological Congress in Algiers, and later went to Spain at the invitation of the Consejo Superior de Investigaciones Cientificas to deliver three lectures at the Instituto de Edafologia in Madrid.

Dr R. L. Mitchell attended the 15th Congress of the Groupement pour l'Avancement des Methodes Spectrographiques in Paris in June 1952, and at Birmingham in September 1952 he contributed a review paper to a Symposium of the Midlands Association of Analytical Chemistry. At the International Symposium on Spectroscopy held at Hoddesden, Herts, in September 1952 the Institute was represented by Dr Mitchell and Dr R. O. Scott.

Several members of staff were present at the joint meeting of Commissions II and IV of the International Society of Soil Science, held in Dublin in July 1952. Papers were read by Dr E. G. Williams and Dr J. W. S. Reith and by a visiting research worker, Dr L. H. P. Jones.

Dr A. B. Stewart was invited by the organizing Committee to be guest foreign speaker at a special symposium on soil and fertilizer phosphorus, sponsored by the National Soil and Fertilizer Research Committee in the United States, in collaboration with the American Society of Agronomy and the Soil Science Society of America, and held in the University of Illinois in August 1952. In a 9-week tour before and after the symposium, Dr Stewart had an opportunity of visiting the Land Grant Colleges and other agricultural research organizations in various parts of the country.

VISITORS

The increasing interest in the work of the Institute is evident from the large number of visitors welcomed during the year. Dr E. Alvsaker (Norway), Professor A. Irmak (Turkey), Professor W. L. Kubiena (Spain) and Dr Kellog (U.S.A.) were amongst the visitors who spent short periods at the Institute, whilst other representatives of research and experimental stations who visited the laboratories and had an opportunity of discussing problems with members of staff included workers from Australia, Belgian Congo, Canada, Denmark, France, Germany, Gold Coast, Greece, Malaya, Natal, New Zealand, Norway, Pakistan, Sudan, Turkey, South Africa, and the

United States. Several organized parties were also shown something of the activities of the Institute, notably members of the Society of Chemical Industry whose annual meeting was held in Aberdeen in July 1952.

POST-GRADUATE RESEARCH WORKERS

Research workers from many countries are taking advantage of the facilities provided for training in the methods of soil research and for post-graduate study, and the following workers were associated in the work of the Institute during the year.

Department of Pedology:

Soil Survey—

J. K. Coulter, Department of Agriculture, Kuala Lumpur, Malaya.
C. W. Montgomery, Department of Soil and Land Use Survey, Aburi, Gold Coast.
R. P. Moss, Colonial Office, London.
A. J. Smyth, Colonial Office, London.

Department of Spectrochemistry—

G. Fleming, Johnstown Castle Soil Laboratory, Wexford, Ireland.
J. McAndrew, University of Melbourne, Australia.
J. Ramirez Muñoz, University of Madrid, Spain.
Susana M. de Salas, University of Buenos Aires, Argentina.
D. J. Swaine, University of Melbourne, Australia.

Department of Soil Organic Matter—

C. S. Read, McGill University, Montreal, Canada.

Department of Plant Physiology—

Ornella Vergnano, University of Florence, Italy.

Department of Soil Fertility—

R. du T. Burger, Stellenbosch-Elsenburg College of Agriculture, Stellenbosch, South Africa.
L. H. P. Jones, University of Melbourne, Australia.
D. H. Romney, Colonial Office, London.
W. M. H. Saunders, Department of Scientific and Industrial Research, Wellington, New Zealand.

REPRESENTATION ON COMMITTEES

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

(1) *Agricultural Research Council*:

(*a*) Conference on Fertilizers.
(*b*) Conference on Mineral Deficiencies of Agricultural and Horticultural Crops.
(*c*) Group for Mineral Deficiencies and Excesses in Animals.
(*d*) Land Drainage Conference.
(*e*) Soil Survey Research Board.
(*f*) Bracken Conference.

(2) *Department of Agriculture for Scotland*:

(*a*) Hill Farm Research Committee and its Sub-Committees dealing with (i) Trace Elements and (ii) Heather.

(*b*) Scottish Agricultural Improvement Council.

(*c*) Field Trials Sub-Committee.

(*d*) Scottish Grassland Sub-Committee.

(*e*) Sugar Beet Sub-Committee.

(*f*) Consultative Committee for the Development of Spectrographic Work, and its Technical Sub-Committee.

(3) *Forestry Commission*:

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

(4) *Colonial Office*:

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

(5) *Secretary of State for Scotland*:

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

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

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

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

PUBLICATIONS

The third volume of "Collected Papers of the Macaulay Institute for Soil Research," covering the years 1948-1951, was issued in February 1952. The Council of Management of the Institute gratefully acknowledges the assistance received from The Carnegie Trust for the Universities of Scotland towards the publication of this volume.

The twenty-three scientific papers issued during the year under review are summarized in this report, and reprints can be obtained on application to the Librarian.

THESES

The following theses were accepted by the University of Aberdeen for the degree of Doctor of Philosophy.

1. An investigation of the mineral changes involved in the weathering of granites in the vicinity of Aberdeen. By Angela A. Milne.
2. The distribution of trace elements in soils. By Dalway J. Swaine.
3. Physiological aspects of the nickel-soil-plant relationship. By Ornella Vergnano.

PEDOLOGY

SOIL SURVEY (SCOTLAND)

The systematic soil survey of north-east, east, south-east and south-west Scotland has been continued on a scale of 2.5 inches to 1 mile on Sheet 95 (Morayshire), Sheets 66 and 57 (Kincardine and Angus), Sheet 17 (Roxburghshire) and Sheet 22 (North Ayrshire). An area of approximately 365 square miles has been mapped and 92 representative profiles have been collected.

The annual field meeting with the soil surveyors of England and Wales was arranged by the Soil Survey of Scotland and held at Edzell, Kincardineshire, from 20th to 25th April, 1952. It was attended by sixteen surveyors of the Soil Survey of England and Wales, eight Scottish surveyors, and sixteen visitors.

NORTH-EAST SCOTLAND

Morayshire (*Geological Survey Sheet* 95)

The mapping of the area between the rivers Spey and Lossie from the coast south to a line from Fochabers to Birnie has been completed and the survey extended westwards to a point on the coast three miles south-west of Burghead, and to the Hill of Monaughty on the southern margin of the sheet. To ensure continuity, small areas of the adjoining sheet to the south have also been mapped. Approximately 75 square miles have been surveyed.

The topography is dominated by a series of well-defined ridges running from north-east to south-west, approximately parallel to the coast. These become progressively higher to the south, from 200 feet at Clarkly Hill to over 700 feet on the Hill of Monaughty. The valleys between these ridges are in part alluvial, notably at Mosstowie and around Waterton where the once extensive Loch Spynie has been drained. The River Lossie, which has a wide flood plain both north and south of Elgin, is the only important river. In the low-lying parts drainage presents serious problems, and it has been necessary to resort to extensive systems of canals and ditches.

With the exception of a small area of gneiss and mica schist at Monaughty Wood, the underlying rocks are sandstones of Upper Old Red Sandstone and Permo-Triassic age. These vary considerably in grain size, colour and hardness. Till, derived mainly from the sandstones, appears to be fairly widespread over the area, but is for the most part covered by later deposits of fluvio-glacial sand and gravel or more recent alluvium. A cherty calcareous rock occupying a small area at New Elgin has no visible influence on the till. Dune sand and sand and shingle of raised beaches are also extensive, particularly at Lossiemouth and south-west of Burghead.

The soils of the area are in the main light-textured and freely drained with, under semi-natural conditions, a well-developed podzol profile. Soils of heavier texture occur on some of the lower ground where the drainage is

generally poor. These include calcareous gley soils and are of high agricultural value when the artificial drainage is adequate. Basin peat occurs in a few small patches throughout the areas of alluvium.

Mixed farming is the common practice in the district, with some emphasis on the raising and fattening of cattle. The favourable climate allows some wheat to be grown, but the main cereal crops are oats and barley, with rye restricted to the poorer light-textured soils. Cash crops include sugar beet and seed potatoes. Market gardening has increased in importance in recent years. A few large farms supply local milk demands. The average holding is approximately 150 acres.

State forests covering several square miles have been established at Monaughty, Quarrywood Hill and Roseisle, the last extending over the sand dunes and links south of Burghead.

The following soils have been distinguished in the area:

Associations

1. Boyndie *see* Annual Report 1950-51.
2. Corby *see* Annual Report 1950-51.
3. Hatton *see* Soil Survey Board Report No. 3, 1952.
4. Elgin New Association.
5. Duffus New Association.

Links

Alluvium

Skeletal Soils

Basin Peat

These soils are described in the appendix to this report.

EAST SCOTLAND

Angus (*Geological Survey Sheet* 57)

An area of about 80 square miles has been surveyed in Angus. Most of the ground covered lies between the River South Esk in the north and the Lunan Water in the south. The western boundary is formed by an irregular line running southwards from Brechin round the west side of Montreathmont Moor to Friockheim; the eastern boundary is formed by the coastline between Montrose and Lunan. A small area of about 3 square miles immediately north-west of Brechin, lying between Dun's Wood and Little Brechin, has also been mapped.

In May, surveying was suspended in the Angus area for several weeks owing to outbreaks of foot and mouth disease near Forfar and Brechin. During this period, some revision surveying over an area of 8 to 10 square miles was carried out in the foothills of the Grampians between Stonehaven and Strathfinella Hill (Sheet 66).

The area between the south side of the Montrose Basin and the Lunan Water is underlain by andesitic lava of Lower Old Red Sandstone age, as is everywhere apparent in the local topography from Rossie Moor eastwards; it frequently outcrops as glacially smoothed ridges. To the west and north,

the underlying strata are Lower Old Red Sandstone in which flaggy sandstone is locally predominant, and a more regular topographic pattern of major and minor undulations results.

Superficial deposits comprising red, water-sorted material and light-textured till cover a large part of the area; these merge into raised beach deposits along the coastal strip between Ferryden and Usan. From the western end of the Montrose tidal basin, there is a considerable inland extension of silty estuarine alluvium interspersed with some large localized occurrences of gravelly moraine. Another stretch of fluvioglacial gravel occurs around the upper reaches of the Lunan Water about Friockheim. Areas of recent alluvium are associated with the River South Esk, the Lunan Water, and their tributaries. There are a few minor occurrences of lacustrine alluvium throughout the area.

The soils of the area are predominantly of light to medium texture, red to reddish brown in colour, and imperfectly drained. Minor areas of freely drained soils are almost invariably associated with conditions of moderate slope and thin till underlain by rock. There is a moderately extensive area of poorly drained estuarine alluvium to the west of the Montrose Basin, otherwise poorly drained soils are of small extent and essentially confined to small hollows, lacustrine deposits and channels.

Most of the area is given over to arable farming with the exception of Montreathmont Moor (the western half of which has been extensively planted by the Forestry Commission), Rossie Moor and the much smaller Arbikie Moor. Farms are generally of moderate to large size, 250 to 500 acres being the usual range; smaller holdings of around 150 acres are not uncommon; one of 1,000 acres was noted. Many of the larger farms are combined holdings comprising two or three smaller units.

Crops regularly grown are oats, barley, wheat, turnips, potatoes, sugar-beet and mangels; a number of farms in the area specialize in raspberries and other soft fruit. Dairy farming is important throughout the area.

The following soils are found in this area:

Associations

1. Corby — *see* Annual Report 1950-51.
2. Balrownie — *see* Annual Report 1950-51.
3. Mountboy — New Association.
4. Usan — New Association.
5. Pow — New Association.

Alluvium

These soils are described in the appendix.

SOUTH-EAST SCOTLAND

Roxburghshire (*Geological Survey Sheet* 17)

Approximately 100 square miles have been surveyed this year in Roxburghshire and the south-east corner of Selkirkshire. The Ettrick Water from Ettrickbridge End to Selkirk forms the northern boundary of the area, which extends southwards as far as Mosspaul Inn and Cauldcleughhead. To the east of Hawick, the survey has been carried as far as Denholm in the north and Wauchope in the south.

Greywackes and shales of the Silurian Age underlie the greater part of the area, the smaller part to the east being underlain by rocks of the Upper Old Red Sandstone Age. Intrusions of trachyte, basalt and agglomerate are common. To the north, where the Silurian strata are isoclinally folded, the topography is rolling to hilly, with many outcrops of greywacke running from north-east to south-west across the slopes. To the south, where the folding is less intense, the topography is smooth, but more mountainous, often with steep slopes to the deeply cut stream and river valleys.

The area is drained by the Ettrick Water, the Teviot, and the Allan and Slitrig Waters and their tributaries, flowing in a northerly or north-easterly direction.

Glacial till, the composition of which is closely related to the nature of the underlying rock, covers most of the area, tending to become shallower and lighter in texture on the steeper slopes and hill tops. The Hindhope Association occupies most of the area mapped. It shows particularly good examples of the normal hydrologic sequence, and also of a new series—poorly drained with a raw humus surface horizon—which tends to become dominant on the hill ground above 900 feet. Small areas of lacustrine alluvium are common, and are often overlaid by peat on the higher ground. Recent alluvium is found to a fair extent along the courses of the larger rivers. Peat occurs most frequently on the higher hills where it is often hagged and eroded.

The main agricultural activity in this region is the breeding and rearing of sheep and, to a lesser extent, of hill cattle. Cropping, for the provision of winter keep, is mainly on the lower slopes and valley bottoms.

The following soils are found in this area:

Associations

1. Bowmont *see* Annual Report 1948-49.
2. Minto *see* Annual Report 1950-51.
3. Hindhope *see* Annual Report 1949-50.
4. Hawick *see* Annual Report 1950-51.

Skeletal Soils

Peat

These soils are described in the appendix.

SOUTH-WEST SCOTLAND

Ayrshire (*Geological Survey Sheet* 22)

The Ayrshire survey has this year covered approximately 125 square miles. In the north-west approximately 50 square miles have been mapped consisting of the Lowlands around the River Garnock from Dalry to Lochwinnoch and the Kilbirnie Hills. In the east, some 75 square miles have been surveyed from Eaglesham south through Darvel to the River Ayr.

The extensive uplands within the area are due mainly to basic and intermediate lavas and associated intrusions of the Calciferous Sandstone Age. In the north-west these form the steep, upstanding Kilbirnie Hills where the highest ground is found at Blacklaw, 1,525 feet. They also underlie the broad moorland area extending from the vicinity of Beith to Darvel. In this undulating tract the highest ground is in the east where Corse Hill and Drumduff Hill rise to 1,250 feet and 1,194 feet respectively. The granodiorite

intrusions of the Distinkhorn (1,258 feet) and Glen Garr (1,403 feet) with their aureole of baked Silurian sediments (Downtonian sandstone) build up the hilly ground between the upper reaches of the rivers Irvine and Ayr. Basalt lavas of the Millstone Grit Age form the low hills south of Dalry, and Old Red Sandstone and contemporaneous lavas the hilly ground immediately south of Newmilns and Darvel. A number of plugs and agglomerate-filled vents pierce the igneous rock cover, one of the most prominent being Loudoun Hill (1,034 feet), east of Darvel. Sedimentary rocks of the Carboniferous Limestone Series underlie the undulating low gravel along the River Garnock from Dalry to Lochwinnoch and to the north-east of Eaglesham.

The principal rivers in the area are the south-flowing Garnock and the west-flowing Irvine. The north-east is drained by the White Cart Water which flows northwards to the Clyde.

The average annual rainfall increases gradually from about 40 inches in the mid Irvine valley to about 70 inches in the Kilbirnie Hills. The effects of altitude on temperature are greatly modified by cloud cover and by the influence of the sea.

The high land in the north and north-west is comparatively free of drift, the ground being irregular and studded with rock outcrops, but the greater part of the area surveyed has a deep covering of glacial till.

South-west of Eaglesham, in the neighbourhood of Dunwan Dam, is a small area of hummocky ground moraine. Extensive spreads of fluvioglacial sands and gravels exist around Darvel and south of Eaglesham, giving rise to hummocky and moundy relief.

Most of the soils mapped are derived from clay or sandy clay tills. On the low ground, imperfectly and poorly drained soils predominate. The topography and climate of the high ground favour humus accumulation and here peaty gley soils are common. Very large areas of deep peat cover the high moorlands in the east and south-east.

Dairy farming is the main activity of the district surveyed, with sheep farming common on the higher ground where soil is thin, rainfall high, and pastures poorer.

The following soils are found in this area:

Associations

1. Ashgrove	*see* Annual Report 1950-51.
2. Darleith	*see* Annual Report 1950-51.
3. Kilmarnock	*see* Annual Report 1950-51.
4. Glenmount	*see* Annual Report 1950-51.
5. Amlaird	*see* Annual Report 1950-51.
6. Bargour	*see* Annual Report 1950-51.
7. Lanfine	New Association.
8. Darvel	New Association.
9. Blackside	New Association.
10. Distinkhorn	New Association.
11. Highfield	New Association.
12. Kirktonmoor	New Association.

Peat

These soils are described in the appendix.

HEATHER SURVEY

Observations begun in 1951 have been continued and extended. In addition, detailed examination of representative hill grazings in the north-east of Scotland has been carried out. Particular attention has been paid to

(*a*) the proportion of heather to other species.

(*b*) the growth form of the heather plants.

(*c*) the ability of the heather to regenerate from seed or stool after burning, and the course of seral development.

By correlating this information with soil, climate and biotic factors and taking into account variations in management practices, it is hoped to establish a sound basis for the classification of heather communities.

As an adjunct to the survey, experimental sites have been selected in east and west Scotland where detailed investigation of regeneration on contrasting types of Callunetum is in progress.

Visits were paid to various centres in Scotland, England and Wales where manurial top-dressing trials are being carried out on hill land.

Plants collected in the course of the heather survey have been incorporated in a herbarium which is being formed in association with the Department of Soil Organic Matter.

SPECIAL SURVEYS

1. A textural survey of sugar-beet fields in Fifeshire affected with "strangles" was made at the request of the Sugar Beet Research and Education Committee (Scottish Sub-Committee). Forty-three farms were visited. Mechanical analyses were made of 46 samples collected.
2. Samples were collected and examined in connection with studies of the breeding grounds of the midge (*Culicoides*) being made in the Department of Zoology, University of Edinburgh.
3. A collection of soil monoliths was made in collaboration with the Forestry Commission for exhibition at the Royal Highland Show, Kelso.

MAPS AND REPORTS

Colour proof copies of Soil Survey Sheets 86 (Huntly) and 96 (Banff) have been twice checked and the final printing is now awaited. The accompanying memoir is well advanced.

The colour proof of Sheet 97 (Fraserburgh) is expected shortly. It has not been possible to complete the mapping of Sheet 66 (Laurencekirk).

The mapping of Sheet 95 (Elgin) is nearing completion.

LABORATORY INVESTIGATIONS AND COLLABORATIVE WORK

Studies on the hydrologic sequence of soils covering (i) fractionation of the phosphate content and (ii) methods of investigating free sesquioxides have been completed. Work is continuing on (iii) the pore-space distribution, (iv) moisture equivalent determinations and (v) mineralogical studies of the fine sand fraction. Various techniques for making thin sections of soils have been tried. The collection of rock specimens characteristic of soil associations has been augmented, and herbarium specimens have also been collected.

Collaboration with various departments of the Institute, with the three Scottish Colleges of Agriculture, and with the Departments of Geography, Geology, Botany and Soils of the University of Aberdeen, has been continued.

A considerable number of overseas visitors, including Dr Kellog and Dr Guy D. Smith, U.S.D.A., Beltsville, Maryland, and Professor Kubiena, Spain, have been shown soils in various parts of Scotland; five of the visitors spent periods of one week or more with survey parties.

Three Colonial Service students spent periods of from one to six months with the soil survey and two Colonial Service officials undertook study leave for periods of six months and three weeks respectively. Assistance has been given to two overseas research students in collecting representative soils for study.

ANALYTICAL SECTION

Routine analyses of the soil samples taken by the Soil Survey Section during 1950 have been completed. During 1951 some 630 samples, representing 123 profiles, were taken by the soil surveyors and on these pH and exchangeable hydrogen determinations have been completed. Moisture, loss on ignition, mechanical analyses. exchangeable cation, total and readily soluble phosphate, carbon and nitrogen determinations, have been completed on approximately half these samples.

Clay analyses and free sesquioxide determinations have been continued on selected profiles from established soil associations in the north-east of Scotland.

Preliminary investigations on a method for determining exchangeable aluminium in soils have been carried out.

In addition the following samples were examined:

(*a*) Breeding grounds of midge	19
(*b*) Serpentine soils	3
(*c*) Seven soil profiles on behalf of the Department of Botany, University of Aberdeen	25
(*d*) Sugar beet areas	46
(*e*) Water samples	3
(*f*) Chloride determinations	11

SOIL GEOLOGY AND MINERALOGY

The field examinations of soils was continued to study the nature of the glacial drift deposits and to determine their lithological characters.

The study of the mineralogy of the matrix of these drifts by microscopic examination of their fine sand fractions was carried out in order to further characterize them and to form them into parent material groups. The mineralogy of the soils developed on these parent materials was similarly investigated.

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

South Scotland

The field examination of farms in Selkirkshire in connection with a sheep pining investigation was carried on, and an area in Peeblesshire was also

visited. The main areas inspected lie in the upper valley of the Yarrow and adjoining waters and are underlain by shale, sandstone and greywacke rocks of Silurian age. The higher hill ground on slopes is generally thin and stony with many rock outcrops, but on the flatter tops the ground is generally peaty. The lower ground is mainly covered by a tough, compact till formed from the local rocks and the soils developed on it are gleys or peaty gleys. Samples of soils were collected for laboratory examination to assist in determining areas for further experimental work in this district.

West Scotland

The survey begun last year of the soils and their parent materials of various farms situated in the Campsie, Fintry and Kilsyth Hills, Stirlingshire, in connection with a joint investigation with the Animal Diseases Research Association, Edinburgh, was extended. Samples of soil and herbage from typical areas were collected for further laboratory investigation. The new areas visited have similar geological features in that the underlying rocks were found to consist of shales, cementstone, and limestone, together with basalt, tuff and dolerite. Peat of varying depths is common on the flat tops of the hills, but the soils on the slopes are thin and residual, generally on the igneous rocks. The lower ground, where the sedimentary rocks occur, is covered in part by boulder clay containing an admixture of the local sedimentary and igneous rocks.

X-RAY INVESTIGATIONS

The study of the clay fractions of Scottish soils has been continued. Illite is the predominating clay mineral in about 60 per cent. of the profiles examined, kaolinite in about 20 per cent., and vermiculite and montmorillonite in the remainder.

A representative selection of forest soils in Turkey was examined. The clay fractions of these were separated by Professor Irmak (Istanbul) who visited the Institute to study the methods used in clay mineral identification. The soils covered a wide range of parent material and climatic conditions and their clay mineralogy showed marked differences. Soils on basic rocks, represented by basalt and diabase, had montmorillonite as their predominating clay mineral. On diorite vermiculite was formed, while one granite soil clay contained 75 per cent. kaolinite. A limestone soil of the black earth type was characterized by illite.

Some Norwegian soils were examined, including one with a pH of 3.7 derived from alum shale. This contained illite and boehmite. Another, from a basin area with a very low rainfall, had a high concentration of soluble salts, including potassium chloride and potassium sulphate, and a pH of 9.5. The other Norwegian soil clays examined showed no abnormalities, illite being the commonest clay mineral.

The clay fraction from boulder clay samples taken from below a deep peat at Alt-na-Breac in Caithness contained illite, kaolinite and vermiculite.

The accuracy of quantitative determinations of clay minerals has been increased by using potassium chloride as an internal standard. Powder photographs of clay with 5 per cent. potassium chloride are compared with

photographs of standard mixtures with varying ratios of potassium chloride and pure clay minerals.

In co-operation with the Physico-Chemical Section, samples of nontronite from various localities were examined. Electron micrographs showed that these had different crystal habits, but the X-ray powder patterns were identical. Quartz, cristobalite and tridymite were identified as impurities.

The study of the weathering of Aberdeenshire granites has been continued, and a thesis on this subject by Miss A. A. Milne has been accepted by the University of Aberdeen for the degree of Doctor of Philosophy. Three types of weathering are recognized:

(1) Under peat the biotite is decomposed while the felspars are little affected. No iron hydroxides accumulate.

(2) With hydrothermal weathering the felspars alone are altered with the formation of illite.

(3) Under normal subaerial weathering both felspars and biotite are attacked, illite, kaolinite and iron hydroxides being formed.

It was found that different felspars weather at different rates, orthoclase being most, and microcline least easily attacked. The plagioclases occupy an intermediate position in this weathering series, the calcic types weathering more easily than the sodic types.

A new type of cathode made of ceramic material has been fitted in the Hilger X-Ray Apparatus and has greatly improved its reliability and stability. One more 9 cm. powder camera has been calibrated and three such cameras are now in constant use. An optical microscope has been added to the laboratory equipment.

A paper on the unidimensional Fourier synthesis of vermiculite has been published.[3]

PHYSICO-CHEMICAL SECTION

Differential Thermal Analysis

The usual clay minerals, hydrous micas, kaolin minerals and montmorillonoids, were found in varying quantities in soil clay samples investigated during the year by differential thermal analysis. Correlation of the development of the thermogram with the intensity of weathering has again been observed. An assessment of the value of this method as applied to soil clays, together with a description of the various trends observed down the profile in the various soil types, formed the subject of a paper read at the Joint Meeting of the British Society of Soil Science and the Clay Minerals Group in April, 1952.

Cold-precipitated hydrated ferric oxide has again been found in many clays, and, occasionally, small amounts of gibbsite and of goethite have been found. A paper on the results of the investigation on pure hydrated ferric oxides will shortly appear[27]. To avoid spurious thermal effects arising from formation of calcium oxalate during peroxidation of soil clays, magnesium chloride is currently being used instead of calcium chloride for coagulation of the clay during separation.

Among the pure minerals investigated during the year were a considerable number of dolomites and sulphides, the former showing amazing differences in characteristics with locality of origin. Three samples of nontronite which

showed different particle shapes under the electron microscope have also been investigated. These were described in a paper read at a meeting of the Fachausschuss für Staubtechnik im Verein deutscher Ingenieure at Wiesbaden which has since been published[4]. Some additional work has been carried out on the kaolin from Pugu, Tanganyika, referred to in last year's report.

The Differential Thermal Analysis Sub-Committee of the Comité International pour l'Etude des Argiles continues its work on standardization and correlation of differential thermal analysis technique and apparatus. The results available from the distribution of "standard" minerals have now been correlated here, and a paper on this subject was read at the meeting of C.I.P.E.A. held in conjunction with the XIX Session International Geological Congress in Algiers[29].

A description of the differential thermal analysis apparatus at present in use has now been published[5], and also the paper on the application of differential thermal analysis to problems of dust research, referred to last year[6]. An account of the work carried out at the Institute by Dr M. Muñoz Taboadela was presented as a paper at the Joint Meeting of the British Society of Soil Science and the Clay Minerals Group and will shortly be published[35]. Three lectures dealing with methods of identification of the minerals in clays and their nomenclature, and with the relationship of clay mineralogy to soil science, were delivered at the Instituto de Edafologia, Madrid, under the auspices of the Consejo Superior de Investigaciones Cientificas. These will be published in the Anales de Edafologia y Fisiologia Vegetal.

A critique of the detailed theory of differential thermal analysis developed by P. L. Arens has been read at a meeting of the Clay Minerals Group and has been accepted for publication[28].

Clay Mineral Separation

The work on the measurement of the electrophoretic mobilities of montmorillonite and kaolinite saturated with various cations has been further developed. For this purpose an ultramicroscope of sufficient accuracy was constructed from readily available materials and operated very successfully. The indications that the electrophoretic mobilities of the two minerals might differ to a greater extent when saturated with polyvalent ions, were confirmed by measurements on suspensions saturated with Ca^{+2}, Al^{+3} and La^{+3}. With La^{+3} the difference in mobility was thought to be sufficient to offer hope of separation if a suitable technique could be found. Consideration of those available suggested that a constant-flow method might be most suitable and consequently a considerable amount of time has been devoted to the development and construction of a constant flow electrophoretic cell, similar, in general, to that employed at Uppsala. An attempt to employ the reputed lyophobic properties of the "clay-organic compounds" of Deuel as a method of separation proved completely impracticable.

Chemical Studies

The methods of removal of free iron oxides from soil clays have been further investigated during the year, using semi-micro methods of analysis to examine selected clays before and after treatment, and the extracts obtained. Semi-micro chemical analytical methods have also been used for further study of the products of grinding of muscovite[30].

SPECTROCHEMISTRY

The Department is primarily concerned with the determination by spectrochemical and related methods of the constituents, both inorganic and organic, of soils, plant materials, and other substances of biological interest, and with the development of improved methods of making these determinations.

The lines of research have been similar to those detailed in previous reports, and in all branches of the work there has been an increase in the number of determinations made. Collaboration with other departments of the Institute and with external research workers has been continued and extended.

Liaison with workers in allied fields has been maintained, and members of the Department have attended the 15th Congress of the Groupement pour l'Avancement des Methodes Spectrographiques in Paris, the International Symposium on Spectroscopy in Hoddesden, Herts., and a symposium of the Midlands Association of Analytical Chemistry, at which a review paper was presented, in addition to the regular meetings of the Consultative Committee for the Development of Spectrographic Work, sponsored by the Department of Agriculture for Scotland, the Interservices-D.S.I.R. Panel on Emission Spectroscopy, the A.R.C. Group on Mineral Deficiencies and Excesses in Animals, and the Glasgow Spectrographic Discussion Group.

Several major items of equipment have been added, notably a Hilger Projection Spectrum Comparator, a Respectra Graphical Calculator, a Stanton M.C.1.A. semi-micro balance and an Ecam C.1. all glass still for high quality distilled water.

Following a recommendation of the Consultative Committee for the Development of Spectrographic Work, a comprehensive scheme for recording and filing trace element data is being introduced. A punched card has been designed to render such references as type of material analysed, trace elements determined, problem involved, geographical location and source of the sample, and analytical technique used, easily accessible.

Following a period of tuition in the methods used in the Department, Dr J. Ramirez-Muñoz (University of Madrid), a British Council scholar, has studied the determination of certain elements by the porous cup solution spark technique. Other workers who have visited the Department for periods of training include Dr S. de Salas (University of Buenos Aires), Mr G. Fleming (Department of Agriculture, Dublin) and Mr J. McAndrew (C.S.I.R.O., Australia).

SPECTROCHEMICAL METHODS OF ANALYSIS

(*a*) *Flame Emission*

The flame photometer designed and built in the Department has been employed on a routine scale for over two years. It is used for the determination of potassium in acetic acid extracts of soils for the Department of Soil Fertility, for potassium, sodium and calcium in ammonium acetate extracts for the Department of Pedology, and for the same elements in plant extracts for the Department of Plant Physiology. In all some 11,000 samples have

been dealt with by the flame photometer in the course of the year, in addition to over 2,000 by the original Lundegardh technique, which is used when determinations of magnesium, manganese and other elements are required. The capacity of the equipment is considerably greater than the current demand.

A modified flame photometer, incorporating an integrating circuit to increase accuracy at very low potassium concentrations and employing a Maurer red-sensitive photomultiplier, is at present under development.

(*b*) *Arc Emission*

The trace elements in some 1,800 samples of soil extracts, plant materials. animal organs, waters and other biological materials have been determined by the cathode layer arc technique, following chemical concentration by organic precipitants. In the samples analysed, up to 16 constituents have been estimated. The standard methods already described have not been modified during the year, as they have proved satisfactory in use over some 10 years, but investigations into the extension of the methods to other elements are in progress.

In view of repeated demands from other laboratories for details of the lathe and cutting tools which have been designed to facilitate the cutting of carbon electrodes for the arc methods and the porous cup solution spark technique mentioned below, a description of these will shortly be submitted for publication. This equipment has proved very convenient in practice and has speeded up the production of electrodes considerably. In collaboration with the manufacturers, tests have been made on a type of purified carbon which is easier to produce, a factor of considerable importance in view of the fact that demand for purified carbons of high quality and reasonable cost exceeds the supply at present. This carbon may serve for certain applications, although it is less pure than the best available grades.

(*c*) *Spark Emission*

The porous cup solution spark technique has been the subject of a comprehensive investigation as it appears to have several possible applications in the analysis of biological materials. It has been found that porous cups cut from 5.5 mm. carbon rods, with a 0.6 mm. base thickness, are suitable for the method, and unlike graphite cups commonly employed by other workers, do not require pre-heating to render them porous. The spark source does not appear to be critical, 10,000-15,000 volts with 0.001-0.005 μF. capacity and 0.03 mH inductance giving satisfactory results.

The limits of detection for some 40 elements, using 0.1 ml. of solution in the electrode, have been found to range from 0.005 p.p.m. for magnesium to 200 p.p.m. for potassium, with most elements falling into the 1-10 p.p.m. range. Increasing the volume of solution supplied to 0.4 ml. gives increased sensitivity in many instances, while by increasing the amount of light falling on the slit the sensitivity can, where background is not too strong, be increased further. For instance, the sensitivity for selenium is then better than 100 p.p.m.

A sensitive quantitative method for the determination of magnesium in acetic acid extracts of soils and in plant ash extracts has been developed and a tentative method for magnesium and manganese in biological materials has also been studied. The Respectra calculating board is proving convenient

for the evaluation of the results obtained by these methods. A description of a convenient spring-loaded electrode clamp has been published[7].

Some preliminary work has been done on the determination of boron by the porous cup technique, and Dr Ramirez-Muñoz has studied the determination of certain less common elements, notably arsenic, antimony, tungsten, tellurium, bismuth and cadmium, and the effects of up to 5 per cent. of alkali and alkaline earth metals, as chlorides, in the solution.

(d) Photometry

An account of the application of Seidel transformed densities to the variable internal standard blackening curve separation method of evaluation has been published[8]. This method is now in routine use in the Department.

A Respectra Calculating Board, made by Messrs Dennert & Pape of Hamburg to the design of Dr H. Kaiser, has been purchased. This instrument, a combined slide rule and graphical calculator, gives spectral line intensity ratios quickly and accurately, makes Seidel transformations directly, and allows for background intensity should this be present.

Development of an electronically scanned display microphotometer has continued, and a suitable plate carriage unit is at present in course of construction.

TRACE CONSTITUENTS IN SOILS, PLANTS AND BIOLOGICAL MATERIALS

The study of trace element problems in their relation to plant and animal disorders has in course of time led to the investigation of the complete cycle from the rock, through the soil to the plant and the animal. A considerable amount of information is now available on igneous rocks and their constituent minerals as sources of trace elements. The principles underlying their distribution in sedimentary rocks and their removal from these by secondary processes are less well understood and work along these lines is projected. In continuation of previous work on igneous rocks, some types from Skye and the Northwest Highlands are being studied in collaboration with Professor L. R. Wager (University of Oxford); some results on the trace element status of the Kinkell tholeiite of Stirlingshire have been published jointly with Professor F. Walker (University of Cape Town)[9].

Work on the determination of trace elements in soil profiles has been continued and extended. The relationship of soil drainage to the amount of extractable material in the lower layers of profiles has become apparent, particularly in soils derived from the more basic rocks, where upwards of 25 per cent. of the cobalt and nickel may be soluble in dilute acetic acid or ammonium acetate. This effect may be related to the presence of infertile spots, ascribed to nickel, in certain limited areas near occurrences of basic rock in Aberdeenshire. It is interesting also to note that some trace elements often occur in relatively high contents in the lower layers of deep peat profiles examined in collaboration with the Department of Soil Organic Matter.

Analyses of agricultural soils and crops, particularly for cobalt in relation to animal disease, have continued. Soils from an extensive area in the south of Scotland have been examined in the course of a cobalt survey of this area. Samples from other areas where plant or animal disorders occur have been analysed for other elements also, and certain possible deficiencies of elements

such as copper and molybdenum have been noted. Detailed investigation in the field is required before these can be confirmed. Unfortunately no satisfactory soil extractant for copper has been found. Numerous samples of plant materials have been analysed for nickel and other trace elements on behalf of the Department of Plant Physiology, and the bulk of the analyses quoted by Dr Vergnano in her Ph.D. thesis were made in this Department. Samples from external sources have included herbages from grass drying manurial trials of the Hannah Dairy Research Institute, and from various centres of the National Agricultural Advisory Service of England and Wales. Overseas samples have come in some number from Malaya, Kenya and the Union of South Africa, the last being a series of typical plants for collaborative examination.

Biological materials examined have included a series of livers from the Animal Diseases Research Association, rumen contents from the Rowett Research Institute, and other miscellaneous samples. A paper on the effect of cobalt administered to sheep by different routes has been published jointly with the Rowett Institute[10] and one on trace elements in Scottish seaweeds with the Institute of Seaweed Research[11].

Requests for analyses of other types of samples reach the Institute regularly; not all of these can be met, but in the course of the year such materials analysed have included fluoride crystals for spectroscope prisms on behalf of the Natural Philosophy Department of the University of Aberdeen, samples of graphite and saline solutions where industrial processes were being interfered with by some impurity, rubber latex, well and river waters, and diverse substances.

ABSORPTION SPECTROMETRY OF SOIL ORGANIC MATTER

Studies on the lignin components of different plant materials have continued, using the Beckman and Hilger Uvispek spectrophotometers in the visible and ultra violet ranges. While the absorption spectrum of the lignin of sphagnum is analogous to that of woods, it has been shown that the alkali nitrobenzene oxidation of sphagnum and of the ethanol lignin of sphagnum both yield p-hydroxybenzaldehyde, but no methylated phenolic aldehydes such as arise from the lignins of gymnosperms and angeosperms. A further distinction lies in the readiness with which the lignin of sphagnum can be obtained in water soluble form by prolonged hydrolysis with dilute acid; in at least some sphagnum species the whole of the lignin can be so obtained. A fractionation of this water soluble lignin indicates that the phenolic nucleus is in part combined with polar groups, with the result that 26 per cent. of the lignin (as indicated by the intensity of absorption at 280 mμ) is associated with material insoluble in 90 per cent. alcohol, and another 44 per cent. with the fraction absorbed on a cellulose column from 90 per cent. alcohol. These polar groups may be removed, at least in part, by further hydrolysis. Their nature is under study and work to isolate a lignin free carbohydrate and protein is proceeding.

An oven and set of small reaction bombs for the nitrobenzene oxidation have been constructed in the Institute workshop for the above investigation.

Absorption studies have also been carried out on behalf of the Microbiology and Biochemistry Sections of the Department of Soil Organic Matter.

SOIL ORGANIC MATTER

The work of this department has been generally speaking a direct continuation of, or development from, that of last year. The trend in both the Chemical and Microbiological Sections has been toward the explanation of natural processes, the complete solution of which depends on the use of biochemical techniques. The work in soil mycology indicates particularly interesting lines of development of studies of the transformation of organic matter in soil and is reported in some detail.

CHEMICAL INVESTIGATIONS

Carbohydrates

Further work has been done on a non-pathogenic micro-organism isolated from soil and capable of synthesising polysaccharides containing rhamnose when grown on glucose, sucrose, fructose, inositol or glycerol media (Forsyth & Webley, *J. Gen. Microbiol.*, **3**, 395, 1949). The organism seems to be closely related to *Aerobacter aerogenes*. In liquid media the metabolic products identified include organic acids and acetylmethylcarbinol. The carbohydrate material produced appears to be a mixture of glucosan and rhamnosan, and these can be relatively easily separated. It appears now that further investigation of this interesting transformation of glucose and other sugars to rhamnose will require the application of the methods of enzyme chemistry.

Investigation is being continued on the methylated sugars obtained in trace quantities from soil or peat, and a preliminary note has been published[12].

It has been found that the methylated sugars are synthesized, presumably by microbial action, when various plant residues (grass, bracken and male fern) are allowed to decompose ("compost"). Unfortunately only small concentrations are produced (comparable with that occurring naturally in soil). The process of preliminary partial sterilization of the plant material is being investigated with a view to improving the yield of methylated sugar.

In a private communication, Dr P. O'Colla (University College, Galway) indicated that a substance had been obtained from methylated Irish moss (*Chondrus crispus*) which appeared similar to one of the methylated sugars obtained from soil. Similarities in behaviour can be demonstrated on the paper chromatogram and by treatment with demethylating reagents. Although they are different substances, the possibility that they are related in structure must be taken into account. It has been suggested that the material obtained from Irish moss may be an anhydromethylhexose.

As previously reported, rhamnose has been detected in the soluble polysaccharides isolated from soil and peat. This identification has now been confirmed by preparation of a crystalline derivative identical with that obtained from an authentic specimen.

Preliminary work on the "fungus cellulose" obtained from *Polyporus betulinus* has been published[13]. Although evidence of the occurrence of 1:3

linked anhydroglucose residues in the fungus flesh was obtained, the starting material was not of proven homogeneity. The necessary large amount of flesh has now been obtained and preparation of a pure polysaccharide is being attempted.

Nitrogenous Compounds

A short communication on the natural occurrence of L-pipecolinic acid has been given (*Proc. Biochem. Soc.*: *Biochem. J.*, **50**, XIV, 1952), and a detailed account of its isolation from *Trifolium repens* and subsequent identification is in the press[31]. Pipecolinic acid is of widespread occurrence in angiospermous plants, and recent work suggests that it may occur in soils, in relatively small quantities, more frequently than was at first believed.

Although fairly satisfactory methods are now available for the determination in microgram quantities of amino-acids after separation by paper chromatography, the useful application of these to soil hydrolysates has been prevented by the large and uncontrolled losses of amino-nitrogen which occur during the precipitation of iron and aluminium as hydroxides from the hydrolysates, a pretreatment which has been found necessary for the successful separation of the amino-acids on paper chromatograms. It has been found possible to reduce, but not completely to eliminate, these losses of amino-nitrogen, by the use of a solution of 8-hydroxyquinoline in chloroform to extract the iron and aluminium, thus avoiding the formation of a precipitate.

The Humus Complex

A study of the products of the catalytic hydrogenation of the humus complex and of certain fractions of it has been initiated, and preliminary work suggests that this is more likely to yield useful information on the constitution of humus than methods based on oxidative degradation.

MICROBIOLOGICAL INVESTIGATIONS

Rhizosphere Work

A paper[14] embodying the results reported last year has been published. Preliminary experiments have been started on the rhizosphere flora of salt marsh plants and its possible relationship to the salt content of their habitat. This work is being carried out in collaboration with Dr C. H. Gimingham of the Department of Botany, University of Aberdeen.

Paraffin Decomposing Organisms

A paper[15] has been published on the metabolism of a strain of *Nocardia opaca* using mainly the Warburg technique. It was found that this organism could metabolize long chain hydrocarbons (for example, *n*-dodecane, *n*-tetradecane and *n*-hexadecane) and also corresponding long chain saturated fatty acids and alcohols. Further work on the fat and hydrocarbon metabolism of this group of organisms is in progress and a paper was read at the Second International Congress of Biochemistry, Paris, July 1952. This work has been carried out in collaboration with Dr P. C. de Kock of the Department of Botany, University of Aberdeen, and a joint paper is in preparation for publication.

Thermophilic Organisms

A study of the respiration of a thermophilic actinomycete, *Micromonospora vulgaris*, at high temperature is being carried out in collaboration with Mrs D. Oxford, Agricultural Research Council, using the Warburg technique. Some interesting results have been obtained and the work is continuing.

Techniques

A paper has been accepted for publication describing a simple method for producing microcultures in hanging drops[37]. The techniques should prove useful to workers with limited facilities at their disposal for this type of work. It has proved useful for the study of the morphology of the paraffin decomposing organisms growing on oil droplets. It has been found that besides hydrocarbons, the organisms will grow on vegetable oils such as olive oil, almond oil, and castor oil.

Mycology

A paper[16] on the mycology of composting was published during the year.

As a preliminary to the study of the degradation of lignin by fungi, a variety of timber rots and soil moulds were supplied with a wide range of aromatic compounds as sole source of carbon. As expected, these on the whole proved toxic, but excellent growth of wide-spread soil forms, such as species of *Aspergillus* and *Penicillium*, was obtained on M/100 solutions of *p*-hydroxybenzoic acid, although catechol and benzoic acid were quite toxic and phenol supported only slight growth. After four days' growth the *p*-hydroxybenzoic acid medium was examined by the method of paper chromatography, using diazotised *p*-nitraniline spray with a concentrated ether extract of the filtered medium. Evidence was obtained that 3:4 dihydroxybenzoic acid was being formed. With 3:4 dihydroxybenzoic acid or phenol as sole carbon source no additional phenolic compounds could be detected, a result which conforms with bacteriological findings that these compounds are altered to an aliphatic molecule, probably β-ketoadipic acid.

A wheat straw lignin prepared after the method of Phillips (*J. Am. Chem. Soc.*, **50**, 1986, 1928) was similarly used with *Aspergillus Wentii* and developed, after an initial lag period, a similar ether soluble phenolic substance. In glucose medium this was not produced, pointing to the conclusion that it is derived from the lignin through the action of the organism.

Phenol-oxidizing fungi were isolated from soil by the dilution plate technique, using a nutrient medium to which gallic acid was added. Garden soil yielded species of *Penicillium*, *Aspergillus* and *Fusarium* capable of forming a dark-coloured oxidation product from the gallic acid; the dark-coloured surface horizon of recently colonized dune-pasture soil similarly yielded species of *Macrosporium*, *Fusarium* and *Coniothyrium* and other members of the Sphaeropsidales. These results are noteworthy in view of the orthodox opinion that only highly organized Basidomycetes are active oxidizers of phenolic compounds.

The polyphenolases in the fructification of a number of terrestrial and litter-decomposing fungi were studied. Strong positive results were obtained from the tissue extracts of *Cortinarius turmalis*, *C. leucopus*, *Coprinus plicatilis*, *C. lagopus* and *Clitocybe nebularis*. The enzyme system of *C. nebularis* is of

the laccase type oxidizing orthodiphenols but not monophenols; that of *C. turmalis* is a tyrosinase type oxidizing the monophenols tyrosine, *o*- and *m*-cresols, *o*-, *m*- and *p*-amino phenols and the diphenol catechol. Both preparations also oxidized l-ascorbic acid, but this would appear to be due to a direct ascorbic acid oxidase rather than to secondary oxidation *via* the polyphenolase system.

Further related studies concerned the carbohydrate metabolism of the fungi *Nectria cinnabarina*, *Coprinus plicatilis* and *Chaetomium globosum*, the last of which has been found to be homothallic in contrast to the heterothallism common in closely related forms.

FORESTRY INVESTIGATIONS

The application of the Lees percolation technique to the study of nitrogen transformation in forest soils has met with only limited success, and appears to suffer from two defects when used in this connection, namely—

(1) The high threshold pH for nitrification necessitates the raising of the pH of all samples of forest soil to an artificially high level.

(2) Nitrate formation appears to be strongly influenced by small changes in pH during percolation, and reproducibility of results has been poor.

For these reasons, the use of this method has been discontinued and an incubation method is being used for further work along these lines.

At Culbin Forest, continuous field records have been made of moisture and temperature fluctuations in both the planted and unplanted dunes. These show that the moisture deficit built up in the rooting zone of the trees during the spring continues throughout the summer in spite of relatively heavy rainfall, and that temperature differences between the various types of habitat are considerable. The moisture status of stands of Corsican Pine has also been found to be correlated with thinning grade.

Further information on the particle size distribution within the dunes has been obtained and the collection of a full year's litter fall from stands of different ages and species has been completed.

In collaboration with the Radioactive Studies Section of the Department of Plant Physiology, preparations are being made to study the neutron absorption method of measuring soil moisture, recently developed by Canadian and American workers (U.S.C.A.A. Tech. Dev. Rept. No. 127).

PEAT INVESTIGATIONS

Pollen Analyses

This work has been continued with analyses and diagrams of profiles from Alt-na-Breac and Flows of Leanas, Caithness, and Badenloch, Sutherland. Profiles from Airds Moss, Ayrshire, and from two areas in Lewis have been taken. Further analyses on some of the peat deposits of the Aberdeen area have been carried out. It is now possible to draw preliminary conclusions from a comparison of the results and diagrams now prepared.

Samples from some of the above mentioned mosses have been taken for the spectrochemical determination of trace elements.

Routine Work

This has been continued in connection with the peat survey carried out by the Peat Division of the Department of Agriculture for Scotland. During the year 654 routine samples have been examined and analysed, in addition to approximately 100 samples submitted for special analysis. The samples of ash obtained during analysis are being examined for radioactivity.

The preparation of a collection of herbarium specimens has begun, in collaboration with the Soil Survey Section.

Advisory work has continued on a somewhat limited scale.

FIELD AND GLASSHOUSE EXPERIMENTAL WORK

This has continued as in previous years, involving the use of peat and composts in the field and of various types of organic ameliorants under glass.

PLANT PHYSIOLOGY

Studies in plant nutrition have dealt mainly with ion relationships and interactions in nutrient absorption using soil, sand, and water culture techniques. Investigations included an examination of the effects of trace elements in toxic amounts on ion uptake, and the evaluation of soil fertility by pot culture studies. Chemical methods used in tissue analysis have been periodically reviewed.

Nickel Toxicity

There are certain areas in Aberdeenshire where toxicity symptoms are produced in plants by excess nickel in the soil (Ann. Rept. 1941-42), and preliminary work on the effects of nickel on plant metabolism has been published[18]. Experiments have confirmed the tentative conclusions made regarding the relationships between major nutrient supply and the uptake of nickel. The maintenance of a high level supply of major nutrients (with the exception of phosphorus) reduces the severity of toxicity symptoms.

The study of the relationship between nickel and iron supply is in progress; results to date indicate that a high iron status delays the onset of toxic symptoms and depresses uptake of nickel. Attempts are being made, using water culture, to ascertain whether this effect occurs wholly within the plant or is partly associated with the substrate. Iron is being supplied either as ferric citrate or sequestrene (ferric potassium ethylenediamine tetra-acetate). The effect of pH on the uptake of nickel in water culture has shown that uptake is greater the higher the pH; the degree of necrosis symptoms produced does not vary markedly over the pH range 4-7, but chlorosis is most severe at pH 6. A pot experiment in which soil from the affected areas was treated with increasing amounts of lime to give final pH values approximately those used in the water culture series, has shown that toxicity symptoms are not produced above pH 5.5 although the acetic-soluble nickel does not vary significantly over pH range 4-7.

The toxicity symptoms produced in sand-culture oats by application of heavy metals in the nutrient solution have been studied. The metals used, other than nickel, were cobalt, chromium, copper, zinc and molybdenum, and of these only cobalt yields symptoms liable to be confused with those of nickel. A paper covering this section of the work has been prepared for publication.

The anatomical changes induced in the oat by nickel and cobalt toxicities, and by iron deficiency have been examined. Results show that cobalt and nickel in excess almost certainly have the same effect—any difference being merely in degree of activity. When experimental plants were compared with plants from the affected areas in Aberdeenshire, it was evident that the symptoms were anatomically of the same type. A paper embodying these results has been accepted for publication[36].

Pot culture studies have been used in the examination of a serpentine soil from the Lizard, Cornwall, undertaken at the request of the Forestry Commission.

Mineral Composition of Bracken

A paper dealing with the major and trace element composition of bracken has been accepted for publication[25]. Variation in composition during the growing season has been established and the effect of soil type on composition has been investigated. A comparison has been made between the mineral composition of bracken and that of moorland plants and certain species of hill pasture grasses.

Advisory Work

The Department continues to collaborate with the Department of Soil Fertility by undertaking the tissue analysis of advisory samples.

Chemical Methods of Analysis

The analytical technique for diagnosing the nutrient status of plants continues to be of great value in current investigations. The methods used are constantly under review, and an account of the recently improved calcium method has been prepared for publication.

A colorimetric method for nickel using dimethylglyoxime is proving satisfactory for estimation in plant dry matter where nickel is present in toxic amount. Interference from other ions normally present was experienced initially, but has been overcome by the use of citric acid. Its use can be extended to extracts of serpentine soils provided organic matter is first destroyed.

RADIOACTIVE STUDIES

The work of the Radioactive Section has been along three main lines. The study of the phosphate relationships of soils using ^{32}P as a tracer has been continued in collaboration with the Department of Soil Fertility. The autoradiograph technique has been used to determine the distribution of mineral nutrients in the plant. A new application of radioactive material, other than as a tracer, has been made in an investigation of a method of determining soil moisture. Delivery of various electronic instruments has been made and two complete sets of counting equipment are now available.

Phosphate Studies

The pot experiments are based on the use of phosphate labelled with ^{32}P to enable the proportion of fertilizer phosphate in the plant to be determined. From this ratio the amount of plant available phosphate in the soil can be calculated. This procedure has been applied to determine the availability of superphosphate residues in samples from field plots and to investigate the effect of diluting the soil with sand. The phosphorus status of subsoils from a number of experimental areas has also been examined.

Complementary laboratory work has been continued to measure solid phase phosphate. This value is found by determining the distribution of added ^{32}P as a result of isotopic exchange when soil is in suspension in various extractants. This work is designed to clarify the significance of the values obtained by conventional extraction methods for evaluating the phosphate status of soils.

Autoradiography

The autoradiograph technique has been used in connection with the research on nickel toxicity. The influence of nickel on the distribution of phosphorus, calcium and iron in plants has been investigated using isotopes of these elements. Radioactive cobalt has been used to study the distribution of the element in plants affected by cobalt toxicity.

Determination of Soil Moisture

When a source of fast neutrons is placed in soil a proportion of the neutrons which encounter the hydrogen in water are slowed down. These slow neutrons can be detected quantitatively by the radioactivity produced in a metal foil placed near the neutron source. This method is being studied as a means of measuring the moisture in soil; in particular, the equipment has been made portable for field use in forest soil investigations.

SOIL FERTILITY—CHEMISTRY AND FIELD EXPERIMENTATION

The improvement of soil fertility in the broad sense of improving both the yield and the feeding quality of crops continues to be the ultimate aim of the three main types of investigation in progress, namely: field experiments, pot experiments and laboratory studies. Field experiments under varying conditions are indispensable to the characterization of the numerous factors determining soil fertility, and also to the assessment of the results of pot experiments and laboratory studies.

A paper[32] dealing with factors affecting phosphate usage in Great Britain and summarizing the results of experimental work to date has been presented at a symposium on soil and fertilizer phosphorus in crop production, which was held in the United States in August 1952. Against the background of land utilization and fertilizer consumption in Great Britain, the results obtained have been discussed under such headings as the relative effectiveness of phosphate in different forms, phosphate fixation, rates and time of application, methods of application, interactions of lime and phosphate, and other factors affecting the efficiency of applied phosphate. Accounts of other experimental findings have been given in two papers[19, 38] presented at the meeting of the International Society of Soil Science which was held in Dublin, in July, 1952. Brief contributions[33, 34] on manuring for the establishment and maintenance of pasture and on cobalt deficiency in pastures in Great Britain have also been made to the programme of the Sixth International Grassland Congress held in the United States in August, 1952.

FIELD EXPERIMENTS

As in previous years all these experiments are designed according to modern statistical requirements; they cover such problems as the following:—

General Manuring and Liming

In these experiments one of the principal objectives is to characterize the yielding capacity and nutrient status of the principal soil associations identified in the soil survey of Scotland. Further yield data for barley and swedes in the long-term liming experiments show that the effects of the dressings applied in 1944 still persist. The study of the effects of ground limestone and ground magnesian limestone on the composition of pasture throughout the growing season has been continued and confirms the preliminary finding that magnesian limestone markedly increases the magnesium content of the herbage. Further results have been obtained in the series of factorial experiments on the effects and interactions of nitrogen, phosphate and potash in the presence and absence of dung on various crops and soils. Experiments to determine the optimum time of applying nitrogen to cereals and the work on the occurrence of blind ears in oats on moderately acid soils have also been continued. An experiment has been undertaken to determine the effects of molybdenum, copper and zinc on the establishment of clover in an area where

growth is particularly poor despite liming and manuring on a normally adequate basis. Collaborative experimental work has also been undertaken along with the North of Scotland College of Agriculture in Orkney to test the effects of various manganese supplements in the prevention of grey speck disease in oats.

In addition to determining the response to lime and fertilizers on different soil associations, one of the main objects of the field experiment work continues to be the building up of an adequate background of response data to permit of the results of laboratory analyses being correlated with field behaviour.

Phosphate Relationships of Soils

Experiments on the residual effects of heavy applications of phosphate on the main soil associations have been continued and extended. These experiments include lime treatments and are designed to measure the effectiveness of one year old phosphate residues in terms of a fresh dressing and to study the effects of ploughing and cultivation on their positional availability. Further experiments are also in progress on the time of application of phosphate for arable crops, the significance of drainage conditions, the effectiveness of nitrophosphate and the comparison of powder and granular forms. New series of experiments have been started on the phosphate manuring of grassland and on the influence of cropping on phosphate fixation.

The paper on phosphate manuring, referred to in last year's report, has been published[20].

Methods of Fertilizer Application

Experiments to compare fertilizers broadcast on the flat before ridging and placed in bands near the seed have been continued with swedes and turnips. The 1951 results are in general agreement with previous preliminary findings, and a report has been submitted to the Agricultural Research Council. The work at present in progress with roots is designed to provide information on the effects of placing sulphate of ammonia and muriate of potash along with superphosphate. Further experiments on cereals have also been started to compare fertilizers (a) broadcast on the ploughed surface before cultivation, (b) broadcast on the seed bed, (c) combine drilled with the seed, (d) broadcast after seeding. The two papers[21, 22] referred to in last year's report covering the results of experimental work to date have now been published.

POT EXPERIMENTS

The pot experiments fall into two main groups. The first represents a continuation and extension of the work on the availability of superphosphate after varying periods of contact with different types of moist soil and the effect of cropping on phosphate fixation. The second covers the use of ^{32}P to estimate the availability of one year old phosphate residues in samples from field plots, and has been conducted in collaboration with the section for Radioactive Studies. The phosphorus status of subsoils from some of the main field experiment areas has also been examined.

In addition to the above, a smaller scale experiment is in progress to test the possible effects of Krilium soil conditioner on the availability of native and applied phosphate.

LABORATORY WORK

Apart from analyses of soil and produce samples from field and pot experiments, the laboratory investigations have been concentrated mainly on the following subjects:—

Phosphate Problems

Phosphate fractionation and retention studies on surface soils and soil profiles have been continued. One of the main aims of this work is to clarify the problems of evaluating the phosphorus status of soils by laboratory methods. This subject has been reviewed in a paper[19] dealing with the categories of phosphorus in soils, their significance in relation to phosphate status, their extraction by different classes of extracting agents, and the inherent limitations of laboratory values as criteria of field conditions. It is concluded that the conventional extracting agents extract varying amounts of several different categories of soil phosphorus and can hardly be expected to give more than an index of the phosphorus status. Further, it is to be expected that the relative and absolute usefulness of different extractants will vary according to the type of soil.

These and other conclusions are supported by the experimental data presented in another paper[38] dealing with the correlation between the values obtained by five widely used extraction methods and the field responses to phosphate of turnips and swedes on four of the main soil associations. The extracting agents tested are 2.5 per cent. by vol. acetic acid, Egner's lactate solution, Truog's reagent and Bray's neutral NH_4F and $NH_4F + HCl$ solutions. Considering all the soils together irrespective of parent material the lactate method gives the best relationships. This comparison, however, is misleading because one of the most striking features of the results is the marked variation in the usefulness of individual methods on soils derived from different parent materials. Neutral NH_4F, for example, gives highly significant correlations and is superior to the other methods on soils derived from Old Red Sandstone, but is quite useless for soils derived from basic igneous drift. Acetic acid, on the other hand, gives the best results on soils derived from granitic drift. For soils derived from basic igneous drift and from schists, Truog's reagent is superior to the other extractants, but the correlations for these two soil associations are poor. The methods tested have a very definite diagnostic value, but it is hoped that better relationships will be found for some of the other categories of phosphorus still to be examined. It is clearly important in investigations of this type to have the background field experiment work distributed over recognized soil types.

The above results point to several inherent differences in the phosphate relationships of the different soil associations. These require further investigation before they can be adequately discussed, but probable explanations for some of the contrasts are provided by other lines of work in progress. An examination of the properties of the phosphorus in the coarser fractions of the soils is now in progress and gives promise of explaining several points in relation to the significance of the values obtained by the various extracting agents.

Laboratory work with ^{32}P has been continued in collaboration with the Section for Radioactive Studies. These experiments are concerned mainly

with measurements of solid-phase phosphorus in equilibrium with that in solution in various suspensions and are complementary to the pot experiments. Progress in this phase of the laboratory work has been retarded by various technical difficulties and it is not yet possible to evaluate the usefulness of this approach to the study of soil phosphorus relationships.

A series of tests has been started on the seasonal variations in readily soluble phosphate and other nutrients.

Manganese

An account of the work carried out by Dr L. H. P. Jones, Nuffield Foundationer from Melbourne University, on the reduction of manganese in neutral to alkaline soils has been accepted for publication[26]. It appears that even within the range 7 to 8, pH has an important effect on the activity of manganese oxides in soils; this should be borne in mind in applying the quinol reduction test for available manganese.

Physico-chemical Studies

Two theoretical papers[23, 24] prepared by Mr Erik Eriksson, of the Royal Agricultural College of Sweden, during his tenure of a British Council Scholarship have now appeared. One deals with the physico-chemical behaviour of nutrients in soils and the other with cation exchange equilibria on clay minerals.

ADVISORY AND OTHER *AD HOC* WORK

The testing of soils for advisory purposes in collaboration with the North of Scotland College of Agriculture has been continued and over 8,500 samples have been examined during the year. Most of these samples have been drawn from agricultural land, but quite a number have come from horticultural areas and sports grounds. Soil samples from forest nurseries, mainly under the Forestry Commission have also been examined and advice given on the maintenance and improvement of soil fertility in these areas. Various liming and by-product materials of potential agricultural value have also been analysed.

The results obtained on further samples of soil from agricultural land in Aberdeenshire and Kincardineshire have been recorded and grouped on the basis of soil association. The differences between the associations noted in previous reports are still evident and show that shortages of lime and phosphate are less pronounced on the Stonehaven and Laurencekirk Associations than on the others. Potash deficiency also is less marked on these two and on the Cruden Association. In spite of the increased use of lime and fertilizers there are still marked shortages of lime and phosphate. Although the shortage of potash is relatively less pronounced there is need for potassium supplements on most soils.

In collaboration with the Departments of Plant Physiology and Spectrochemistry, a considerable amount of attention has again been given to the examination of soil and produce samples from areas in which there are abnormalities either in crop growth or in animal health. Numerous reports on such areas have been prepared and in doubtful cases *ad hoc* experiments have been suggested or arranged in collaboration with other research organizations.

PUBLICATIONS

(A) *Published during the year—*

1. The Macaulay Institute for Soil Research. By D. N. McArthur. (*Chem. and Ind.*, 579-581, 1952).

2. The determination of total phosphorus in soil with particular reference to the control of interference by soluble silica. By J. W. Muir. (*Analyst*, **77**, 313-317, 1952).

   Describes a method for routine determination of total phosphorus in soil. The phosphorus is released from the soil material by fusion with sodium carbonate and extracted from the melt with water. An aliquot of the solution is taken and the phosphorus in it determined by the blue colour formed with sodium molybdate in acid solution and aqueous hydrazine sulphate. The colour is stable for at least 24 hours. Interference from silicates rendered soluble by the fusion is controlled effectively by the use of tartaric acid. The colorimetric method can determine between 0.06 mg. and 0.30 mg. of phosphorus pentoxide. By taking a suitable aliquot of the extract, the total phosphorus content of any soil containing more than 0.06 per cent. phosphorus pentoxide can be determined.

3. Unidimensional Fourier synthesis of vermiculite. By G. F. Walker and A. A. Milne. (*Clay Min. Bull.*, **1**, 171-174, 1951).

   Discrepancies are found between the theoretical and observed F values and electronic distribution curves normal to (001) for postulated structures based on the montmorillonite structures both of Edelman & Favejee and Hofman, Endell & Wilm.

4. Teilchenform und Mineralogie einiger Nontronite. By R. C. Mackenzie, R. Meldau (Harsewinkel, W. Germany) and R. H. S. Robertson (Glasgow). (*Ber. dtsch. keram. Ges.*, **29**, 221-226, 1952).

   Three nontronite samples, *viz.*, nontronite from Hoher Hagen, nr. Göttingen, Germany, nontronite from California, and chloropal from Saxony, were examined by differential thermal analysis, X-rays, and the electron microscope. Although all three were good nontronite samples, it was found that the first contained quartz, the second cristobalite, and the third tridymite, all in very small quantity. The particle shape was also found to vary from platy to lathe-like, depending upon locality of origin.

5. Aparato de analisis termico diferencial para trabajos en serie e investigacion. By R. C. Mackenzie. (*An. Edafol. Fisiol. veg.*, **11**, 159-184, 1952).

   Gives a complete description of the differential thermal analysis apparatus in use at the Macaulay Institute, with details of design, construction, operation and interpretation of results. The implications of the design and capabilities of the apparatus are discussed, together with the simplified theory of differential thermal analysis, and it is concluded that such an apparatus is very suitable for laboratories where both routine and research work are in progress.

6. Differentialthermoanalyse und ihre Anwendung auf technische Stäube. By R. C. Mackenzie. (*TonindustrZtg.*, **75**, 334-340, 1951).

   The technique of differential thermal analysis is reviewed, with special reference to its applicability to problems of dust technology. Notes are given on the history of its development and on the theory. Several different types of apparatus currently in use are briefly described and sets of curves given for minerals likely to be found in technical dusts, *e.g.*, silica minerals, clays, oxides, carbonates, etc. Reference is also made to the effect of grinding upon the curve and the use of the method for quantitative determination.

7. Electrode clamps for spectrochemical analysis. By R. O. Scott and A. M. Fraser. (*Spectrochim. Acta*, **4**, 472, 1952).

   Describes spring loaded clamps to hold electrodes in the *Hilger de Gramont* stand.

8. Application of the Seidel transformation to the determination of intensity ratio by blackening curve separation. By I. A. Black. (*Spectrochim. Acta*, **4**, 519-524, 1952).

   Methods for shortening the work required to obtain blackening curve separations at a low constant density are discussed. By employing Seidel densities, blackening

curves are obtained sufficiently straight for accurate separations to be derived by plotting two points on each curve and joining these points by a straight line, thus reducing the number of microphotometer readings required and eliminating curve fitting. A simple method of plotting Seidel densities directly from galvanometer readings by means of a suitable graduated scale is described and this, in conjunction with a special scale for measuring lines to background separations, shortens the method and renders the use of mathematical tables unnecessary, even when background correction is required.

9. The chemistry and mineralogy of the Kinkell tholeiite, Stirlingshire. By F. Walker (University of Cape Town), H. C. G. Vincent (University of Cape Town) and R. L. Mitchell. (*Min. Mag.*, **29**, 895-908, 1952).

   The unaltered tholeiite of Kinkell quarry, Stirlingshire, has been reinvestigated and the mineral constituents have been separated and analysed both chemically and spectrographically. No anomalies were found and the distribution of trace elements in the rock is normal. The two main mineral constituents—augite and labradorite—had the same crystallization ranges and maintained approximately equal rates of crystallization until the rock was 70 per cent. crystalline.

10. The administration of cobalt by different routes to lambs maintained on a low-cobalt diet. A. T. Phillipson (Rowett Research Institute) and R. L. Mitchell. (*Brit. J. Nutrit.*, **6**, 176-189, 1952).

    Cobalt deficiency in lambs has been maintained or produced by feeding a cobalt-low ration. Administration of cobalt intravenously or into the duodenum at the rate of 0.1 mg. daily did not cure the deficient lamb. Administration of cobalt into the duodenum or abomasum in quantities greater than 0.1 mg. allowed growth to occur at a rate similar to that of lambs receiving 0.1 mg. cobalt daily by mouth. A higher concentration of cobalt was found in the rumen of lambs receiving cobalt into the abomasum or duodenum than in those receiving no cobalt. The concentration of cobalt in the liver was substantially increased by the administration of cobalt intravenously, into the duodenum or by mouth, but there was no correlation between liver cobalt and signs of deficiency. The weight changes of cobalt-deficient lambs were closely related to the quantity of food consumed.

11. Trace elements in the common brown algae and in sea water. By W. A. P. Black (Institute of Seaweed Research) and R. L. Mitchell. (*J. Mar. biol. Ass.*, **30**, 575-584, 1952).

    Some common Scottish Laminariaceae and Fucaceae have been analysed spectrographically, and 17 of the minor elements determined. Results show that there is a seasonal variation and considerable variation in the content of these elements in different species taken from the same habitat. With the Laminariaceae the trace elements are more concentrated in the perennial stipe than in the attached frond, and are generally less than in the Fucaceae.

    Samples of sea water taken off Plymouth and the West coast of Scotland have also been analysed spectrographically and 14 of the minor elements determined. Concentration factors are given showing the extent to which marine algae can accumulate the trace elements. Values of over thousand-fold concentration are reported. Fucus spiralis, for example, contains 10,000 times more titanium than the surrounding sea water.

12. The occurrence of methylated carbohydrates and rhamnose as components of soil polysaccharides. By R. B. Duff. (*J. Sci. Fd. Agric.*, **3**, 140-144, 1952).

    A complex of polysaccharides and humic substances has been extracted from various soils. Somewhat impure syrupy fractions have been obtained by partition chromatography of the hydrolysate on a cellulose column, and the methoxyl content of these fractions approximated to that required for a monomethyl hexose. Demethylation and examination of the products on the paper chromatogram indicated that the products were hexoses, probably galactose and glucose. A rich soil contained a total of about 0.006 per cent. of the syrupy methylated fraction. The demonstration of the presence of methylated sugars in soil indicates a wider distribution of these substances than hitherto supposed. The soil polysaccharide hydrolysate also appeared to contain L-rhamnose, and a rich soil contained about 0.006 per cent. of this fraction.

13. The constitution of a glucosan from the fungus *Polyporus betulinus*. By R. B. Duff. (*J. Chem. Soc.*, 2592-2594, 1952).

The flesh of the bracket fungus *Polyporus betulinus* gave glucose (ca. 60 per cent.) and a residue (ca. 30 per cent.) on hydrolysis. Only traces of sugars other than glucose were present. Examination of the products of hydrolysis of the methylated fungus flesh indicated a ratio of approximately 1 mole of tetra- to 12-14 moles of tri-, 4 moles of di- and 1 mole of mono-methyl glucose. 2 : 3 : 4 : 6-tetramethyl, 2 : 4 : 6-trimethyl and 4 : 6-dimethyl glucose were obtained crystalline.

14. Development of a soil microflora in relation to plant succession on sand-dunes, including the "rhizosphere" flora associated with colonizing species. By D. M. Webley, D. J. Eastwood and C. H. Gimingham (University of Aberdeen). (*J. Ecol.*, **40**, 168-178, 1952).

In a series of samples from the main seral stages of two dune systems, taken along transects passing inland from the bare sand above high-water mark, bacterial and fungal populations showed a marked increase with the start of plant colonization. "Rhizosphere" floras were demonstrated round the root systems of three species colonizing the foreshore above high-water mark, *viz.*, *Atriplex babingtonii*, *Agropyron unceum* and *Ammophila arenaria*. Morphological investigation of isolates from the root surface of *Ammophila* and *Agropyron* indicated a high proportion of organisms having affinities with *Corynebacteria*, *Mycobacteria* or *Nocardia*. The flora from the root surface of *Ammophila* differed from that of *Agropyron* in that there was a greater proportion of Gram-negative non-sporing rods in the former. This result introduces the possibility that the dominants of succeeding stages of dune colonization develop a characteristic root-region flora of their own. The need for further work on this point is emphasized.

15. The metabolism of some saturated aliphatic hydrocarbons, alcohols and fatty acids by *Proactinomyces opacus* Jensen (*Nocardia opaca* Waksman and Henrici). By D. M. Webley and P. C. de Kock (University of Aberdeen). (*Biochem. J.*, **51**, 371-375, 1952).

A study of the aerobic metabolism of a strain (T 16) of the non-pathogenic *Pro. opacus* (Jensen) employing the Warburg technique. The oxygen uptake of washed suspensions of *Pro opacus* is increased in the presence of *n*-dodecane, *n*-tetradecane, *n*-hexadecane, *n*-octadecane and paraffin wax. Decyl, lauryl (dodecyl) and octadecyl alcohols give increased oxygen uptake, but amyl, *iso*amyl, *iso*hexyl, and heptyl alcohols are toxic. The long chain fatty acids (C_7-C_{16}) are all actively metabolized at very low concentrations (0.0012M). At 1 per cent., octanoate, decanoate, undecanoate and laurate (dodecanoate) are toxic. The rate of methylene-blue reduction by the supernatant liquid obtained from the crushed cells of *Pro opacus* is increased in the presence of dodecane and hexadecane.

16. The fungus flora of composts. By D. J. Eastwood. (*Trans. Brit. Mycol. Soc.*, **35**, 215-220, 1952).

Quantitative determinations of fungi in composts of fresh lawn mowings and barley straw have shown that these organisms are destroyed in the centre of both kinds of compost by the high temperature which develops. After the high temperature phase, greater development of fungi occurs in the straw compost. It is thought that adverse physical and chemical conditions limit their development in grass composts.

Some of the fungi carried by the material initially survive round the edges of the compost and persist during the period of composting. In the straw composts the cellulose decomposers become particularly active.

17. The afforestation of Tentsmuir Sands. By J. D. Ovington. (*J. Ecol.*, **39**, 363-375, 1951).

At Tentsmuir the Forestry Commission have successfully developed the open heather moorland and converted it to close coniferous forest. Observations have been made on the effects of the afforestation by comparing plantations of *Pinus sylvestris* established for 11 and 19 years with an unplanted area. *Calluna vulgaris* shows increased vigour in the shelter of the young plantations but is suppressed under the old plantations. Although the water-table fluctuates considerably, it is 17 cm. lower in the old plantation than in the unplanted area. Aeration is greater in the plantations and the effective soil volume is increased as the water-table is lowered. The heather raw humus is replaced by less acid pine humus with a greater nutrient content. The nutrient content and pH (4.7) of the sand decreases with afforestation. The organic content of the sand is increased in the plantations. A comparison has been made of the ecological conditions at Tentsmuir and Culbin forests.

18. Nickel toxicity in plants. By J. G. Hunter and O. Vergnano. (*Ann. appl. Biol.*, **39**, 279-284, 1952).

Infertility of certain Aberdeenshire soils is ascribed to the high concentrations of Ni occurring in them (acetic soluble, 49-403 p.p.m.; exchangeable 22-61 p.p.m.). Plants growing on these soils have a high Ni content (*e.g.*, fully expanded leaves of oat plants before flowering, 16-134 p.p.m.). Symptoms on affected crops are described; oat plants are useful indicators of the toxicity since characteristic white necrotic tissue is produced as longitudinal stripes on their leaves. The Ni content of plants in soil is found to be inversely related to soil pH (though directly related in water culture). The reduction in plant gowth produced by Ni, and the degree of necrotic symptoms produced, are increased when the Ca, Mg, N or K supply is low or when the P supply is high; the Ni content of the plants is usually unrelated to the major nutrient supply. Figures for the concentration of Ni in various crop plants, and in parts of the plants, at several nutrient levels are given. The diagnosis of trace element toxicity is discussed.

19. Evaluating the phosphorus status of soils. By E. G. Williams. (*Trans. Int. Soc. Soil Sci.: Joint Meeting Comm. II and Comm. IV, Dublin, July* 1952, **1**, 31-47, 1952)

The general problem of evaluating the phosphorus status of soils is reviewed. The interrelationships and possible significance of conventional laboratory tests are assessed from consideration of (1) the categories of phosphorus in soils, (2) their solubility in different classes of extractants, (3) their significance in relation to phosphorus status, and (4) the limitations of laboratory values as criteria of field conditions. It is concluded that laboratory tests can hardly be expected to give more than an index of the phosphorus status, and that their relative and absolute usefulness depends on the type of soil and must be judged ultimately from the degree of correlation with the results of field experiments.

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

The amount, frequency, time and method of application, the effectiveness of different forms, and the effects of soil conditions are reviewed in the light of field experiment results. It is concluded that each crop should receive a dressing according to its responsiveness and the degree of deficiency in the soil, and that it is uneconomical to attempt to build large reserves quickly by applying single heavy dressings. Suitable placement and adequate liming are also of prime importance. Under Scottish conditions, citric soluble forms of phosphate provide very effective alternatives to superphosphate.

21. Factors affecting the methods of applying fertilizers. By J. W. S. Reith. (*Scot. Agric.*, **31**, 101-109, 1951).

Discusses factors, such as individual plant foods, soil climate and crops, which affect the question of when, where and how fertilizers should be applied and gives a general account of results obtained from placement experiments. In Scotland at present the case for placement hinges mainly on the cereal crop with which combine drilling of superphosphate or mixtures containing phosphate gives better yields than normal broadcast application. With other crops more experimental data are required before placement methods can be recommended. It is pointed out that with tillage crops broadcast dressings of phosphate and potash, particularly phosphate, should be cultivated into the land and not left on the surface.

22. Fertilizer placement for cereal crops. By J. W. S. Reith. (*Emp. J. expt. Agric.*, **20**, 103-114, 1952).

Field experiments show that sulphate of ammonia and muriate of potash can be safely combine drilled with oat seed at rates up to 1½ and 1 cwt. per acre respectively, and generally the yields are the same for both broadcast and drill applications. Drilling superphosphate is more effective than broadcasting it, and 25-30 lb. P_2O_5 per acre drilled produces yields at least as good as double this amount broadcast. It appears that potash manure salts (40 per cent. K_2O) should not be placed with cereal seed, especially if sulphate of ammonia is drilled along with it. Mixtures of sulphate of ammonia and superphosphate can be combine drilled at normal rates and drilling generally produces slightly higher yields than broadcasting. It seems quite safe to drill up to 4 cwt. per acre of an NPK mixture made from sulphate of ammonia, super-

phosphate and muriate of potash and containing 6 per cent. N and 12 per cent. K_2O. As the percentages of N and K_2O in the mixture decrease, the rate at which it can be safely drilled can be increased. Placing superphosphate seems to allow the crop to take up its phosphate more quickly during early growth and this may be the reason why drilling this fertilizer is superior to broadcasting it. There are no differences in the contents of N, P_2O_5, K_2O and CaO in the mature grain and straw attributable to the two methods of application.

23. The physico-chemical behaviour of nutrients in soils. By E. Eriksson. (*J. Soil Sci.*, **3**, 238-250, 1952).

    The physico-chemical behaviour of the common ionic nutrients is examined on the basis of series of relationships derived from existing data on pH, solubility products, dissociation constants, and oxidation-reduction potentials. The probability of formation of various compounds and the order of magnitude of the equilibrium concentrations of different nutrients under various soil conditions are assessed.

24. Cation-exchange equilibria on clay minerals. By E. Eriksson. (*Soil Sci.*, **74**, 103-113, 1952).

    Cation-exchange equations derived by regarding the exchanger + solution phase as a Donnan system are compared with various other equations that have been proposed. A theoretical treatment is given also for the case where the exchanger phase consists of, for instance, a comparatively dilute montmorillonite suspension, where the exchangeable ions form a swarm or so-called diffuse double layer around each particle.

(B) *Submitted for publication—*

25. The composition of bracken: some major and trace element constituents. By J. G. Hunter. (To appear in *J. Sci. Fd. Agric.*).
26. A note on the reduction of manganese in neutral to alkaline soils. By L. H. P. Jones. (To appear in *Trans. Int. Soc. Soil Sci.*: *Joint Meeting Comm. II and Comm. IV, Dublin, July* 1952. Vol. 2).
27. Investigations on cold-precipitated hydrated ferric oxide and its origin in clays. By R. C. Mackenzie. (To appear in *Min. Engng.*).
28. Some notes on Arens' theory of differential thermal analysis. By R. C. Mackenzie and V. C. Farmer. (To appear in *Clay Min. Bull.*).
29. Standardization of differential thermal analysis technique. By R. C. Mackenzie and K. Farquharson. (To appear in *Trans. XIX Session Int. Geol. Cong.*).
30. Effect of grinding on micas. By R. C. Mackenzie and A. A. Milne. (To appear in *Clay Min. Bull.*).
31. The isolation of L-pipecolinic acid from *Trifolium repens*. By R. I. Morrison. (To appear in *Biochem. J.*).
32. Factors influencing phosphate usage in Great Britain. By A. B. Stewart. (To appear in a special monograph to be published by The American Society of Agronomy).
33. Manuring for establishment and maintenance of pasture. By A. B. Stewart. (To appear in *Trans. VI Int. Grass. Cong.*).
34. Cobalt deficiency in pastures in Great Britain. By A. B. Stewart. (To appear in *Trans. VI Int. Grass. Cong.*).
35. The clay mineralogy of some soils from Spain and from Rio Muni (West Africa). By M. Muñoz Taboadela. (To appear in *J. Soil Sci.*).
36. Nickel and cobalt toxicities in oat plants. By O. Vergnano and J. G. Hunter. (To appear in *Ann. Bot.*).
37. A simple method for producing microcultures in hanging drops, with especial reference to organisms utilizing oils. By D. M. Webley, with an appendix by V. C. Farmer. (To appear in *J. gen. Microbiol.*).
38. Readily soluble phosphate values and crop responses for different soils. By E. G. Williams, J. W. S. Reith and R. H. E. Inkson. (To appear in *Trans. Int. Soc. Soil Sci.*: *Joint Meeting Comm. II and Comm. IV, Dublin, July* 1952. Vol. 2).
39. Soil Survey maps (1 inch to 1 mile) based on Ordnance Survey Sheets 86 and 96 (3rd ed.), and descriptive memoir.

APPENDIX

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

NORTH-EAST SCOTLAND

Morayshire (*Geological Survey Sheet* 95)

ASSOCIATIONS

Boyndie Association

Distribution . . Extensive areas south and east of Elgin; between Lossiemouth and Spynie; and generally flanking the ridges described in the text.

Parent Material . Fluvio-glacial sand.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1950-51.

Topography . . Undulating to hummocky.

Corby Association

Distribution . . In a ¼-mile wide strip south of main Elgin-Forres road from Sheriffmill to Knock of Alves; in Loch na Bo Wood; around Miltonduff; in small isolated patches throughout the areas of the Boyndie Association.

Parent Material . Water-sorted and morainic gravels.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Moundy.

Hatton Association

Distribution . . In Ordiga Wood; in the area of Cranloch; in parts of the higher ground in the south of the Sheet.

Parent Material . Till derived mainly from the conglomerate beds of the Upper Old Red Sandstone.

Dominant Series . Freely drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Grey-brown, stony, sandy loam; weak crumb structure. Sharp change into

B_2	8-14 in.	Brownish-yellow, stony loamy sand; weak crumb structure. Merging into
B_3	14-26 in.	Light reddish-brown, very stony, gritty sandy loam; indurated. Merging with decreasing induration and increasing redness into
C	28-42 in.	Reddish-brown, very stony, gritty loam till; compact.
Topography	. .	Smooth, gentle slopes.

ELGIN ASSOCIATION

Distribution	. .	On the higher ground around Covesea, Inverugie, Findrassie, Quarrywood and Monaughty; on isolated rises throughout the rest of the area.
Parent Material	.	Sandstones of Upper Old Red Sandstone and Permo-Triassic age.
Dominant Series	.	Freely drained.

Profile

Horizon	*Depth*	
A_0F	0-1 in.	Partly decomposed plant material.
A_1	1-2½ in.	Dark grey-brown organic loam with bleached quartz grains.
A_2	2½-8 in.	Grey-brown, stony sand; soft cloddy structure. Merging into
B_1	8-10 in.	Dark brown humus concentration. Sharp change into
B_2	10-20 in.	Brownish-yellow, stony, loamy sand; indurated, platy structure. Merging into
B_3	20-30 in.	Light reddish-brown, stony sandy loam till; induration decreasing downwards. Merging into
C	30-42 in.	Reddish-brown, stony sandy loam till; compact, cloddy structure.
Topography	. .	Slopes and flat tops of ridges.

DUFFUS ASSOCIATION

Distribution	. .	Around the margin and including part of the drained bed of the former Loch Spynie, notably at Shempston, Waterton and Rosehaugh.
Parent Material	.	Lacustrine sediments.
Dominant Series	.	Poorly drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Grey-brown clay loam; cloddy structure. Sharp change into
G	9-22 in.	Brown to reddish-brown clay; well-defined prismatic structure; grey and ochreous mottling. Merging into
G-C	22-40 in.	Brown clay; massive.
Topography	. .	Flat to gently undulating.

LINKS

Distribution . . In the half-mile wide strip of raised beach from Lossiemouth to Covesea, and the corresponding raised beach area south and west of Burghead.

The soil is developed on sand (in part blown) with, occasionally, interbedded shingle. It is mainly freely to excessively drained and has a few inches of brown loamy sand with weak cloddy structure over light yellow-brown single-grain sand.

ALLUVIUM

Distribution . . Wide spreads occur on both sides of the River Lossie north and south of Elgin; in the valley running east-west from Aldroughty to Alves; in the western part of the area, around Milton Brodie and Coltfield; in the central part of the Spynie basin.

The soils are immature and show little profile development. Loamy sand is the predominating texture, but all grades from gravel and coarse sand to silty clay and clay are encountered.

SKELETAL SOILS

Dune Sands

Distribution . . A very narrow strip on the seaward edge of the Links area from Lossiemouth to Covesea; an extensive area south of Burghead where the dunes have been stabilized and planted as part of the Roseisle Forest.

Parent Material . Blown sand.

The sand is excessively drained and shows no profile development.

BASIN PEAT

A few small patches of peat occur throughout the areas of alluvium. A thin deposit of highly calcareous marl underlies some of the peat at Newton and Waterton.

EAST SCOTLAND

Angus (*Geological Survey Sheet* 57)

ASSOCIATIONS

Corby Association

Distribution . . Moraines and river terraces along the south bank of the River South Esk in the vicinity of the Montrose Basin. An area on the south bank of the Lunan Water near Friockheim.

Parent Material . Fluvio-glacial gravel.

Dominant Series . Freely and imperfectly drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Undulating to flat.

BALROWNIE ASSOCIATION

Distribution . . Between the River South Esk and the Lunan Water, bounded to the east by an irregular line running southwards from the west end of Kinnaird Deer Park round the east end of Rossie Moor to the Lunan near Courthill Farm, and extending to the west to the present survey limits.

Parent Material . Red water-worked till on till of sandy loam to loam texture.

Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Gently undulating with generally low angle slopes. A tendency to east-west orientation in the vicinity of Montreathmont Moor.

MOUNTBOY ASSOCIATION

Distribution . . The rising ground between the Montrose Basin and the Lunan Water, east of the area occupied by the Balrownie Association, and excluding the coastal strip of the Usan Association.

Parent Material . Red-brown, water-worked till and till of sandy loam to loam texture similar to the parent material of the Balrownie Association but containing a variable percentage of andesitic lava.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-12 in.	Medium brown sandy loam to loam; compact cloddy crumb structure. Fairly sharp change into
$(B_2\text{-}B_3)G$	12-20 in.	Reddish grey-brown sandy loam with rusty and grey mottling (texture rather heavier—sandy loam to loam—in lower 3 inches of this horizon); compact indurated. Merges over 2 inches into
C	20-24/27 in.	Dull red-brown with slight purple cast stony loam till; slightly indurated above, compact cloddy structure below. Irregular boundary.
	24/27 in.	Jointed andesitic lava rock.

Topography . . Irregular with many smooth hillocks and rises; frequent rock outcrops generally smooth in outline, sometimes showing glacial striae.

Usan Association

Distribution . . Occupies a coastal strip around the Scurdie Ness-Usan peninsula.

Parent Material . Raised beach deposits rather variable in composition; often characterized by a deep surface horizon and immature profile.

Dominant Series . Imperfectly drained or freely drained.

Profile

Horizon	*Depth*	
S	0-16 in.	Grey-brown sandy loam to loam; upper 9 inches rather "caked" crumb structure, lower 7 inches crumb structure. Sharp change into
B_2	16-22 in.	Medium brown sandy loam; loose soft crumb structure. Fairly sharp change into variably stratified material below without definite morphological characteristics.
	22-27 in.	A band of small angular lava chips, closely packed with a little brown sandy loam material in the interstices. Fairly sharp change into
	27-36 in.	Closely packed slightly angular lava scree; interstitial material varies from sandy loam to coarse sand below. Merges gradually into
	36 in. +	Coarse sandy gravel with loose single grain structure.

Topography . . Gently sloping.

Pow Association

Distribution . . Occupies the low ground about the River South Esk between Kinnaird Castle and the Montrose Tidal Basin—excluding some areas of the Corby Association.

Parent Material . Silty estuarine alluvium.

Dominant Series . Poorly drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Light brown silty fine sandy loam; cloddy prismatic structure; few stones. Sharp change into
G	9-18 in.	Pale grey-brown compact silty loam with extensive pale rusty mottling; cloddy prismatic structure; stones absent. Merges gradually into
G	18-29 in.	Light brown silty loam, upper 6 inches with very strong orange mottling, the intensity decreasing slightly with depth; prismatic structure in upper 6 inches merges into cloddy amorphous structure below. Merges into
G	29-41 in.	Pale greyish brown fine sandy to fine sandy silty loam with orange mottling; cloddy amorphous structure; no stones. Merges into

G-C	41-50 in.	Pale grey fine sandy silty loam with orange mottling; cloddy amorphous structure; no stones. Merges gradually into
	50 in. +	Blue-grey fine sandy to fine sandy silty loam; amorphous structure; no stones.
Topography	. .	Flat.

ALLUVIUM

Deposits of recent alluvium occupy the lowest terraces of the River South Esk and the Lunan Water and several minor tributary streams; in addition there are a few small areas of lacustrine alluvium.

SOUTH-EAST SCOTLAND

Roxburghshire (*Geological Survey Sheet* 17)

ASSOCIATIONS

Bowmont Association

Distribution	. .	A small area in the east extending from Denholm to the south of Ruberslaw.
Parent Material	.	Till derived from Upper Old Red Sandstone formation, overlying solid.
Dominant Series	.	Freely drained.

Profile

As described in Annual Report 1950-1951.

Topography	. .	Rolling.

Minto Association

Distribution	. .	A small area between the Bowmont and Hindhope associations.
Parent Material	.	Mixed till derived from Old Red Sandstone and Silurian formations.
Dominant Series	.	Poorly drained.

Profile

As described in Annual Report 1950-1951.

Topography	. .	Broadly rolling.

Hawick Association

Distribution	. .	Alluvium of the Teviot above Hawick, the Ettrick above Selkirk, and of the Allan and Slitrig Waters.
Parent Material	.	Alluvium of Silurian origin.
Dominant Series	.	Poorly drained.

Profile

As described in Annual Report 1950-1951.

Topography	. .	Flat.

HINDHOPE ASSOCIATION

(a)

Distribution . . North-eastern part of the area from south of Hawick northwards to Ashkirk.

Parent Material . Till derived from rocks of Silurian formation.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
A_0L	0-1 in.	Plant litter.
A_0F	1-1½ in.	Partially decomposed plant material.
A_0H	1½-2 in.	Brownish-black humus.
A_1	2-11 in.	Brown loam; crumb structure; uniform organic staining; very slight ochreous mottling. Fairly sharp change into
B_2-G	11-19 in.	Light yellowish brown silt loam; cloddy; patches of dark brown organic staining, ochreous and brown mottling.
C	19 in. +	Yellowish grey brown silt loam; cloddy; brown mottling and black staining.

Topography . . Hilly with north-east to south-west ridges clearly defined on the hill slopes.

(b)

Distribution . . The higher ground in the southern and western part of the area.

Parent Material . Till derived from rocks of Silurian Age.

Dominant Series . Raw humus phase of the poorly drained series.

Profile

Horizon	*Depth*	
A_0L	0-1½ in.	Plant litter.
A_0F	1½-2 in.	Partly decomposed plant material.
A_0H	2-7 in.	Black humus.
A_1	7-11 in.	Light brown-grey loam; small cloddy; slight ochreous mottling and organic staining. Sharp change into
G	11-18 in.	Light grey-brown silt loam; cloddy; strong orange mottling. Merging into
G	11-23 in.	Light grey silt clay loam; cloddy; orange and grey mottling. Fairly sharp change into
C	23 in. +	Reddish-brown, gritty silt clay loam; cloddy and compact; orange mottling and black staining.

Topography . . The topography is mountainous, often with extensive high level plateaux.

SKELETAL SOILS

SILURIAN SEDIMENTS

Distribution . . Throughout the area of the Hindhope Association where rock is close to the surface.

Parent Material . Weathered Silurian rocks.

Profile

As described in Annual Report 1950-1951.

Topography . . Hilly.

HILL PEAT

Limited areas of hill peat are found, mainly in the southern and western parts of the area surveyed.

SOUTH-WEST SCOTLAND

Ayrshire (*Geological Survey Sheet* 22)

ASSOCIATIONS

ASHGROVE ASSOCIATION

Distribution . . An extensive area around Dalry, stretching north-eastwards up the River Garnock to Kilbirnie and Barr Lochs; south-west of East Kilbride.

Parent Material . Mixed till derived from sedimentary rocks, mainly sandstones and shales of the Carboniferous formation.

Dominant Series . Poorly drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Undulating.

DARLEITH ASSOCIATION

Distribution . . High ground north-east of Beith, around Brownsmuir Plantation and Row Bank Reservoir; Kilbirnie Hills; high ground north-east and south of Eaglesham.

Parent Material . Thin till derived from basic and intermediate lavas.

Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Hilly with many rock outcrops.

KILMARNOCK ASSOCIATION

Distribution . . Small area in the vicinity of Beith; immediately north of Kilbirnie; extensive area around Eaglesham, particularly to the north and south-east.

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

Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Rolling in the Beith and Kilbirnie areas and gently undulating in the Eaglesham area.

GLENMOUNT ASSOCIATION

Distribution . . In localized pockets throughout the Ashgrove Association, the most extensive being north and north-east of Highfield.

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

Dominant Series . Poorly drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Undulating.

AMLAIRD ASSOCIATION

Distribution . . High ground north-west of the River Garnock and north-east of Beith, where confined to depressions; on gentler slopes and hills between Eaglesham and Darvel.

Parent Material . Heavy till derived from basic and intermediate lavas.

Dominant Series . Poorly drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Varies between hilly and broadly rolling.

BARGOUR ASSOCIATION

Distribution . . Small area south-west of Newmilns and around Mean Muir.

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

Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1950-1951.

Topography . . Rolling.

LANFINE ASSOCIATION

Distribution . . High ground south of Newmilns and Darvel.

Parent Material . Mixed till derived from Old Red Sandstone and contemporaneous lavas.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Brown loam; soft cloddy structure. Sharp change into
B_2-G	10-16 in.	Brown, sandy clay loam; cloddy structure slightly compacted; slight ochreous mottling and slight gleying. Sharp change into
B_3-G	16-20 in.	Strong brown coarse sandy heavy loam; weak laminated structure; indurated; slight ochreous staining and slight gleying; slight manganese staining. Sharp change into
G-C_1	20-30 in.	Dark brown clay; massive structure; slight gleying along old channels. Merging into
G-C_2	30-40 in.	Reddish brown clay; massive structure.
Topography	. .	Hilly.

DARVEL ASSOCIATION

Distribution . .	In the Eaglesham and Darvel districts.
Parent Material .	Fluvio-glacial sands and gravels.
Dominant Series .	Freely drained.

Profile

Horizon	*Depth*	
S	0-12 in.	Brown sandy loam; weak crumb structure. Sharp change into
B	12-20 in.	Brown to dark brown gravelly loamy sand; structureless; some grains have slight iron coating. Sharp change into
C	20-38 in.	Brown to dark brown, alternating beds of sand and sand and gravel.
Topography	. .	Hummocky with ridges and terraces.

BLACKSIDE ASSOCIATION

Distribution . .	Blacksidend and Auchinlongford Hill and the immediate vicinity.
Parent Material .	Till derived from Downtonian sandstone.
Dominant Series .	Very poorly drained.

Profile

Horizon	*Depth*	
A_0L	Trace	Undecomposed litter.
A_0F	0-1 in.	Decomposing fibrous organic matter.
A_0H	1-9 in.	Dark brown greasy humus.
A_2-G	9-18 in.	Light grey sandy silty clay; amorphous structure, sticky iron staining along root channels, the whole completely gleyed. Moderately sharp change into
B-G	18-26 in.	Light yellowish brown sandy clay; massive structure; heavy ochreous mottling; iron pipes along root channels with inner gleyed core; marked gleying around stones. Sharp change into

G-C	26-42 in.	Light grey clay; massive structure; occasional iron pipes; heavy gleying around weathering stones.
Topography	. .	Steep and hilly.

Distinkhorn Association

Distribution . .	On the steep slopes of the Distinkhorn, Glen Garr and Mule Hill.
Parent Material .	Thin till derived essentially from granodiorite and diorite.
Dominant Series .	Poorly drained.

Profile

Horizon	*Depth*	
A_0F	0-1 in.	Partially decomposed litter.
A_0H	1-11 in.	Black greasy humus.
A_1	11-18 in.	Very stony; large and small diorite boulders; matrices filled with dark brown humus loam. Sharp change into
G	18-26 in.	Light grey sandy clay; strong cloddy structure; the whole completely gleyed. Sharp change into
G-C	26-36 in.	Light brown sandy clay loam; weak laminated structure; slightly indurated; stony; slight ochreous mottling.
	36 in.	Parent rock.
Topography	. .	Hilly.

Highfield Association

Distribution . .	Small areas around Highfield, Barr Loch and north-west of Kilbirnie and Dalry.
Parent Material .	Carboniferous sediments (Limestone Coal Group, etc.).
Dominant Series .	Imperfectly drained.

Profile

Horizon	*Depth*	
A_0L	0-½ in.	Grass litter.
A_1	½-5 in.	Grey-brown loam; soft crumb structure. Sharp change into
B_2-G	5-11 in.	Pinkish-grey heavy loam; soft cloddy structure; slight ochreous staining. Merging into
C	11-16 in.	Pinkish-grey sandy clay loam; slight platy structure.
	16 in. +	Carboniferous sandstone pavement.
Topography	. .	Flat, terraced.

Kirktonmoor Association

Distribution . .	Small area west of Eaglesham.
Parent Material .	Morainic debris.
Dominant Series .	Freely drained.

Profile

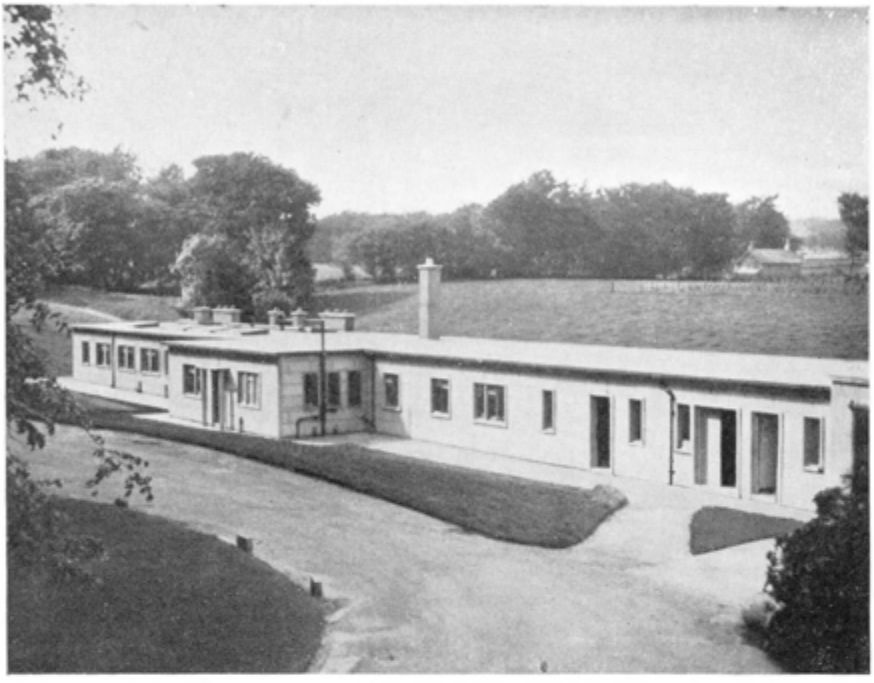
Horizon	*Depth*	
A_0F	0-2 in.	Decomposing organic material.
A_1	2-14 in.	Dark brown light loam; crumb structure; many well rounded pebbles. Sharp change into
B	14-25 in.	Dark brown gritty loam; soft cloddy structure; many rounded pebbles; colour uniform. Sharp change into
C	25-33 in.	Brown, gritty heavy loam; amorphous structure; many small rounded stones and several large angular igneous stones.
Topography . .		Hummocky.

HILL AND BASIN PEAT

Hill and basin peat of varying depth occurs throughout the extensive moorland to the north and south of Darvel.

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.		
PARENT MATERIAL		GLEYED PARENT MATERIAL	
C	undifferentiated	G-C	gleyed C.
GLEY HORIZONS			
G	undifferentiated.		
CULTIVATED HORIZONS			
S	undifferentiated.		



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