THE MACAULAY INSTITUTE FOR SOIL RESEARCH

FOUNDED 1930

ANNUAL REPORT 1952-1953

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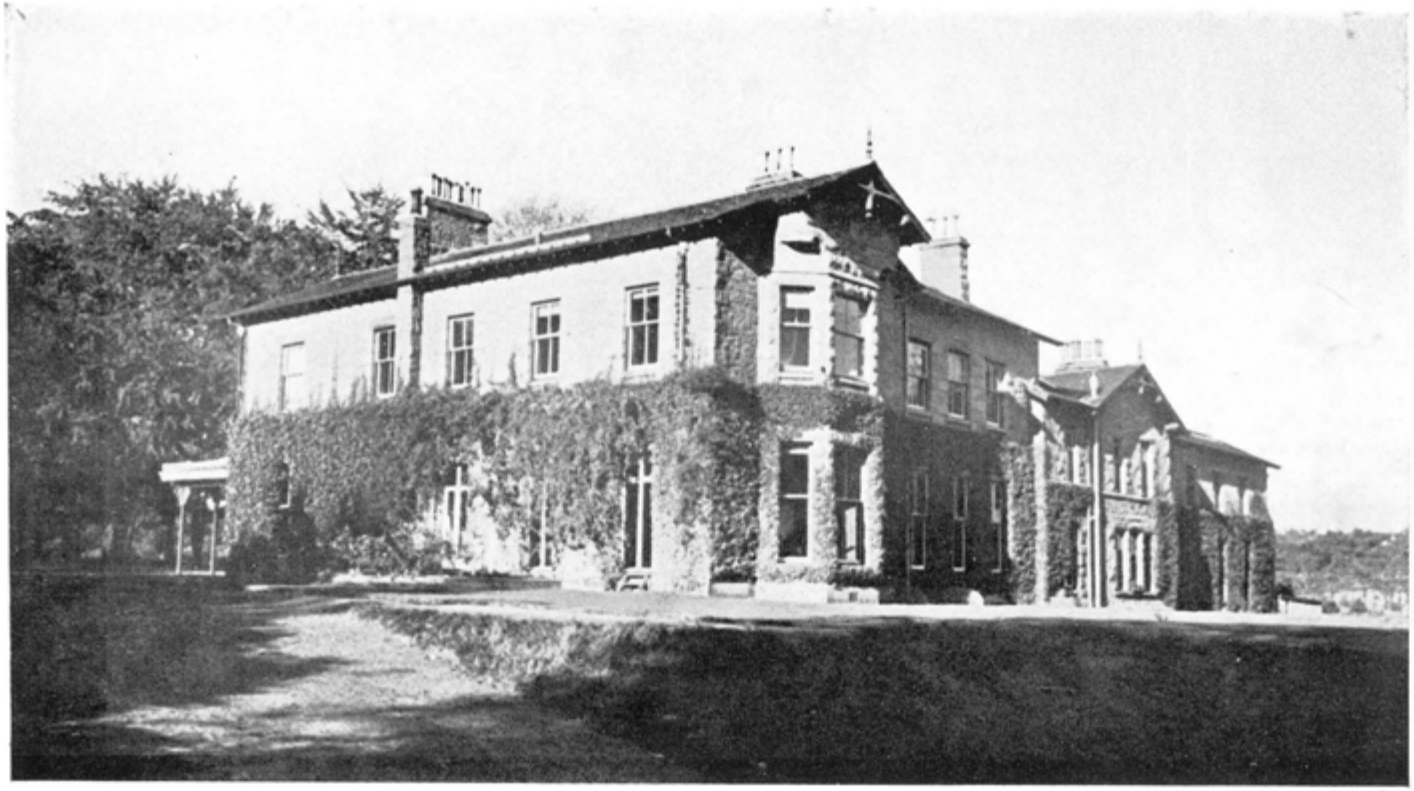

THE MACAULAY INSTITUTE FOR SOIL RESEARCH

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CRAIGIEBUCKLER, ABERDEEN
(Founded 1930)

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B. H. Cho (Seoul National University, Suwon, Korea).
J. D. Colwell (Department of Agriculture, Sydney, New South Wales, Australia).
E. J. B. Cutler (Soil Bureau, Timaru, New Zealand).
G. Jefford (Geological Survey, Kaduna Junction, N. Nigeria).
K. Kristjansdöttir (Department of Agriculture, University of Reykjavik, Iceland).
C. Lippi-Boncambi (Institute of Geology, University of Perugia, Italy).
I. R. MacDonald (Agricultural Research Council Training Grant).
R. K. Richardson (Department of Agriculture, Kingston, Jamaica).
W. M. H. Saunders (Department of Scientific and Industrial Research, Wellington, New Zealand).
E. L. Strmecki (Faculty of Agriculture and Forestry, University of Ljubljana, Yugoslavia).

CONTENTS

INTRODUCTION

The work of the Institute is concerned with the diverse problems of soil, both from the fundamental viewpoint and as they affect the maintenance and improvement of soil fertility; steady progress and development have been made during the year. Collaboration was maintained with sister Research Institutes, The Colleges of Agriculture in Scotland, the Forestry Commission, and the Department of Agriculture for Scotland, and facilities were granted to several research workers for post-graduate training in the various branches of soil research.

In carrying out its extensive research programme, the Institute is greatly indebted to the Department of Agriculture for Scotland, the Agricultural Research Council, and the Forestry Commission for grants in aid of the work, and the Council of Management again makes grateful acknowledgement to these bodies and to other benefactors for generous support.

COUNCIL

On 21st July, 1953, Major James Keith, C.B.E., died at his residence, Pitmedden, Udny. Major Keith was appointed to the Council in 1940, as a representative of the North of Scotland College of Agriculture, and throughout his tenure of office showed an unfailing interest in the welfare of the Institute. The Council of Management records its appreciation of the services which he rendered.

Professor V. C. Wynne-Edwards, M.A., F.R.S.C., University of Aberdeen, was appointed to the Council as a representative of the North of Scotland College of Agriculture, in succession to the late Sir Garden B. Duff.

STAFF

(*a*) *Resignations*:

Department of Pedology—

Mr M. J. Mulcahy, B.Sc.(For.) (Soil Survey Section), on appointment to the staff of the Department for Scientific and Industrial Research, New South Wales, Australia.

(*b*) *Appointments*:

Department of Pedology—

Mr E. L. Birse, B.Sc. (Soil Survey Section).
Mr J. Smith, B.Sc. (Soil Survey Section).

In collaboration with Dr W. Holmes of the Hannah Dairy Research Institute, Dr A. B. Stewart contributed a paper on the manuring of grassland to the January meeting of the Agriculture Group of the Society of Chemical Industry. In March, Dr R. B. Duff attended a symposium on carbohydrate chemistry organized by the University of London. Dr D. M. Webley represented the Institute at an Agricultural Research Council discussion on the microbiology of the rhizosphere held in London in March; in September he presented a paper at the Sixth International Congress on Microbiology in Rome. At a meeting held in Ipswich in May, Dr R. L. Mitchell read a paper on semi-quantitative methods of spectrochemical analysis to the Physical Methods Group of the Society of Public Analysts, and whilst on leave in Switzerland he took the opportunity to attend the International Symposium on Geochemistry held in Zurich in August. At the beginning of July, the British Council held a course in Aberdeen on the mineral nutrition of farm animals, and talks were given by several members of the Institute staff. At the request of the Forestry Commission, Dr T. W. Wright attended the September meeting of the British Association in Liverpool, to take part in a discussion on the afforestation of sand dunes. Dr A. B. Stewart, Mr B. D. Mitchell, and Mr J. M. Ragg were present at the summer conference of the British Soil Science Society, held in Newcastle in September.

LABORATORIES

Laboratory accommodation has now been provided at Craigiebuckler for the Microbiological Section of the Department of Soil Organic Matter. The Council of Management takes this opportunity of expressing its gratitude to the University of Aberdeen and to Professor J. R. Matthews of the Department of Botany in whose laboratories the Unit has been housed since its formation in 1944.

VISITORS

The activities of the Institute continue to attract visitors from all parts of the world, and amongst the many research workers welcomed during the year were representatives of institutions in Australia, Austria, Belgian Congo, Canada, Denmark, Fiji, Finland, France, Germany, Gold Coast, Haiti, India, Israel, Italy, Japan, Malaya, New Zealand, Netherlands, Nigeria, Norway, Southern Rhodesia, Tanganyika, Uganda, and the United States. Organized parties included members of Boots' Field Staff, the British Council "Mineral Nutrition Course," the Clay Minerals Group of the Mineralogical Society, and the Interservices D.S.I.R. Panel on Emission Spectrography.

POST-GRADUATE RESEARCH WORKERS

The Institute is now an established centre for training in the methods of soil research and for post-graduate study, and during the year under review the following research workers were associated in the work of the Institute:

Department of Pedology:

Soil Survey—

E. J. B. Cutler (Soil Bureau, Timaru, New Zealand).

Department of Spectrochemistry:

G. Jefford (Geological Survey, Kaduna Junction, N. Nigeria).
R. K. Richardson (Department of Agriculture, Kingston, Jamaica).

Department of Plant Physiology:

I. R. MacDonald (Agricultural Research Council Training Grant).
E. L. Strmecki (Faculty of Agriculture and Forestry, University of Ljubljana, Yugoslavia).

Department of Soil Fertility:

R. du T. Burger (Stellenbosch-Elsenburg College of Agriculture, Stellenbosch, South Africa).
J. D. Colwell (Department of Agriculture, Sydney, New South Wales, Australia).
K. Kristjansdottir (Department of Agriculture, University of Reykjavik, Iceland).
W. M. H. Saunders (Department of Scientific and Industrial Research, Wellington, New Zealand).

In addition to these post-graduate workers, Professor B. H. Cho (University of Seoul, Suwon, Korea), and Professor C. Lippi-Boncambi (Institute of Geology, University of Perugia, Italy) spent several weeks at the Institute.

REPRESENTATION ON COMMITTEES

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

(1) *Secretary of State for Scotland*:

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

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

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

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

(2) *Department of Agriculture for Scotland*:

(*a*) Scottish Agricultural Improvement Council.

(*b*) Field Trials Sub-Committee.

(*c*) Scottish Grassland Sub-Committee.

(*d*) Sugar Beet Sub-Committee.

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

(3) *Agricultural Research Council*:

(*a*) Conference on Fertilizers.

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

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

(*d*) Land Drainage Conference.

(*e*) Soil Survey Research Board.

(4) *Forestry Commission*:

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

(5) *Colonial Office*:

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

PUBLICATIONS

Twenty-three scientific papers were issued during the year and are summarized in this report. 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—

(*a*) "Profile development in sandy soil under the influence of heath and forest," by T. W. Wright.

(*b*) "Studies of some contrasting Scottish soils, with particular reference to the distribution of phosphorus throughout the profiles," by W. M. H. Saunders.

PEDOLOGY

SOIL SURVEY (SCOTLAND)

In the systematic survey of the soils of Scotland, mapping is usually on a scale of 2.5 inches to 1 mile. Selected areas are surveyed in more detail (6 inches to 1 mile). Maps in process of publication are on a scale of 1 inch to 1 mile, based on the 3rd edition of the Ordnance Survey maps.

Approximately 250 square miles have been mapped in the systematic survey. Field work has been completed on Sheet 95 (Elgin), Sheets 17 (Jedburgh) and 18 (Morebattle), and Sheet 22 (Kilmarnock). It has continued on Sheet 57 (Brechin).

The reduction in area covered, as compared with former years, has been due to the considerable demands for special surveys, and to the necessity for revision and checking of previously surveyed areas on the now completed sheets. An overlap has been surveyed on all adjacent sheets.

NORTH-EAST SCOTLAND

Morayshire (*Geological Survey Sheet* 95)

The survey of Sheet 95 has been completed. Approximately 24 square miles at the western end of the sheet have been mapped this season. Another area, of some 30 square miles, has been revised in greater detail, in view of its complexity, and the whole area has been checked to ensure correlation and continuity.

The physiography and geology of most of the area have been described in previous reports (1950-51; 1951-52). The additional part extends westwards from Alves to Findhorn Bay and Forres, bounded in the north by the coast, and in the south by a line through Burgie and Tarras. The northern part is low-lying, consisting mainly of 25- and 50-foot raised beach, with an alluvial spread around Damhead and Miltonhill. Grange Hill (120 feet) and the narrow ridge from Coltfield to Milton Brodie are the only prominent features. Southwards the ground rises to the western extension of the Alves ridge at Brodieshill and Hillhead, reaching 250 feet at Burgie Castle on the southern edge of the sheet.

With the exception of small areas of quartzite at Tarras and Burgie, the underlying rocks are sandstones of Upper Old Red Sandstone age, but the rock is rarely exposed. Raised-beach material and fluvio-glacial sand and gravel are the dominant superficial deposits. Till, derived mainly from Old Red Sandstone, is found on the slopes in the south. The influence of the quartzite is seen locally in an increase in the stoniness of the till. A reddish silty clay, probably of lacustrine origin, occurs in limited areas and similar deposits have been seen interbedded in some of the sands. The northern part

of the area has been considerably affected by blown sand. This has mostly been incorporated in the existing soils by cultivation, but buried soils are frequently encountered.

The soils on the till and fluvio-glacial deposits are light-textured and free-draining generally. The flat raised-beach and alluvial areas present serious drainage problems, but when these are overcome, good agricultural soils are obtained. The heavier-textured lacustrine soils have a justifiably high reputation for crop production.

The area revised in detail includes the raised-beach deposits at Roseisle, the complex lake margins around Duffus, and the flanks of the Inverugie-Covesea ridge.

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

Associations

1. Boyndie	*see* Annual Report 1950-51.
2. Corby	*see* Annual Report 1950-51.
3. Elgin	*see* Annual Report 1951-52.
4. Duffus	*see* Annual Report 1951-52.
5. Whitehills	*see* Annual Report 1948-49.
6. Muirton	New Association.
7. Carden	New Association.

Alluvium
Skeletal Soils
Basin Peat

EAST SCOTLAND

Angus (*Geological Survey Sheet* 57)

Some 45 square miles have been surveyed in Angus; about 25 square miles lie on the west side of the sheet around Forfar and the rest between Inverkeilor and Arbroath.

The areas have a common topographic feature in the deeply scored valley system extending from west of Forfar to Lunan Bay and including a string of lochs—Loch of Forfar, Restenneth Moss, Loch Fithie, Rescobie Loch and Balgavies Loch; the system drains westward *via* the Dean Water and eastwards through the Lunan Water. To the north-west of Forfar, the ground rises in gradual undulations reflecting the regional strike of the underlying Old Red Sandstone strata. To the south, a more broken pattern of hills and valleys characterizes the north-easterly outliers of the Sidlaw Hills, developed in the main from rather flaggy Old Red Sandstone beds, with some interspersed conglomerate forming occasional scenic scarps like those on the south-facing side of Turin Hill. South of Inverkeilor, the land forms a rising promontory jutting into the sea at the south end of Lunan Bay, and falling gently away towards Arbroath. The underlying rocks are again mainly red sandstone and occasional conglomerates—with the addition of contemporaneous lavas of andesitic or more basic composition.

That part of the ground surveyed lying at above approximately 200 feet is covered by superficial deposits comprising red water-sorted till material and red tills. The lower-lying areas carry spreads, locally extensive, of sand, sandy gravel and light-textured moraine, with some alluvium and peaty areas. West of Forfar Loch and at Restenneth Moss, there are minor occurrences of calcareous marl: a patch of lacustrine clay at Anniston is sufficiently extensive to support a brick and tile works.

Soils are generally of light to medium texture and imperfectly drained; and, excepting those soils developed on sands, gravel and alluvium, subsoil colours are predominantly red or reddish brown. Some freely-drained soils occur in the gravel areas, and on the steeper hill slopes around and to the south-west of Forfar. Poorly-drained soils are relatively infrequent and are confined to small areas of sand and sandy alluvium often around the margins of patches of basin peat.

Arable farming is generally practised in both areas, while dairying and soft-fruit-growing are locally important variants. Crops regularly grown include oats, barley, wheat, potatoes, turnips and sugar-beet: less commonly, beans, canning peas, carrots, and various silage mixtures have been noted.

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

Associations

1. Boyndie — *see* Annual Report 1950-51.
2. Corby — *see* Annual Report 1950-51.
3. Balrownie — *see* Annual Report 1950-51.
4. Turin — New Association.
5. Drumgley — New Association.
6. Dean — New Association.

Alluvium
Lacustrine Alluvium
Basin Peat

SOUTH-EAST SCOTLAND

Roxburghshire, Dumfriesshire and Selkirkshire

(*Geological Survey Sheets* 17 *and* 18)

The survey of Sheet 17 has been completed this season. This amounts to approximately 75 square miles, of which 50 square miles lie between Cauldcleuch Head in the west and Peel Fell in the east; this area extends north as far as Windburgh Hill and Wauchope Forest and south to the boundary of the sheet. The remaining 25 square miles surveyed consisted of small disconnected areas, mostly in the Borthwick and upper Teviot valleys.

The solid geology of the main area consists of alternating belts of Silurian, Upper Old Red Sandstone and Lower Carboniferous sediments, together with Lower Carboniferous basaltic lavas in the north. The pedology and topography bear a close relationship to the solid geology despite the fact that glacial till covers the whole area.

Podzolic and peat-topped soils, together with hill peat, are dominant in the area. However, where the slope is steep and the till thin, brown earth types occur, and in the valleys below about 750 feet and where the till is thick and of heavier texture, low humic gleys predominate.

The only agricultural activities are the breeding and rearing of hill sheep and to a lesser extent of hill cattle, and cropping of oats, turnips and hay for winter feeding. Wauchope Forest of some 11,500 acres in the north has now 3340 acres of well established trees.

On completion of the two sheets the whole region was revised where necessary. The main alteration to the original mapping was the delineation of podzolic and peaty gley soil series on the Bowmont, Hindhope, Martinlee, Minto and Sourhope Associations, and of corrugated complex topography (skeletal ridges alternating with imperfectly drained soil in the hollows) on the Hindhope Association. The Windburgh Association, a new association, has been introduced to incorporate the residual soils developed on basaltic intrusions and lavas. This association is morphologically identical with the Darleith Association of south-west Scotland, but more chemical data are required before a definite correlation can be established.

The following soils are found in the 50-square mile area described above, and are described in the appendix.

Associations

1. Hindhope — *see* Annual Report 1949-50.
2. Martinlee — *see* Annual Report 1949-50.
3. Minto — *see* Annual Report 1950-51.
4. Windburgh — New Association.

Hill Peat
Skeletal Soils
Undifferentiated Alluvium

SOUTH-WEST SCOTLAND

Ayrshire (*Geological Survey Sheet* 22)

The mapping of Sheet 22, with an overlap on all surrounding sheets, has been completed. Approximately 100 square miles have been surveyed in three widely separated and distinctive areas. A general revision is now in progress.

Area I extends from the coast near Prestwick north-eastwards to the village of Craigie and eastwards to the Parish of Sorn, where it reaches a maximum elevation of 750 feet. Sedimentary rocks underlie the greater part of the area, Productive Coal, Barren Red Measures, Calciferous, Old Red Sandstone and Permian Sandstones being represented. The topography alters from gently rolling in the west to undulating in the east. Basalt or Permian age forms the curving Mauchline Tarbolton ridge and also Barnweill Hill west of Fail Loch. On the hilly ground at Craigie teschenite, olivine-dolerite, and monchiquitic basalt sills occur. The River Cessnock, flowing north to the Irvine, the Water of Fail, a tributary of the River Ayr, and the Pow Burn, which flows out at Monkton, form the main drainage system.

Deep heavy-textured mixed till derived from the local rock formations, cover most of the ground. Soils developed on these tills show a general gradation from grey-brown podzolic in the west through gley to peaty gley in the east, associated with an increase in annual rainfall and decrease in temperature. Light-textured soils are restricted to the raised beach deposits fringing the coast and to small upland areas near Craigie, Barnweill and Mauchline where the till is extremely thin.

Dairy farming is the main agricultural activity.

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

Associations

1. Lanfine — *see* Annual Report 1951-52.
2. Bargour — *see* Annual Report 1950-51.
3. Kilmarnock — *see* Annual Report 1950-51.
4. Darleith — *see* Annual Report 1950-51.
5. Mauchline — New Association.
6. Sorn — New Association.

Alluvium

Hill and Basin Peat

Area II occupies the extreme north-east corner of Sheet 22, extending from Eaglesham northwards to the suburbs of Glasgow and eastwards to the new town of East Kilbride. Basalt lavas of Calciferous Sandstone age build up the high ground north and south of Eaglesham; they also form the Cathkin ridge. Sediments of the Carboniferous Limestone Series underlie the undulating ground around East Kilbride. The altitude range is from 200-700 feet. The area includes a section of the valley of the White Cart Water.

Heavy textured till on which gley soils are developed covers the lower ground. The high ground is relatively free of superficial deposits and shallow freely drained soils predominate, with frequent rock outcrops.

As in Area I, dairy farming is the main agricultural activity.

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

Associations

1. Darleith — *see* Annual Report 1950-51.
2. Kilmarnock — *see* Annual Report 1950-51.
3. Ashgrove — *see* Annual Report 1950-51.

Alluvium

Area III includes the coastal strip from West Kilbride to Largs and part of the Kilbirnie Hills which rise to 1584 feet at Irish Law. The lower undulating ground is underlain by sediments of Old Red Sandstone age which also extend some distance into the hills, but most of the high ground consists of basalt lavas of Calciferous age. Several intrusions of felsite, basalt and agglomerate form prominent features. The area is drained by numerous short streams flowing directly into the sea.

Raised beach deposits form a narrow coastal strip from West Kilbride to Largs. The drainage of the light-textured soils developed on these deposits is in places seriously affected by the presence of a rock platform close to the surface. The proportion of ground covered by deep till is much smaller than in Areas I. and II. Most of the cultivated soil is developed on a clay loam till of Old Red Sandstone origin and is imperfectly drained. Humus podzols, with or without iron pan, are common on the high ground and are particularly well-developed on the more acidic parent materials—Old Red Sandstone and felsite tills.

This area, unlike areas I and II, is not devoted entirely to dairy farming, the West Kilbride district being renowned particularly for early potatoes. Sheep farming is carried on in the hills.

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

Associations

1. Darleith *see* Annual Report 1950-51.
2. Amlaird *see* Annual Report 1950-51.
3. Dreghorn *see* Annual Report 1950-51.
4. Kirkland *see* Annual Report 1949-50.

Links

Alluvium

Hill and Basin Peat

SPECIAL SURVEYS

Detailed surveys on a scale of 6 inches to 1 mile were made of the following areas:

1. The flood-plain (alluvium) of the River Spey from Laggan Bridge to Grantown and of a major tributary, the River Dulnain, from Carrbridge to its mouth, an area of approximately 15,000 acres. Samples of mineral soil for mechanical analyses and samples of peat to assess the probable degree of shrinkage on draining were collected.
2. The West of Scotland Agricultural College Farm, Auchincruive, Ayrshire—660 acres.
3. The farm of Boghall and the Bush Estate, West Lothian, administered by the Edinburgh and East of Scotland College of Agriculture—approximately 3,000 acres.
4. The Hannah Dairy Research Institute Farm, Ayrshire—146 acres.
5. East Craigs Plant Breeding Research Station.
6. The Hill Farm of Lephinmore, Argyllshire, administered by the West of Scotland Agricultural College—3,951 acres.
7. Three areas of the Forestry Commission Glenisla State Forest, Angus, at Tulloch, Newton Burn and Clautschip.

A reconnaissance survey of the Beinn Eighe (Loch Maree) Nature Reserve Ross-shire, was made at the request of the Nature Conservancy (Scottish Committee). A report and map were prepared and a list of flora was made.

Representative profiles from all the above areas were collected and the information obtained will ultimately be incorporated in the systematic soil survey of Scotland.

Open-cast coal sites in the Cumnock and Muirkirk districts of Ayrshire have been inspected at the request of the Department of Agriculture for Scotland.

HEATHER SURVEY

Observations and experiments have been continued, the former being extended to representative areas in the Ochil and Pentland Hills, the mountainous region of South Perthshire and the Dunbartonshire Highlands.

In addition, a detailed ecological survey of Glensaugh Research Farm has been completed in collaboration with Mr Ian A. Nicholson of the North of Scotland College of Agriculture. By studying the structure and relationships of some of the more important plant associations within this localized area, it is hoped to establish a classification of broader application.

The work of co-ordinating the manurial top-dressing trials on hill land has been continued and the initial soil and botanical analyses have been completed at most centres. Special attention is being paid to the effect of the various treatments on heather areas.

During the field season, approximately 400 plant specimens were collected and identified. These have been incorporated in the herbarium which is being formed in association with the Department of Soil Organic Matter.

MAPS AND REPORTS

The Soil Survey (Scotland) memoir covering the areas about Huntly and Banff (Aberdeenshire and Banffshire), is being printed by Her Majesty's Stationery Office, and the accompanying maps, an integral part of the memoir, are ready for printing by the Ordnance Survey. It has been decided to standardize the form of publication of the Soil Survey memoirs of England and Wales and of Scotland.

LABORATORY INVESTIGATIONS AND COLLABORATIVE WORK

(*a*) Studies have continued on the air-space distribution in the horizons of soil series representative of the hydrologic sequences of various soil associations. Some examinations have been made of indurated horizons and other layers under wind-blown trees.

(*b*) Detailed mechanical analyses, using Wentworth Grade Sizes at logarithmic intervals, are being made of soils of a hydrologic sequence of the Hindhope Association (Silurian till), with a view to finding out the horizons where breakdown of minerals is taking place, and where clay accumulation is occurring.

(*c*) The distribution of manganese in various forms throughout the profiles of a hydrologic sequence of soils of the Laurencekirk Association—soils in which blue-black manganese staining is often apparent—has been investigated.

(*d*) Photographic work has been done in connection with the Heather Survey, and diagrams and illustrations have been compiled for prospective soil survey bulletins.

(*e*) Collaboration has been maintained with various departments of the Institute in—

(i) the selection of representative sites for field trials.

(ii) the supply of soils for clay investigations.

(iii) the selection of samples for a survey of the distribution of trace constituents throughout typical Scottish soil profiles.

Assistance has also been given to the Departments of Geology, Geography, Botany and Soil Science of the University of Aberdeen, and to the Forestry Commission.

SOIL GEOLOGY AND MINERALOGY

The study of the mineralogy of soils and their parent materials has been carried on by examining their fine sand fractions, in order to characterize them and to aid in defining soil associations. The materials examined were mainly soils and glacial drifts of mixed rock origin.

South-east Scotland

A survey was carried out on the soils and their parent materials from various farms in Berwickshire and East Lothian, as part of a joint investigation with the Animal Diseases Research Association. Samples of soil and herbage from typical areas were collected for further laboratory examination. The area is underlain by rocks of the Ordovician and Silurian systems, and consist mainly of shales, sandstones and greywackes. The lower ground is generally covered by glacial drift but this appears to be mainly local in origin.

Field work in connection with the sheep pining investigation was continued in Selkirkshire. The areas visited lie in the valleys of the Upper Yarrow Water and associated waters and are underlain by shales, grits and greywackes of Silurian age. The flat ground on the hill tops is generally peaty, while the steeper slopes of the hills are covered by a thin stony soil with frequent rock outcrops. The lower slopes and the valley bottoms are covered by a tough, compact boulder clay, formed mainly from the local rocks. Samples of typical soils were collected for laboratory examination to assist in determining areas for further experimental work by the Animal Diseases Research Association in this district.

X-RAY

The development of an internal standard method for quantitative mineralogical analysis of soil clays has been continued and an automatically recording photometer has been used to compare the densities of powder diffraction lines.

The examination of Scottish soil clays has continued. Dioctahedral illite has been found to be the dominant clay mineral in most soils on acidic rocks, while rocks containing ferromagnesian minerals usually give soils containing montmorillonite or vermiculite.

The study of the clay fraction of Turkish forest soils has been continued. Some Australian soils have been examined, and the results have agreed well with those obtained by differential thermal analysis. Large amounts of gibbsite and haematite were found in some of the red Australian soils.

Rock Weathering

A mineralogical analysis of samples from the Inter-Basaltic beds of County Antrim has been started in collaboration with the Department of Geology of the University of St. Andrews.

Differences between contemporary and Carboniferous weathering of Lower Carboniferous basalts in Kintyre have been studied in samples taken from surface exposures and from below the Coal Measures in the Argyll colliery at Machrihanish. The influence of carbonaceous solutions from the Coal Measures was seen in the pale colour of the underlying weathered basalts.

Optical and X-ray methods have been used in an investigation into the changes on weathering in sedimentary and igneous rocks from Ayrshire and Roxburghshire, which has been started in collaboration with the Section for Physical Chemistry.

Techniques

A new method for making oriented aggregate specimens of clay for X-ray analysis has been developed and is now in routine use. The specimens are made by pressing the dry clay between two flat, polished steel surfaces. This produces parallel orientation of the platy clay mineral crystals, and is much more rapid than the sedimentation method. A paper describing this technique has been accepted for publication in the Clay Minerals Bulletin[29].

General

A note on calcined cold-precipitated hydrated iron oxide has been published in Mining Engineering[1].

Collaborating with the Section for Physical Chemistry, the work on the effects of grinding on micas has been continued, and two papers have been published[2, 3].

A chapter on the clay minerals has been written for the Soil Survey (Scotland) memoir to Ordnance Survey Sheets 86 and 96[31].

PHYSICAL CHEMISTRY

Differential Thermal Analysis

The routine differential thermal analysis investigation of Scottish soil clays has continued, with the examination of samples from Banffshire, Aberdeenshire and Kincardineshire. Hydrous mica has again proved to be in general the major component of these clays. One clay from a soil developed upon serpentine was of particular interest, as it showed a considerable amount of antigorite, especially in the surface layers of the well-drained profile. Some soil clays from other countries, for example, Algeria and Malaya, have also been investigated, in collaboration with the X-ray Section, and a special study has been made of clays from Australian Krasnozems.

Some experiments on precipitated aluminium oxides, parallelling those on iron oxides, have also been carried out during the year. A description of the initial work on iron oxides has now been published[4].

Among minerals investigated during the year have been quartz, vermiculites, dolomites, bauxites, some minerals from Spain, and some further samples of kaolinite from Pugu, Tanganyika. A paper describing the work on this kaolinite has now been accepted for publication[30]. The study of the effect of grinding upon pure samples of micas has been continued in collaboration with the X-ray Section, and two papers on this work have now appeared[2, 3].

During the year work has begun on the investigation of the decomposition products of rocks (whether by sub-aerial or by hydrothermal means) and correlation with the clay mineralogy of soils derived from these rocks. Samples of fresh and weathered rocks have been collected from Roxburghshire and Ayrshire for this purpose.

A paper on the international standardization of differential thermal analysis technique, presented at last year's International Geological Congress[27], and a paper summarizing the lectures delivered in Madrid last year[26] are in press. The critique of Arens' theory of differential thermal analysis[5] and the account of the work carried out at the Institute by Dr M. Muñoz Taboadela[6] have now appeared.

Clay Mineral Separation

The constant-flow electrophoresis cell referred to last year has been used in an attempt to separate kaolinite and montmorillonite from mixtures. Clays saturated with La^{3+} were first used, and concentration of one component with respect to the other, although not complete separation, was observed. In attempting to increase this concentration difference, difficulty was experienced with coagulation. In consequence, Ca-saturated materials were tried, but other difficulties were encountered. During this investigation a technique employing vacuum distillation at low temperatures has been evolved for the concentration of very dilute clay suspensions without coagulation. Further work is in progress. An account of the work to date was read as a paper at a meeting of the Clay Minerals Group in April, 1953.

Chemical Studies

Accounts of the work on the development of satisfactory methods for free iron oxide removal from soils and clays have been accepted for publication[25,28]. Semi-micro methods of analysis have been used for the further investigation of the grinding products of the micas—muscovite and biotite.

SOIL ANALYSIS

Routine analyses have been completed on the samples taken by the Soil Survey Officers during 1951 (comprising 630 samples, representing 123 profiles) and on a number of samples taken during 1952.

Three profiles—12 samples—have been examined for the Forestry Commission.

Routine analyses have been done on 26 samples from the Sands of Forvie, and on 11 of these samples more detailed analyses (free iron oxide and silica-sesquioxide ratio determinations) have been carried out. Twenty-five samples have been analysed for the Department of Plant Physiology. Eight samples have been examined for the Department of Botany, University of Aberdeen. One profile (5 samples from Norway) has been analysed for water-soluble salts.

Further work on a method for determining exchangeable aluminium in soils has been carried out.

Preliminary studies on a method for improved dispersion of soils for mechanical analysis have been started.

SPECTROCHEMISTRY

The Department of Spectrochemistry is engaged in the analysis of soils, plants and related materials by spectrochemical and other physical methods. Much of the work is in collaboration with other departments of the Institute, or with outside Institutions, and details of practical applications of the results from the agricultural standpoint are to be found in the relevant sections of this report. In addition to this service of analytical determinations carried out on a large scale by methods which have been developed in the Department, a considerable amount of time is being devoted to the development of extraction and pretreatment techniques in relation to the interpretation of the results obtained from the analysis of soils and plants. Other applied research being carried out in the Department relates to the geochemical distribution of trace elements in rocks and soil parent materials and their behaviour in the course of soil development. The investigation of spectrochemical methods involves considerable development work on instrumental design and electronic techniques. Difficulties in accommodation are causing some delay in this work.

New equipment added during the year includes a Grubb Parsons S4 Infra-red Spectrometer. This is being set up initially as a single beam unit, pending the delivery of the associated double beam source unit. A second Ecam C.1. all-glass still for the supply of distilled water has been obtained, in view of the efficiency and convenience of this type of equipment.

The punched card filing system for the recording of analytical work, introduced on the recommendation of the Consultative Committee for the Development of Spectrographic Work, has been in use for over a year and is proving of considerable value, facilitating reference to filed results appreciably.

Members of the Departmental staff have attended meetings of the Consultative Committee for the Development of Spectrographic Work, the Interservices-D.S.I.R. Panel on Emission Spectroscopy, the A.R.C. Group on Mineral Deficiencies and Excesses in Animals, the Glasgow Spectrographic Discussion Group, the Infra-Red Discussion Group, and the Physical Methods Group of the Society of Public Analysts to which a review paper on semi-quantitative methods of spectrochemical analysis was presented. Contact with the developments occurring in the various branches of research has also been maintained by numerous visits to other laboratories, including the Theodor Kocher Institute in Berne.

Training in the methods of spectrochemical analysis has been given to a number of visiting workers, including Mr G. Jefford (Geological Survey, Nigeria), Mr R. K. Richardson (Department of Agriculture, Jamaica) and Mr E. L. Strmecki (University of Ljubljana, Yugoslavia).

SPECTROCHEMICAL METHODS OF ANALYSIS

(*a*) *Flame Emission*

The use of flame emission methods is becoming restricted more and more to the determination of potassium, sodium and calcium by flame photometry. This tendency has been more pronounced this year, following the development here of the porous cup solution spark technique for magnesium; the original Lundegardh technique has been used mainly for solution samples in which the determination of manganese is required. and for certain specialized applications, such as the determination of rubidium and caesium in solutions submitted by the Department of Chemistry of the University of Aberdeen.

The use of the flame photometer mentioned in earlier reports is increasing and demands by the Department of Soil Fertility and other departments for determinations of potassium, sodium and calcium in upwards of 100 soil or plant extracts per day are readily met. Development of methods of flame photometry is proceeding, particularly in the direction of integrating techniques for low contents of potassium.

(*b*) *Arc Emission*

The determination of trace elements in concentrates derived from soils, plants or biological materials by the cathode layer direct current arc method remains the chief occupation of the Department. This technique, when the procedure developed in the Department is followed strictly, gives very satisfactory reproducibility and adequate sensitivity, despite reports to the contrary from one or two other laboratories. Full particulars have not been published in the instances in question, but it is possible that the electrodes have not been accurately machined to the prescribed dimensions, or even that graphite is being used instead of carbon for the electrodes. In all spectrochemical techniques careful attention to detail and regular standardization is essential, and it is for this reason and in view of the extent of the standardization, that the method is better applied to the serial determination of a number of similar samples for a number of constituents rather than to the determination of one or two elements in but a few samples.

In the course of the year some 2,000 samples of soil extracts, plant materials, animal organs, waters and other materials have been analysed for up to 16 trace elements. This figure is an increase of some 10 per cent. over previous years. The method has been extended to include gold, which has been determined in urine samples following gold therapy.

The description of the electrode cutting tool, mentioned in last year's report, has now been published[7].

(*c*) *Spark Emission*

The porous cup solution spark technique has been studied further, with particular reference to the determination of certain trace elements, notably copper and boron. Tentative methods for the determination of copper extracted from soils by dilute acetic acid, boron in plant materials and fertilizers, and calcium and magnesium in dilute soil extracts have been developed.

This technique is exceedingly versatile and is perhaps the spectrochemical method most generally applicable to the determination of many of the major and some of the trace constituents in plant materials and soil extracts. It is

particularly adaptable to such special determinations as the determination of manganese at the microgram level in samples of wheat embryo and scutellum, an investigation carried out on behalf of the Research Association of British-Flour-Millers.

(*d*) *Photometry*

Modifications to the Hilger Non-Recording Spectral Line Microphotometer include the incorporation of a parallel glass plate in the galvanometer beam of the Galvoscale Unit for zero setting and the use of electronically stabilized power pack for the galvanometer lamp. A power pack of adequate output and stability for the purpose has been designed and built in the Department.

The construction of a new multi-purpose microphotometer is in progress. This instrument is for use in conjunction with the display microphotometer with image-converter scanning mentioned in previous annual reports.

The Respectra Calculating Board has proved of considerable value in certain of the methods of analysis in use, particularly the determination of magnesium by the porous cup solution spark method. After certain modifications, the Hilger Projection Comparator has proved useful in the assessment of contents by semi-quantitative techniques.

TRACE CONSTITUENTS IN SOILS, PLANTS AND BIOLOGICAL MATERIALS

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

The investigation of the distribution of trace elements in soil profiles has been continued and extended to soils from South Scotland: the results obtained confirm previous findings, and the chief points of interest may be summarized briefly; full results will be published elsewhere in due course. In general, little or no profile differentiation can be observed when total contents are considered, although there is some indication of lead accumulation in surface layers of most soils. Greater differences are observed when the amounts of trace elements extracted from different horizons by various types of extractant are compared. In particular the effect of impeded drainage (gleying) in increasing the solubility of cobalt, nickel, iron and vanadium has been confirmed. In the lower layers of certain profiles derived from basic igneous rocks, up to 25 per cent. of the cobalt and nickel is soluble in dilute acetic acid. This effect is much greater in magnitude than that of other pedological processes: some accumulation in the illuvial horizon of podzols has however been observed, and work on this type of soil is being continued. Most of the determinations on soil profiles have been on Scottish soils, but a few Australian examples have also been examined.

With these investigations are associated geochemical studies of the total contents of different rock types; and, in collaboration with Professor L. R. Wager (University of Oxford), a study of some basic rocks of Hawaii has been published[8].

As noted above, a method is now available for the determination of copper in soil extracts, and the relationship of extractable copper to plant uptake is being studied.

Many of the samples received from the Department of Soil Fertility are for the determination of extractable cobalt in areas where animal disorders occur and a number of soils of low cobalt content (< 0.2 p.p.m. soluble in dilute acetic acid) have been encountered, particularly from the counties of Moray and Nairn.

The systematic examination of soils from selected areas for extractable cobalt has been continued, and a considerable number of samples from the south of Scotland, chiefly from Selkirkshire, have been analysed.

(*b*) *Plant Materials*

A large number of determinations have been carried out on samples from various experimental areas in order to ascertain normal contents of trace elements in different types of plant material and the effect thereon of different manurial treatments. Work of this nature in association with the Hannah Dairy Research Institute has been reported in previous years; areas in Aberdeenshire with experimental treatments of fertilizers, lime, and certain trace elements have been examined this year for some 15 trace constituents.

Other investigations have included analyses of produce samples from farms where acetonaemia occurs, in collaboration with the Animal Diseases Research Association, of grain and straw from areas of suspected low copper content where cereal disorders are reported, and, on behalf of the Department of Plant Physiology, of a considerable number of oats seedlings, particularly for nickel.

Samples submitted from external sources have included various plant materials from National Agricultural Advisory Service centres, samples of tea from Nyasaland and of groundnuts from French colonies in Africa, the last submitted for comparative check analysis.

(*c*) *Miscellaneous Samples*

Among the many miscellaneous types of samples which have been examined in the course of the year may be mentioned a number of well, spring and river waters on behalf of the National Vegetable Research Station in connection with their investigation of Crook Root in water cress, a fungal disease widespread in the south of England. Comprehensive trace element examinations of some 15 samples have been carried out, and this work is being continued and extended.

Analyses of materials of animal origin have included determinations of trace elements in sheep and cattle livers from the Animal Diseases Research Association and Veterinary Investigation Officers and in rats' teeth dentin and enamel from the Dunn Nutritional Laboratory in Cambridge, and of gold in urine samples obtained following gold therapy submitted by the Biochemical Laboratory of the Northern General Hospital, Edinburgh.

ABSORPTION SPECTROMETRY OF SOIL ORGANIC MATTER

Studies on the lignin of sphagnum and of other peat-forming plants have continued. It has been established that dilute acid hydrolysis of sphagnum liberates the lignin as a water-soluble lignin:carbohydrate complex, and an account of the work has been published[9]. Continued hydrolysis splits off

the carbohydrate part of the molecule, but the lignin becomes altered in the process, and tends to form dark coloured artifacts. Methods are being sought which will stabilize the lignin molecule and so permit its isolation unchanged. The Department of Soil Organic Matter is co-operating in this work.

The nitrobenzene oxidation of sphagnum yields 0.8 per cent. *p*-hydroxybenzaldehyde. When the sphagnum is first methylated with diazomethane, the oxidation yields only traces of this aldehyde. Oxidation of this methylated sphagnum with neutral permanganate yields about 3 per cent. *p*-methoxybenzoic acid, along with smaller amounts of other aromatic acids not yet identified. These results indicate that a *p*-hydroxyphenyl building unit plays as important a part in the structure of the lignin of sphagnum as does a 4-hydroxy-3-methoxyphenyl unit in the lignin of conifers. They indicate further that the phenolic group of this building unit is free in sphagnum.

A preliminary study of the lignin of phragmites has been made. In common with that of other monocotyledons much of this lignin may be extracted by cold dilute alkali. The water-soluble fraction of this extract has been found to contain *p*-hydroxycinnamic acid, together with a smaller amount of ferulic acid. The absorption spectrum of *p*-hydrocinnamic acid has a maximum at 308 mμ. It is perhaps significant that the absorption spectrum of the ethanol lignin of phragmites, and that reported for native lignin of bagasse both have maxima at this wavelength, not shown by lignins from wood.

SOIL ORGANIC MATTER

The general aim of the Department is the study of soil organic matter and its transformations, particularly by chemical and microbiological methods; the sections of Forest Soils and Peat deal with these soils from both the investigative and advisory aspects.

CHEMISTRY

Carbohydrates

Work on the soluble polysaccharides isolated from soil and peat has been continued. The techniques used previously (chromatography of the polysaccharide hydrolysate on paper and on a column of powdered cellulose in conjunction with an automatic fraction cutter) do not separate or distinguish ribose from fucose. By the recently introduced technique of Waldron (*Nature, Lond.*, **170**, 461, 1952) fucose, and substances similarly giving acetaldehyde on oxidation with sodium metaperiodate, can be detected on the paper chromatogram, either when alone or when mixed with other sugars. An examination of the polysaccharide isolated from various north-east Scotland soils by this method showed that fucose was present. The sugar was also found in samples of peat (Lewis, *Trichophorum* (scirpus); Netherley, sphagnum; Redhills, phragmites). In one case (Craigiebuckler surface soil), the fucose-containing fraction was obtained in quantity sufficient for the presence of the sugar to be confirmed and its configuration determined by isolation of the crystalline phenylmethylhydrazone with physical properties (including the X-ray diffraction pattern) identical with those obtained for authentic L-fucose phenylmethylhydrazone. The ribose-fucose fraction contained a minimum of 30 per cent. L-fucose. It is possible that the remainder of the fraction consists of ribose (cf. Forsyth, *Biochem. J.*, **46**, 141, 1950).

Fucose amounts to only a small proportion (0.5 per cent.) of the soluble polysaccharide fraction from Craigiebuckler soil, corresponding to about 20 lb. of the sugar per acre of the original soil. The sugar is thought to be of microbial origin as bacteria isolated from Dunnottar soil (Webley & Forsyth, *J. gen. Microbiol.*, **3**, 395, 1949) grown on synthetic media produce a polysaccharide containing a small quantity of fucose. As far as is known, this is the first report of the presence of fucose in a microbial polysaccharide. This work has been published[10].

From time to time, work has been continued with a view to identifying the interesting series of methylated sugars obtained in small quantity from soil, peat and compost (Duff, *J. Sci. Fd. Agric.*, **3**, 140, 1952; *Ann. Rept. Macaulay Inst.*, 1951-52). Specimens of sugars thought to have properties similar to these have been obtained (from Professor T. Reichstein of Basle, from Dr J. Baddiley of the Lister Institute, and other sources) and compared with the soil

sugars on the paper chromatogram. In all cases differences were observed and the problem of the constitution of these methylated sugars remains unsolved. In the case of one sugar-containing substance obtained from natural sources, the carbohydrate moeity was found to be extremely sensitive to heat and (it now appears) traces of alkali contained in the paper of a chromatogram. Either one or two spots could be obtained after development, depending on whether the spot initially applied to the chromatogram was dried at room temperature or at 100-110°C. Some of the common sugars were found to exhibit this effect in that aldose and the corresponding ketose sugars were interconvertible to some extent. A quantitative study of the interconversion process was made in the case of glucose and fructose. The effect was explained by the presence of alkaline impurities in water eluted from the paper of the chromatogram, which altered the pH and which were detected by analyses carried out by the Department of Spectrochemistry. A useful application of this effect consists of the rapid and easy distinction of sugars which otherwise behave similarly on the paper chromatogram, for example, glucose and galactose. This work has been published[11].

The "fungus cellulose" obtained from *Polyporus betulinus* is of interest in that preliminary work (Duff, *J. Chem. Soc.*, 2592, 1952) has shown that the material contains α-1 : 3 linked anhydroglucose residues. A procedure has been devised yielding a product which appears to be homogeneous, and the properties of this material are now being determined.

Work is in progress on the development of a convenient method of estimating the total (soluble and insoluble) carbohydrate content of soil. Preliminary work has shown that the proposed method gives higher values than those obtained by the Waksman procedure.

Nitrogenous Compounds: the Humus Complex

A paper dealing with the isolation of L-pipecolinic acid from *Trifolium repens* has been published[12].

It is known that humic acid—the alkali-soluble, acid-insoluble fraction of soil organic matter—contains amino-acids which can be separated by hydrolysis with acid or alkali, and although there are grounds for the belief that these amino-acids are present in the form of protein, there seems to be no direct evidence of this and it seems at least possible that they might be individually combined with the humic material. Some experiments have now been performed, in which the course of hydrolysis of humic acid by concentrated hydrochloric acid at 37°C. has been followed by means of paper chromatography, and in the intermediate stages of the hydrolysis the presence of peptides has been detected in the products. Moreover, the general course of the hydrolysis as revealed by paper chromatography, has corresponded closely with that of typical proteins, for example casein, hydrolysed under similar conditions. These results, though not conclusive, appear to support the view that protein is indeed present. This work is continuing and efforts are being made to isolate relatively intact protein from humic acids.

The study of high pressure catalytic hydrogenation of humic acids has continued, but the results so far obtained have failed to provide any additional information on the constitution of the humic acids.

The oxidation of various humic acids by nitrobenzene in the presence of alkali has been found to yield small quantities of vanillin, syringaldehyde and *p*-hydroxybenzaldehyde which could be separated and identified by means of paper-chromatography. Of the humic acid types examined, that from a peat produced the highest yield of aldehydes (2 per cent.); a humic acid from grass compost gave a somewhat lower yield, but the yield from a brown earth humic acid was very much lower. Since it is known that relatively high yields (up to 26 per cent.) of these phenolic aldehydes may be obtained from lignins under such conditions of oxidation, this result appears to provide support for the view that humic acids are derived at least in part directly from lignin. Efforts are being made to isolate and identify an unknown aldehyde detected among the products of alkali-nitrobenzene oxidation of a *Phragmites* peat.

The identification of amino-acids in various materials has been performed on behalf of the Department of Plant Physiology and in *Micromonospora vulgaris* for Mrs Oxford, Agricultural Research Council.

MICROBIOLOGY

Rhizosphere Studies

The investigation of the rhizosphere of salt marsh plants has been continued. It was found that the root-surface flora of *Glyceria maritima*, a dominant plant of the salt marshes at St. Cyrus, Kincardineshire, was unaffected by sea water and 3 per cent. sodium chloride. *Senecio jacoboea*, growing to the landward side of the dunes near the salt marsh, carried a root-surface flora the growth of which, on the other hand, was markedly affected by sea-water and 3 per cent. sodium chloride.

Thermophilic Organisms

A paper[13] on the respiration at 60°C. of the thermophilic actinomycete *Micromonospora vulgaris* was published in collaboration with Mrs Oxford of the Agricultural Research Council. By the use of the Warburg technique and of special cultural methods and heat treatments, it was found possible to separate the growth phases of this structurally complex organism. It appears that the metabolic activity of the organism resides in the aerial mycelium. Spores were inactive as measured by the technique used, as was also vegetative mycelium harvested from culture flasks; but vegetative mycelium developing from spores *in situ* in Warburg vessels proved to be metabolically active. Further work on the high temperature metabolism of *M. vulgaris* was presented in a paper to the Sixth International Congress of Microbiology in Rome (September, 1953). The salient feature of this part of the work was the unexpected finding that pure oxygen at one atmosphere inhibits the respiration of this aerobic organism. It was also found that inhibitors specifically affecting the -SH groups in enzymes (for example, *p*-chloro-mercuri-benzoate) were inhibitory to the respiration at high dilutions (for example, M/35,000). A correlation between oxygen inhibition and the inactivation of -SH groups in trials containing the enzyme from the organism is suggested. This aspect of the work is being continued and extended.

Paraffin Decomposing Organisms

Work already reported on these organisms is being continued. In addition, special attention is being paid to the effect of vegetable oils, triglycerides, plant and soil waxes, and surface active agents on the growth and metabolism of strains of *Nocardia opaca. N. salmonella*, and *N. paraffinae*.

The paper[14] describing a simple method for obtaining micro-cultures in hanging drops, especially in oils, has now been published.

Mycological Studies

Work has been continued on a study of fungi concerned with the degradation of lignin in the soil. The work has fallen into two main sections—(*a*) a study of the distribution of such fungi, and (*b*) a study of their metabolism. In view of the present state of knowledge of the chemical structure of lignin and uncertainty regarding the purity of preparations, experiments have been based on the reactions of fungi, through their phenol oxidase systems, on various aromatic compounds which are believed to be structurally related to lignin.

Preliminary distribution studies were made in the autumn of last year and further investigations are being carried out at present. Soil samples for mycological analysis have been collected from various soil types with attention directed principally to the vegetation type. The areas studied include sand-dunes, woodland (both coniferous and broad-leaved), peat moss, heath, moorland and grassland. Fungi from the samples have been enumerated and isolated by means of the plate dilution technique. The addition of tannic acid to the medium permits the isolation of phenol-oxidizing fungi, which produce round the growing colonies a distinctive brown coloration, due to the oxidation of the acid. A considerable number of fungi capable of performing this oxidation have been isolated, with different species predominating in different types of ground. The isolation of macro-fungi cannot be carried out by means of this technique, but several of these have been isolated directly from fructifications collected from tree stumps.

Metabolic studies have been made on those fungi which were isolated in the preliminary distribution work. The activity of their phenol oxidases has been investigated by means of growth experiments and of respiration studies by means of the Warburg technique. Growth experiments revealed the ability of certain of the soil micro-organisms to utilize phenols as a source of carbon, a property not possessed by the macro-fungi. An example of this was *Penicillium sp.* which developed as well on gallic acid as on glucose. The utilization of these substrates by this organism was also studied in the Warburg apparatus, but considerable difficulty has been experienced hitherto, due to the high rate of endogenous respiration. In addition, polyphenolase activity was found in extracts prepared from fructification of macro-fungi.

It would appear that the methods of attack on phenols shown by micro- and macro-fungi are basically different; only the former are able to utilize these compounds as a source of carbon.

PEAT

Routine Work

As in previous years, this has continued mainly in conjunction with the Department of Agriculture for Scotland (Peat Division). A total of 769 samples from the mosses of Flanders West and Strathy-Halladale has been examined and analysed. Additional help with the preparation and presentation of data was given.

About 50 samples from other sources have also been dealt with.

A visit was paid to the Strathy-Halladale Moss during which a brief description of the main vegetational features was prepared. This has been submitted to the Department of Agriculture for Scotland (Peat Division).

Samples for the spectrochemical determination of trace elements have been taken from various mosses.

Pollen Analysis

Pollen diagrams of profiles taken from the basin peats at St. Fergus and Burreldale, Aberdeenshire, have been completed. Diagrams of profiles from Airds Moss, Ayrshire and Goyle Hill, Kincardineshire are in preparation.

Peat profiles from four deposits in the Beinn Eighe Nature Reserve were sampled and are now undergoing preparation for pollen analysis. A deep profile from the Strathy-Halladale blanket moss was also sampled with a view to carrying out pollen analysis.

FOREST SOILS

The study of profile development as a result of the fixation and afforestation of the Culbin sand dunes has been completed. In addition to the results of the soil moisture and temperature investigations previously reported (Ann. Rept. 1951-52), mechanical analysis of the sand from both planted and unplanted dunes shows that variations in grain size may be ascribed to topographical irregularities rather than to the effect of tree growth. Chemical analysis of the sand indicates that profile development by leaching begins as soon as the sand is stabilized, and that afforestation initiates a circulation of nutrients, which is superimposed on this downward leaching.

Nutrient content of the sand is found to be lowest under young trees; after the closure of canopy, enrichment of the surface soil from the litter begins, although depletion at rooting depths is still discernible. Analysis of incubated samples of surface soil from plots bearing trees shows that the rate of ammonification tends to increase with the age of the crop, but that it is more rapid under Corsican than Scots Pine; production of nitrite or nitrate during incubation was not observed.

Chemical analysis of the litter collected from the sample plots over a full year shows that at Culbin there is an abnormally abrupt decrease in the amount of calcium, potassium, sodium and magnesium contained in the litter collected in the July-August period. It is known from the results of the moisture investigations that moisture deficiency reaches a maximum in the afforested dunes towards the end of June, and it is possible that the deficiency is sufficiently severe to interfere with the nutrient uptake by the trees. In

order to investigate this point more fully, periodic analyses are being made of foliage samples collected from Corsican Pine in temporary thinning plots established at Culbin by the Forestry Commission.

An experimental apparatus for the measurement of soil moisture by the method of neutron scattering has been completed with the assistance of the Section for Radioactive Studies. It has been shown to be capable of recording the mositure content of a garden soil under laboratory conditions, and further development work is proceeding.

Advisory work on forest soils has been carried out in co-operation with the Department of Soil Fertility on behalf of the Forestry Commission and other bodies.

FIELD AND GLASSHOUSE EXPERIMENTAL WORK

From work on the use of Krilium as a soil conditioner in the Greenhouse, it has been found that with (*a*) a heavy silty clay soil, (*b*) a humose soil, and (*c*) a light sandy silt soil, no detectible improvement in the rate of growth of tomato plants took place. During the present season, trials have been carried out on the manurial effects of seaweeds supplied by the Institute of Seaweed Research. Preliminary results indicate that the effect of adding seaweed to greenhouse soil is not a simple one.

PLANT PHYSIOLOGY

Work of the past year has been in part a continuation of previous studies and partly the introduction of new physiological and biochemical techniques. Fundamental studies are being carried out on salt uptake and the influence of ions and compounds on metabolic precesses investigated.

Phosphate Absorption

The absorption of phosphate by washed sugar beet disks has been studied, using a Warburg respirometer constructed in the Department. Various organic soil constituents and related substances have been shown to increase phosphate absorption to a marked extent. Particular attention has been paid to the humic acids, as recent work had indicated that many physiologically important metal ions occur in the soil in the form of chelates of humic acid. Radioactive phosphorus has been used in these studies with great advantage. Tedious chemical analysis is reduced and the difficulty of phosphorus determination in deeply coloured solutions eliminated.

The physiology of starving sugar beet disks has been investigated, employing chromatographic techniques. It has been found that fructose, amino acids and phosphate are rapidly lost from the disks whereas sucrose gradually decreases. The ability to absorb phosphate from solution only becomes appreciable when the total phosphorus in the disk has fallen to a low level. There is, however, no reduction in the polyphenolase activity. Other enzyme studies are being carried out.

The form in which absorbed phosphate appears in sugar beet tissues has been investigated by a combination of radioactive tracer and paper chromatographic techniques. A considerable proportion of the absorbed phosphate appears as hexose diphosphate.

A study on the fertilizing action of a Yugoslav brown coal has been carried out. The coal was fractionated and the growth promoting effect of these fractions observed in water culture. From results so far obtained, it would appear that the humate content is largely responsible for the growth promoting effect. Comparative experiments were carried out with humic acids and ethylene diamine tetra-acetic acid (E.D.T.A.) and the superior effect of the latter established. Complementary physiological studies have been made on the effect of E.D.T.A. and its metal complexes on respiration and salt absorption.

Nickel Toxicity

The study of the relationship between nickel toxicity and iron supply continues. Aspects of the work dealing with the effects of a high level iron supply and pH on the intensity of the toxic symptoms produced in oat plants have now been completed and a paper is in preparation. The influence on toxicity of the iron-nickel ratio as opposed to the absolute level of

nickel supplied is now under investigation. Necrosis is prevented in oats grown in water culture receiving 1 p.p.m. nickel if the ratio is 5 or more, and the nickel level can be increased to 2.4 p.p.m. in the nutrient solution without producing necrosis if the ratio is increased to 10.

Oat plants raised in nutrient solutions containing a high level of iron were transferred to solutions of varying iron-nickel ratio. With the initial high iron supply the toxicity symptoms produced were as severe as in plants raised on normal levels of iron. This suggests that the governing factors influencing toxicity are the nickel level and the iron-nickel ratio in the substrate.

A further examination has been made of the effect of a high level phosphorus supply in intensifying the toxicity symptoms produced by nickel. A possible explanation is the precipitation or immobilization of iron by the excess phosphorus present, thus allowing nickel to exert its full toxic effect. Preliminary experiments with oats in sand culture have suggested that the effect is too great to be explained on this basis alone.

The lack of toxicity symptoms in certain legumes led to an examination of the effect of different nitrogen sources on the uptake of nickel. For oats and sugar beet, nickel uptake appears to be independent of nitrogen source.

The investigation of the effects of toxic levels of various heavy metals on iron absorption and metabolism has now been completed. The effect of adding a second heavy metal on the uptake of nickel and symptoms of nickel toxicity has been examined. In general, toxicity symptoms are intensified, but in the case of copper a beneficial effect is observed. These findings, together with descriptions of the symptoms produced in oat plants by the individual metals have been embodied in a paper which has been accepted for publication[24].

A paper dealing with the anatomical changes induced in the oat plant by nickel or cobalt toxicity has now been published[15].

Mineral Composition of Bracken

A paper dealing with the major and trace element composition of bracken has now been published[16].

Collaborative

Observations have been carried out on the occurrence of June Yellows in Auchincruive Climax strawberries at the request of the North of Scotland College of Agriculture. Plot experiments have been laid down and various biochemical analyses made. Advisory and experimental work has been continued in collaboration with the Department of Soil Fertility.

Chemical Methods of Analysis

A turbidimetric method for the determination of calcium in plants and soils has now been published[17].

RADIOACTIVE STUDIES

Phosphate Absorption Studies

As mentioned above, the radioactive tracer technique has proved useful in the work on the absorption of phosphate by sugar beet tissue. Results

deduced by radioactive measurements agree with those obtained by conventional analytical methods. The value of the method has been shown in the estimation of phosphate in solutions which would have proved difficult to analyse chemically due to the presence of interfering substances. Another advantage of the radioactive technique is the sensitivity in locating labelled compounds on chromatograms and in detecting absorbed phosphate within the tissue by autoradiography.

Soil Phosphate Studies

Soil experiments with radioactive phosphorus have been continued in collaboration with the Department of Soil Fertility.

In the pot experiments work has been concentrated on the determination of the plant available phosphate in a range of granitic soils. The objective has been to obtain a sufficient number of results to enable a statistical assessment to be made of the value of the radioactive method when compared with crop yields and chemical extraction methods for estimating the phosphorus status of soils. A number of Australian Krasnozem soils have also been examined.

Complementary laboratory experiments have been made on a range of soils to determine the solid phase phosphate.

Determination of Soil Moisture

A radioactive method has been studied with the section for Forest Soils. The apparatus constructed has been found adequate for the study of soil in the laboratory. Several factors influencing the determination of soil moisture have been examined.

SOIL FERTILITY—CHEMISTRY AND FIELD EXPERIMENTATION

Field experiments, pot experiments and laboratory studies continue to be the basis of the programme of work which has as its ultimate object the improvement of soil fertility in the broad sense of improving both the yield and the feeding quality of crops. The practical implications of both recently published and current work have been discussed in addresses given to various agricultural and technical bodies during the year. Collaborative work with other research organizations both directly and through the agency of technical committees has been continued. An account of joint work with the Hannah Dairy Research Institute on the manuring of grassland with special reference to the effects of heavy dressings of nitrogen on the mineral composition of the herbage has been published[18]. The results indicate that high yields of pasture herbage of high protein and normal mineral contents can be maintained over a period of years by the use of fertilizer nitrogen, provided adequate fertilizer dressings of other major nutrients are given. Attention has also been drawn to various ion antagonism effects which may influence the mineral composition of the herbage. Two short papers on manuring for the establishment and maintenance of pasture and on cobalt deficiency in pastures in Great Britain, which were mentioned in last year's report, have now been published[19, 20]. The paper dealing with factors affecting phosphate usage in Great Britain, which was presented at a symposium on soil fertilizer phosphorus in crop production held in the United States in 1952, has been published as a chapter in a special monograph prepared under the auspices of the American Society of Agronomy[21].

FIELD EXPERIMENTS

By means of experiments designed according to modern statistical requirements further basic field information has been obtained in the investigation of: general problems of liming and manuring; the agronomic characterization of different types of soil identified in the soil survey of Scotland; the effects of different times and methods of applying fertilizers; response to magnesium and such trace elements as manganese and copper in specific problem areas. The results for the 1952 experiments on the occurrence of blind ears in oats on a moderately acid soil show that the application of copper sulphate produced a small but significant increase in the yield and also in the volume-weight of grain. Other trace element work has involved studies of the effects of copper, molybdenum and zinc on the growth and composition of pasture plants. Experiments on the effects of various manganese supplements on the growth of oats on calcareous soils in the north of Scotland have been continued in collaboration with the North of Scotland College of Agriculture. As in previous years special attention continues to be given to the study of:

Phosphate Relationships of Soils

In these investigations attention has been concentrated on extending and broadening the characterization of the main soil types in terms of responses shown by different crops and the residual effects of phosphate in the presence and absence of lime. In the latter experiments, a new design permitting continued evaluation of phosphate residues in terms of fresh dressings applied to successive crops is being used. Experiments have also been continued on the positional availability of phosphate residues as affected by ploughing and cultivations, on the effectiveness of different forms of phosphate and on the effect of time of application with particular reference to the phosphate manuring of grassland. An evaluation of the effects of time of application and of ploughing and cultivation on the effectiveness of phosphate applied for arable crops is in progress.

Methods of Fertilizer Application

With oats, combine drilling of fertilizer with the seed is generally the most effective method of application. Broadcasting after seeding, broadcasting on the seed bed and broadcasting on the ploughed surface before cultivation appear to be equally effective, but all are considerably inferior to drilling. In three fertilizer placement experiments on potatoes, which were carried out in collaboration with the North of Scotland College of Agriculture, the following results have been obtained. At the 5 cwt. per acre rate of fertilizer application, broadcasting on the flat before ridging was slightly but not significantly inferior to placing the fertilizer either in contact with the seed tubers or at a depth of one inch below and three inches to the side of the tubers. At higher levels of fertilizer application there were no differences between the three methods of applying the fertilizer mixture.

With turnips and swedes further data have been obtained in support of the previous finding that placing superphosphate directly below the seed is superior to broadcast application. The 1952 results, a report on which has been submitted to the Agricultural Research Council, suggest that it is safer to broadcast than to place muriate of potash directly below the seed, but that the effectiveness of placing superphosphate is not reduced by placing muriate of potash along with it. The placing of a mixture of sulphate of ammonia and muriate of potash directly below the seed reduced both the number of plants and the ultimate yield, but when the mixture is placed about two inches to the side of the seed there is practically no difference between broadcasting and placing. Further experiments on turnips and swedes are in progress in order to obtain more data on the interaction effects of N, P and K dressings when applied broadcast and when placed in different positions relative to the seed.

POT EXPERIMENTS

These fall into three main groups. The first is 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 measurement of the effect of cropping on phosphate fixation. The second group of experiments has been conducted in collaboration with the Section for Radioactive Studies and

covers the use of ^{32}P to estimate the plant-available phosphate in soils. This has also involved the determination of phosphate responses and the effect of drying on the availability of native and applied phosphorus in a series of Australian Krasnozem soils. The third group of experiments is concerned with the determination of potassium responses in a number of Scottish and South African soils, with special reference to the effect of continued cropping with rye grass on the potassium status of the soil.

LABORATORY WORK

Analyses of soil and produce samples from field experiment areas have been continued in the general integration of field, pot and laboratory studies. The possible importance of seasonal variation in the routine examination of soil samples is also being examined. Outside these investigations, work has been concentrated mainly on the following subjects.

Phosphate Problems

The fractionation and retention of phosphate in different soil types continues to be examined. A section of this work, dealing with the distribution of phosphorus in soil profiles corresponding to the soil substitution experiments at Craigiebuckler, formed the subject of a thesis presented by Mr W. M. H. Saunders of the Soils Bureau, New Zealand, and accepted for the degree of Doctor of Phi¹osophy by the University of Aberdeen. This work covered the determination of the total organic and total inorganic phosphorus, fractionation of the inorganic phosphorus into various solubility categories and examination of the amount and characteristics of the phosphorus present in the four main mechanical fractions of seven soil types, including three pairs of corresponding well drained and poorly drained soils. A supplementary pedological characterization of the profiles, with particular reference to the distribution of reactive iron and aluminium, was also carried out. Separation of the mechanical fractions was effected by means of a relatively mild water dispersion without appreciable loss of phosphate or disturbance of its distribution. The separated fractions were also used to study the interactions taking place when soils are extracted by some of the conventional methods for evaluating phosphorus status. It was also found necessary to investigate the determination of the total organic phosphorus in soils because of serious discrepancies between results obtained by some of the established methods. Accounts of the various aspects of the above work are being prepared for publication.

In view of the fact that up to one half or more of the total phosphorus in Scottish soils is present in organic form, an investigation of the organic phosphorus fraction has been started. This covers further work on the determination of total organic phosphorus and the development of techniques for identifying and separating specific compounds. In this connection, preliminary work is in progress on the extraction and precipitation of phytin and its derivatives and on the application of paper chromatography.

Studies involving the use of ^{32}P have been continued in collaboration with the Section for Radioactive Studies. Attention has been concentrated mainly on the chemical significance of values obtained by conventional methods of

extraction. The relative and absolute usefulness of such values as criteria of phosphorus status have been found to vary greatly depending on the nature of the soil parent material. The account of this work on readily soluble phosphate values and crop responses for different soils, which was referred to in last year's report, has now been published[22].

An investigation of the factors affecting the solubility and retention of phosphate in eight Krasnozem soil profiles from Eastern Australia has been started. These soils have high sesquioxide contents and present special problems, and one approach being followed is identification of specific minerals and oxides of iron and aluminium in the soils by differential thermal analysis and other methods, coupled with examination of the behaviour of laboratory specimens.

Work on the solubility of the residues of field dressings of phosphate and on seasonal variation in readily soluble phosphorus has been continued, and a detailed examination of the nutrient status of soil samples from the Craibstone lysimeters is also in progress.

Potassium Studies

An examination of the potassium relationships of selected Scottish and South African soils has been started with particular reference to the amount and solubility of the non-exchangeable potassium in soils derived from different parent materials, the occurrence and nature of potassium fixation and the significance of fixed potassium in relation to plant growth.

Manganese

An account of the work on the reduction of manganese in neutral to alkaline soils, which was referred to in last year's report, has now been published[23].

ADVISORY AND OTHER *AD HOC* WORK

The Institute continues to collaborate with the North of Scotland College of Agriculture in advisory work on soils. The demand for this service has increased considerably and during the year over 11,000 soil samples have been tested. In addition, numerous samples of soil and produce from areas in which there have been abnormalities either in crop growth or in animal health have been examined in collaboration with the Departments of Spectrochemistry and Plant Physiology. In many of these problem areas where the cause of the trouble is uncertain, *ad hoc* experiments have been arranged in collaboration with other research organizations.

In spring several cases of boron toxicity in oats were diagnosed. These all occurred in fields in which a boronated fertilizer mixture had been combine-drilled with the seed. This serves to draw attention to the dangers of using mixtures containing boron on cereals.

The examination of soils from forest nursery areas in Scotland has been continued principally on behalf of the Forestry Commission. This work is concerned with both the Conservancy and Research Branch problems of soil fertility.

The results for lime, phosphate and potash in all the soil samples taken during 1952 from the North of Scotland College of Agriculture area have been recorded. These show that in the area as a whole only 6 per cent. of the soils examined had a satisfactory lime content, 45 per cent. required between 10 and 35 cwt. calcium carbonate and the remainder required over 2 tons calcium carbonate per acre. These figures serve to emphasize the fact that there is still a very pronounced need for lime in the north of Scotland. For phosphate, 13 per cent. of the soils had a relatively satisfactory content, 51 per cent. were slightly low, and the remaining 36 per cent. were low and could be expected to respond markedly to phosphatic fertilizers. For potash the corresponding figures are 24 per cent. satisfactory, 62 per cent. slightly low and 14 per cent. low.

The recording of the results for agricultural soils for Aberdeenshire and Kincardineshire has been continued on the basis of the soil association. The results indicate that shortages of lime and phosphate are somewhat less pronounced on the Stonehaven and Laurencekirk Associations than on the others, while shortage of potash is least pronounced in these two and in the Cruden Association.

PUBLICATIONS

(A) *Published during the year—*

1. Calcined cold-precipitated hydrated iron oxide. By W. A. Mitchell. (*Min. Engng*, **5**, 904, 1953).

   An X-ray diffraction pattern of calcined cold-precipitated iron oxide gave what was apparently a new crystal structure. It was found that the copper target used was contaminated with molybdenum and the diffraction pattern was that of haematite with molybdenum radiation.

2. The effect of grinding on micas. By R. C. Mackenzie and A. A. Milne. (*Clay Min. Bull.*, **2**, 57-62, 1953).

   Relationship of cation-exchange capacity to time of grinding is described for a reputed sample of biotite (actually a mixture of biotite and hydrobiotite) and a sample of vermiculite. The changes occurring have been followed by differential thermal analysis and X-ray studies of selected samples. Vermiculite and hydrated micas generally are shown to be relatively stable to dry grinding, presumably because of the lubricative action of the water between the structural layers.

3. The effect of grinding on micas: I. Muscovite. By R. C. Mackenzie and A. A. Milne. (*Min. Mag.*, **30**, 178-185, 1953).

   Chemical, X-ray, and thermal methods have been used to examine the changes induced by dry-grinding muscovite for periods up to 24 hours. The cation-exchange capacity increases with time of grinding up to about 150 m.e./100 g., and this figure can be approximately related to the amount of K^+ rendered exchangeable; the crystal structure appears to suffer almost complete breakdown after 8 hours, but a re-crystallization occurs thereafter, the product differing from muscovite in several respects; an increase in hydration is shown by thermal measurements. After heating to 1000°C. the unground material is relatively unchanged but the ground material recrystallizes to leucite. These changes are correlated and discussed.

4. Investigations on cold-precipitated hydrated ferric oxide and its origin in clays. By R. C. Mackenzie. (pp. 65-75 of "*Problems of Clay and Laterite Genesis*"—Symposium held at St. Louis, Missouri, U.S.A., Feb. 1951. Published by the American Institute of Mining and Metallurgical Engineers, New York, 1952).

   In spite of the widespread occurrence of cold-precipitated hydrated ferric oxide, especially in soil clays, it has not yet been possible to determine the conditions necessary for its formation. In an attempt to gain an insight into these conditions pure laboratory-prepared material has been studied. The chemical identity of the material and the changes occurring with changes in the mode of formation have been studied by differential thermal, X-ray, and electron diffraction methods and the results obtained have suggested possible modes of origin of the mineral in nature. Further X-ray and electron diffraction results are necessary, however, before any definite conclusion can be reached.

5. Some notes on Arens' theory of differential thermal analysis. By R. C. Mackenzie and V. C. Farmer. (*Clay Min. Bull.*, **1**, 262-265, 1952).

   Some inaccuracies in the theory of differential thermal analysis recently proposed by Arens are pointed out and discussed in relation to the validity of the theory.

6. The clay mineralogy of some soils from Spain and from Rio Muni (West Africa). By M. Muñoz Taboadela. (*J. Soil Sci.*, **4**, 48-55, 1953).

   An account of the clay mineralogy of some soils from Spain and from West Africa representative of the following types: (1) Dry calcareous soils (including Mediterranean terra rossa); (2) Andalusian black soils; (3) Iron-humus podzols; (4) Tropical loams. In addition to the clay mineralogy of the various soils, other factors such as parent materials, climate, etc., are described and an attempt is made to correlate all the available information.

7. A cutter for the preparation of carbon electrodes. By R. O. Scott and A. M. Fraser. (*Spectrochim. Acta*, **5**, 422-425, 1953).

   A tool for the preparation of carbon or graphite electrodes is described. This comprises a cutting head, on the lever tailstock of a lathe, which is fed to the rotating carbon. The outside diameter of the electrode is reduced, the end faced and the cavity drilled in one operation. Electrodes with 2.8 mm. outside diameter and a cavity of either 0.8 or 1.0 mm. diameter and 8 mm. depth can be produced at the rate of about 100 per hour. Porous cup electrodes can also be machined with the same equipment, using a scroll type chuck to hold the electrode.

8. Trace elements in a suite of Hawaiian lavas. By L. R. Wager (University of Oxford) and R. L. Mitchell. (*Geochim. et cosmochim. Acta*, **3**, 217-223, 1953).

   Analyses for trace elements of a series of Hawaiian lavas from olivine basalt to trachyte are given and comparisons made with data from the Skaergaard intrusion, East Greenland. The results are in conformity with the view that the Hawaiian series are essentially the result of fractional crystallization.

9. The lignin of sphagnum. By V. C. Farmer. (*Research*, **6**, No. 8, 47S-48S, 1953).

   Sphagnum contains a lignin-like substance which yields p-hydroxybenzaldehyde on nitrobenzene oxidation. Hydrolysis with dilute hydrochloric acid liberates the lignin as a lignin-carbohydrate complex containing glucose, xylose, rhamnose and traces of mannose and fructose. The absorption spectrum of the lignin shows analogies with that of the water-soluble ethanol lignin of spruce.

10. The occurrence of L-fucose in soil, peat, and in a polysaccharide synthesized by soil bacteria. By R. B. Duff. (*Chem. & Ind.* 1104, 1952).

    L-fucose has been isolated from soil, peat and from a polysaccharide synthesized by soil bacteria. The sugar was characterized unequivocally. The technique used in earlier work did not distinguish ribose and fucose.

11. The interconversion of aldose and ketose sugars effected by alkaline impurities in the paper of a chromatogram. By R. B. Duff. (*Chem. & Ind.* 898, 1953).

    Aldose and ketose sugars can be interconverted to some extent when the spot initially applied to the paper of a chromatogram is dried at 111°C. The amount of isomerisation is estimated in the case of glucose and fructose. The effect is shown to be due to alkaline impurities in the paper and is useful in that some sugars which otherwise behave similarly on the paper chromatogram can be easily distinguished from one another.

12. The isolation of L-pipecolinic acid from *Trifolium repens*. By R. I. Morrison. (*Biochem. J.*, **53**, 474-478, 1953).

    An unknown amino-acid appearing on paper chromatograms of aqueous ethanol extracts of leaves of white clover (*Trifolium repens*) has been isolated by chromatographic methods using columns of cation-exchange resin and powdered cellulose. This amino-acid has been shown by analysis, racemization and comparison with a synthetic preparation to be pipecolinic acid (piperidine-2-carboxylic acid). The natural amino-acid was optically active and had a laevo rotation, but was presumed to

be partially racemized. The behaviour of pipecolinic acid on paper chromatograms is described and compared with that of nipecotinic acid. A limited survey has been made of the occurrence of pipecolinic acid in plants.

13. The respiration of a thermophilic actinomycete, *Micromonospora vulgaris*. By D. Erikson (University of Aberdeen) and D. M. Webley. (*J. gen. Microbiol.*, **8**, 455-463, 1953).

The respiration of *Micromonospora vulgaris* at 60°C. was studied by means of the Warburg technique. Various cultural methods and heat treatments were used to separate the different growth phases of this structurally complex organism. One-to two-day growths bearing aerial mycelium were most active. Spores were inactive. Vegetative mycelium which developed within 24 hr. in the Warburg vessels was active, but similar one-day or older growth harvested from cultures proved to be inactive.

14. A simple method for producing microcultures in hanging drops with special reference ot organisms utilizing oils. By D. M. Webley, with a note by V. C. Farmer. (*J. gen. Microbiol.*, **8**, 66-71, 1953).

An aseptic technique is described for obtaining small hanging drops on the surface of coverslips, using only apparatus that is cheap and easy to obtain. The technique has been used to demonstrate the growth of *Nocardia salmonicolor* on liquid parraffin droplets.

15. Nickel and cobalt toxicities in oat plants. By O. Vergnano and J. G. Hunter. (*Ann. Bot.*, **n.s.17**, 317-328, 1952).

The types of symptoms and anatomical changes produced in oat plants by the addition of nickel and cobalt to nutrient solution or by iron deficiency have been compared with those occurring in oat plants from serveral areas of Aberdeenshire and shown to be similar. Nickel contents are comparable whilst the cobalt content of the sand-culture plants is considerably higher.

16. The composition of bracken: some major and trace element constituents. By J. G. Hunter. (*J. Sci. Fd Agric.*, **4**, 11-20, 1953).

Periodic samples of bracken taken during the growing season have shown that the concentration of major elements (except calcium and sodium) decreases with age in fronds and remains relatively constant in rhizomes, whereas trace-element concentration varies widely. Soil type has little effect on the mineral composition of fronds. Examination of three rhizome types revealed no wide differences in the content of major elements; pinnules generally contained higher concentrations of major and trace elements than fronds. Comparison of results with those published elsewhere for moorland plants grown under similar conditions indicates that bracken contains rather more potassium and less molybdenum.

17. The determination of calcium in plants and soils. By J. G. Hunter and A. Hall. (*Analyst*, **78**, 106-110, 1953).

The method is based on the turbidity formed on adding a precipitating reagent to a sodium acetateacetic acid buffer solution containing the calcium. The precipitating reagent consists of a solution of ammonium oxalate and citric acid in water, ethanol and butanol-1-01. The reagent is stable for 8 hours, and the turbidity, which is determined by means of a photo-electric absorptiometer, is constant from 5 to 60 minutes after adding the reagent. The method, which was devised for calcium in plant and soil extracts, determines from 0.05 to 0.50 mg. of calcium with an accuracy of within ± 5 per cent. Permissible concentration limits of certain interfering ions are given, and the examination of the amounts of these ions in plant and soil extracts indicates that significant interference will seldom be encountered.

18. Manuring of grassland. I. Some effects of heavy dressings of nitrogen on the mineral composition of grassland herbage. By A. B. Stewart and W. Holmes (Hannah Dairy Research Institute). *J. Sci. Fd Agric.*, **4**, 401-408, 1953).

Results are given for the effects of heavy dressings of nitrogen, in the presence and absence of phosphorus and potassium supplements on: dry-matter yield; botanical

composition of herbage; contents of crude protein, phosphorus, potassium, calcium magnesium, sodium and manganese. Brief reference is also made to the effects of the various experimental treatments on the uptake of certain other trace constituents. The results indicate that high yields of pasture herbage having high protein and normal mineral contents can be maintained over a period of years by the use of fertilizer nitrogen, provided adequate fertilizer dressings of other major nutrients are given. Attention is drawn to various ion-antagonism effects that may influence the mineral composition of the herbage.

19. Manuring for establishment and maintenance of pasture. By A. B. Stewart. (*Proc. VI. Int. Grassl. Cong.*, **1**, 702-704, 1952).

    This gives a brief account of the importance of plant food supply and other factors in the establishment and maintenance of pasture under British conditions. Attention is drawn to the possible importance of ion antagonism effects when heavy replacement manuring becomes necessary.

20. Cobalt deficiency in pastures in Great Britian. By A. B. Stewart. (*Proc. VI Int. Grassl. Cong.*, **1**, 718-719, 1952).

    A short account is given of experiments on the top dressing of cobalt-deficient pastures with fertilizer supplements containing cobalt. The relative merits of soil and herbage analyses in the diagnosis of cobalt deficiency are discussed.

21. Factors influencing phosphate usage in Great Britain. By A. B. Stewart. (Chap. XIV. in "*Soil and Fertilizer Phosphorus in Crop Nutrition*," edited by W. H. Pierre and A. G. Norman, New York, Academic Press Inc., 1953).

    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.

22. Readily soluble phosphorus values and crop responses for different soils. By E. G. Williams, J. W. S. Reith and R. H. E. Inkson. (*Trans. Int. Soc. Soil Sci.: Joint Meeting Comm. II. and Comm. IV., Dublin, July* 1952, **2**, 84-91, 1952).

    Readily soluble phosphorus values by five conventional extraction methods together with the corresponding field responses to phosphate by turnips and swedes are presented for 74 soils covering four main parent material groups in north-east Scotland. The inter-relations of the phosphorus values and their correlations with field responses are statistically examined. The correlations with field responses show that the methods have a very definite diagnostic value, but their relative and absolute usefulness differ greatly, depending on the nature of the soil parent material. It cannot therefore be concluded that any one of the methods is clearly better than the others. The importance of the soil parent material is also reflected in marked variations in the interrelations of the phosphorus values. Attention is also drawn to the importance of factors such as pH, period of extraction, soil/solvent ratio, and nature of the extractant.

23. A note on the reduction of manganese in neutral to alkaline soils. By L. H. P. Jones. (*Trans. Int. Soc. Soil Sci.: Joint Meeting Comm. II. and Comm. IV., Dublin, July* 1952, **2**, 164-166, 1952).

    Liming a black clay soil from pH 7 to 8 was found to reduce greatly its ability to reduce added managanese oxide. The implications of this finding are discussed in relation to evaluation of the manganese status of soils by the quinol reduction method.

(B) *Submitted for publication—*

24. Trace element toxicities in oat plants. By J. G. Hunter and O. Vergnano. (To appear in *Ann. appl. Biol.*).

25. Free iron oxide removal from soils. By R. C. Mackenzie. (To appear in *J. Soil Sci.*).

26. The minerals in clays—their identification and relation to soil science. By R. C. Mackenzie. (To appear in *An. Edafol. Fisiol. veg.*).

27. Standardization of differential thermal technique. By R. C. Mackenzie and K. R. Farquharson. (To appear in *Trans. XIX Session Int. Geol. Congr.*).

28. Removal of free iron oxide from clays. By B. D. Mitchell and R. C. Mackenzie. (To appear in *Soil Sci.*).

29. Oriented aggregate specimens of clay for X-ray analysis made by pressure. By W. A. Mitchell. (To appear in *Clay Min. Bull.*).

30. Mineralogy of some kaolins from Pugu, Tanganyika. By R. H. S. Robertson (Glasgow), G. W. Brindley (Pennsylvania State College) and R. C. Mackenzie. (To appear in *Amer. Min.*).

31. Soil Survey (Scotland) descriptive memoir of Ordnance Survey Sheets 86 and 96, and maps (1 inch to 1 mile) based on Sheets 86, 96 and 97 (3rd ed.).

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 . . Fairly widespread throughout the area, notably at Hempriggs, Struthers, Kirkhill, and around Grange Hall.

Parent Material . . Fluvio-glacial sand. In this area frequently contains thin layers of finer sand and silt.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1950-51

Topography . . Undulating to hummocky.

Corby Association

Distribution . . Occurs sporadically in association with the Boyndie sands; main areas around Morayscairn and from Scotsburn to Newmill.

Parent Material . . Fluvio-glacial gravel.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1950-51

Topography . . Moundy.

Elgin Association

Distribution . . On the higher ground in the south of the area, well seen at Brodieshill; two small isolated areas at Earnside and Grange Hill.

Parent Material . Till derived mainly from Upper Old Red Sandstone.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1951-52

Topography . . Gently sloping.

Duffus Association

Distribution . . Around the western margin of the former Loch Spynie basin at Bridgend, Kaim and Orchardfield.
Parent Material . Lacustrine sediments.
Dominant Series . Poorly drained.

Profile

As described in Annual Report 1951-52

Topography . . Flat, to gently undulating.

Whitehills Association

Distribution . . A very small occurrence capping a knoll at Shempston.
Parent Material . Till derived from dark shale.
Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
A_0F	0-3 in.	Partially decomposed organic matter; abundant tree roots.
A_1	3-12 in.	Dark grey brown clay loam; crumb to sub-angular block structure; profuse fine rusty mottling. Sharp change into
B_2-G	12-23 in.	Dark grey brown clay loam; sub-angular block to nutty structure; much rusty mottling. Sharp change into
B_3	23-36 in.	Grey-brown and yellowish brown silty clay; compact with angular fracture to medium blocks; some large rusty mottles. Merging into
C	36-56 in. +	Dark brown silty clay till with abundant partly weathered shale fragments.

Muirton Association

Distribution . . Small areas at Kinloss, Roseisle and Rosevalley.
Parent Material . Raised beach deposits.
Dominant Series . Poorly drained with high water-table.

Profile

Horizon	*Depth*	
S	0-9 in.	Grey-brown loamy sand; weak cloddy structure. Sharp change into
G_1	9-20 in.	Light yellowish brown sand; very weak cloddy structure; much fine orange mottling, increasing in intensity with depth. Sharp change into
G_2	20-28 in.	Grey-brown loamy fine sand; weak cloddy structure; iron deposition limited to concentric "drain-pipes" $\frac{1}{4}$-$\frac{1}{2}$ in. diameter round old root channels. Sharp change into

G_2	28-55 in.	Pale brown sand; very weak cloddy structure; some bright orange mottling decreasing in intensity and frequency downwards. Sharp change into
C-G	55 in. +	Dark blue-grey sand; compact; wet.
Topography		Flat.

CARDEN ASSOCIATION

Distribution . .	Occurs on some of the higher mounds and low ridges in the western part of the area, notably at Wester Alves, Hillhead and Carden.
Parent Material .	Lacustrine deposits, probably associated with the retreat stages of the last glaciation.
Dominant Series .	Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-12 in.	Brown loam; medium angular shattering to crumb structure; very sharp change into
B-G	12-40 in.	Reddish brown silty clay loam; well defined prismatic structure; diffuse rusty mottling with some grey mottling and greying of cleavage faces. Merging into
C	40 in. +	Reddish brown clay; becoming more massive with depth.
Topography	. .	Undulating to moundy.

LINKS

Distribution . .	The coastal strip from Burghead to Findhorn; approximately ½ mile wide.

The soils are described in Annual Report 1951-52

ALLUVIUM

Distribution . .	Considerable spreads of alluvium occupy the low ground between Milton Brodie and Kinloss; from Arran Wood to Hatton and southwest from Leys.

The soils are described in Annual Report 1951-52

SKELETAL SOILS

DUNE SANDS

Distribution . .	Sand dunes occur throughout the Links area above, but chiefly along the seaward edge.

BASIN PEAT

A few small patches of peat occur within the areas of alluvium. At Wards of Alves, the peat is underlain by a thin deposit of marl.

EAST SCOTLAND

Angus (*Geological Survey Sheet* 57)

ASSOCIATIONS

Boyndie Association

Distribution . . An area between Inverkeilor and Lunan—bounded to the north by the alluvial flat of the Lunan Water and to the south by the Keilor Burn; also a limited area between Loch of Forfar and the western edge of the sheet.

Parent Material . Fluvio-glacial sand.

Dominant Series . Freely and imperfectly drained—with some poorly drained.

Profile (freely drained)

Horizon	*Depth*	
S	0-18 in.	Brown sandy loam; upper 9 in. slightly compact crumb structure. Sharp change into
B_2	18-21 in.	Dark brown coarse sandy loam; loose crumb structure. Merging over 2 in. into
B_2	21-28 in.	Medium brown loamy coarse sand to sand; loose crumb to single grain structure. Sharp change into
B_3	28-33 in.	Light brown, compact, slightly indurated coarse sand. Sharp change into
C	33 in. +	Light brown coarse sand; rather compact.

Topography . . Undulating or moundy in the Inverkeilor area; flat or moundy in the west.

Corby Association

Distribution . . Several square miles immediately east of Forfar. A small area along the east bank of the Brothock Water between Leysmill and Letham Grange.

Parent Material . Moraines and fluvio-glacial gravel.

Dominant Series . Freely and imperfectly drained.

Profile

As described in Annual Report 1950-51

Topography . . Undulating to moundy.

Balrownie Association

Distribution . . Between the south end of Lunan Bay and St. Vigeans; an area around Forest Muir to the north-west of Forfar; an area around Brigton Hill south-west of Forfar.

Parent Material . Red water-worked till material on till of sandy loam to loam texture.
Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1950-51

Topography . . Undulating with generally low angle slopes.

TURIN ASSOCIATION

Distribution . . High ground on the hills about Forfar.
Parent Material . Till derived mainly from flaggy and shaly beds of the Lower Old Red Sandstone.
Dominant Series . Imperfectly and freely drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Brown fine sandy loam to loam; rather cloddy crumb structure. Sharp change into
B_2	9-12 in.	Orange-red brown sandy loam to loam; slightly compact sharp crumb structure. Merges gradually into
B_2-G	12-15 in.	Grey-red sandy loam to loam; soft cloddy crumb structure; some grey and rusty mottling present. Sharp change into
B_3-G	15-23 in.	Grey-red fine sandy loam to loam; compact and rather indurated; grey and rusty mottling present. Merges gradually into
B_3	23-29 in.	Grey-red loam; compact cloddy structure; Merges gradually down into
C	29 in. +	Dull red fine sandy loam to loam till.

Topography . . Hilly.

DRUMGLEY ASSOCIATION

Distribution . . A belt up to a mile wide between Kirriemuir Junction and the north-west side of Pitscandly Hill.
Parent Material . Light-textured red water-worked till material—rather variable.
Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-11 in.	Brown sandy loam; slightly cloddy crumb structure. Sharp change into
B_2-G	11-15 in.	Light orange-brown sandy loam; slightly compact crumb structure; a little diffuse grey and rusty mottling. Sharp change into
B_3-G	15-25 in.	Red-brown loamy sand; compact, slightly indurated; diffuse grey and rusty mottling. Sharp change into

B_3-G	25-31 in.	Dull grey-red sandy loam to loam; compact, slightly indurated; sharply-defined rusty mottling. Merges into
B_3-G	31-41 in.	Dull grey-red sandy loam to loamy sand; compact cloddy structure; some grey and rusty mottling. Merges into
C	41 in. +	Dull red coarse sandy loam.
Topography	. .	Gently undulating.

DEAN ASSOCIATION

Distribution . .	Occupies a limited area on the north side of the Dean Water.
Parent Material .	Light-textured morainic material of mixed origin.
Dominant Series .	Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-8 in.	Brown sandy loam to loam; slightly cloddy crumb structure. Fairly sharp change into
S	8-13 in.	Medium brown sandy loam to loam; soft cloddy crumb structure. Sharp change into
B_2-G	13-19 in.	Light brown sandy loam; slightly compact cloddy crumb structure; very slight rusty mottling. Merges gradually into
B_3-G	19-27 in.	Lighter brown sandy loam; compact cloddy, slightly prismatic structure; faint grey and rusty mottling. Merges into
B_3-G	27-40/42 in.	Pale grey-brown sandy loam; rather compact; diffuse patchy grey and rusty mottling.
	40/42 in. +	Flaggy red sandstone rock.
Topography	. .	Moundy to gently sloping.

ALLUVIUM

Silty alluvium, similar in profile to the estuarine alluvium of the Pow Association, occurs in a limited area about the Kirbet Water in the west.

Recent alluvium occurs about the upper reaches of the Brothock Water and tributaries south of Leysmill.

There is a moderately extensive area of lacustrine alluvium (varved clays) around the Anniston Brick and Tileworks about one mile south-west of Inverkeilor.

PEAT AND MARL

Small areas of basin peat and occasional patches of calcareous marls are associated with the line of lochs and hollows between the Dean Water in the west and Rescobie Loch in the east.

SOUTH-EAST SCOTLAND

Roxburghshire, Dumfriesshire and Selkirkshire
(*Geological Survey Sheets* 17 *and* 18)

ASSOCIATIONS

Hindhope Association

Distribution . . East and central parts of the area.
Parent Material . Till derived from Silurian grey-wackes and shales.
Dominant Series . Peaty gleyed podzol, with iron pan.

Profile

Horizon	*Depth*	
A_0L	0-1 in.	Molinia litter.
A_0F	1-1½ in.	Decomposed grass and roots.
A_0H	1½-12 in.	Very dark brown or black greasy humus.
A_2-G	12-14 in.	Grey-brown silt loam; small cloddy; slight dull ochreous mottling. Very sharp change into
B_1	14 in.	Continuous iron pan about 1/8 in. thick.
B_2	14-19 in.	Strong brown loam; loose crumby; very slight grey mottling. Merges into
C	19 in. +	Strong brown very stony loam; crumby; slightly compacted.

Topography . . Mountainous.

Martinlee Association

Distribution . . West and central parts of the area.
Parent Material . Till derived from Carboniferous cementstones, shales, limestones and sandstones of the Calciferous Sandstone Series.
Dominant Series . Peaty gley.

Profile

Horizon	*Depth*	
A_0L	Trace	Grass litter.
A_0F	0-1 in.	Decomposed grass roots.
A_0H	1-7 in.	Very dusky red greasy humus.
A_1	7-9 in.	As horizon above with intimately mixed mineral matter present.
A_2-G	9-13 in.	Brown fine sandy loam, small cloddy; faint dark and light brown mottling. Fairly sharp change into
B-G	13-20 in.	Grey-brown clay loam to clay; cloddy to massive; yellowish-red and light grey brown mottling intense. Merges into
B-G	20-28 in.	As horizon above with bluish-grey background colour and higher stone content. Merges into

C-G	28 in. +	Grey clay loam; massive; stones frequent; mottles similar to horizon above but less intense.
Topography	. .	Rolling to hilly.

MINTO ASSOCIATION

Distribution . .	In two narrow belts from Stonedge Hill to Maiden Paps and from Lurgiescleuch to Sundhope, and also a small area one mile north of Riccarton Junction.
Parent Material .	Mixed till derived from Old Red Sandstone and Silurian sediments.
Dominant Series .	Peaty gley.

Profile

Horizon	*Depth*	
A_0L	Trace	Grass litter.
A_0F	0-½ in.	Decomposed grass roots.
A_0H	½-6 in.	Very dark brown greasy humus.
A_2-G	6-8 in.	Grey-brown fine sandy clay loam; cloddy. Fairly sharp change into
B-G	8-20 in.	Light yellowish brown fine sandy clay; prismatic; ochreous mottling. Merges into
C-G	20 in. +	Brown stony clay loam; indefinite structure; slight ochreous mottling.
Topography	. .	Rolling to hilly.

WINDBURGH ASSOCIATION

Distribution . .	Windburgh Hill and Kiln Knowe.
Parent Material .	Lower Carboniferous extrusive and intrusive basalts.
Dominant Series .	Freely drained.

Profile

Horizon	*Depth*	
A_0L	0-½ in.	Matted grass litter.
A_0F	½-1 in.	Decomposed grass roots.
A_0H	1-2 in.	Very dark brown friable humus.
A_1	2-3 in.	Very dark brown humus with some intimately mixed mineral matter.
B_2	3-7 in.	Reddish brown loam; crumby. Merges into
B_3	7-14 in.	As horizon above but with higher stone content and slightly indurated.
C	14 in. +	Basalt stones and rubble.
Topography	. .	Hilly.

HILL PEAT

Extensive areas of hill peat are found upon the flat tops of the hills above 900 feet.

SOUTH-WEST SCOTLAND

Ayrshire (*Geological Survey Sheet* 22)

ASSOCIATIONS

Lanfine Association

Distribution . . South of Galston and the Burn Anne.
Parent Material . Mixed till derived from Old Red Sandstone and contemporaneous lavas.
Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1951-52

Topography . . Rolling.

Bargour Association

Distribution . . Narrow curving strip west and south of Crosshands; on the lower ground west of Barnweill Hill.
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 1950-51

Topography . . Rolling.

Kilmarnock Association

Distribution . . Small patch immediately south of Craigie; extensive area in the neighbourhood of Busby and Carmunnock.
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 1950-51

Topography . . Rolling in the Craigie area and undulating in the Carmunnock-Busby district.

Darleith Association

Distribution . . On high ground east and north-west of Mauchline; throughout the Kilbirnie Hills; on the Cathkin ridge.

Parent Material . Thin till derived from basic and intermediate lavas.
Dominant Series . Imperfectly drained.

Profile

As described in Annual Report 1950-51

Topography . . Hilly, with frequent rock outcrops.

MAUCHLINE ASSOCIATION

Distribution . . Considerable area on the lower ground between Mauchline and Tarbolton.
Parent Material . Till derived from Permian sandstone.
Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-10 in.	Light brown sandy loam; weak cloddy structure. Sharp change into
B_2-G	10-19 in.	Reddish yellow sandy clay loam; cloddy structure; slight ochreous mottling and slight gleying. Moderately sharp change into
B_3-G	19-29 in.	Light reddish brown coarse sandy clay loam; weak prismatic structure; slight ochreous mottling and slight gleying. Sharp change into
C	29-36 in.	Reddish brown sandy clay; laminated structure; slightly compacted; many pseudo-concretions of manganese.

Topography . . Undulating.

SORN ASSOCIATION

Distribution . . Large area around the Cessnock Water above Auchmillan.
Parent Material . . Till derived from calciferous sandstones with slight Barren Red Measure and Old Red Sandstone admixture.
Dominant Series . Poorly drained.

Profile

Horizon	*Depth*	
S	0-11 in.	Grey brown loam; soft cloddy structure. Sharp change into
B_2-G	11-18 in.	Sandy clay loam; cloddy structure; many highly weathered sandstones; heavy ochreous mottling and slight gleying. Sharp change into
B_3-G	18-31 in.	Sandy clay loam; massive structure; many weathering sandstones; heavy ochreous mottling and heavy gleying; iron pipes along root channels. Merges into

C-G 31-42 in. Sandy clay; massive structure; stones less highly weathered than in horizons above; gleying reduced.

Topography . . Undulating.

ASHGROVE ASSOCIATION

Distribution . . Extensive area in the vicinity of East Kilbride and west of Carmunnock.

Parent Material . . Heavy till derived mainly from sandstones and shales of the Carboniferous Limestone Series.

Dominant Series . Poorly drained.

Profile

As described in Annual Report 1950-51

Topography . . Undulating.

AMLAIRD ASSOCIATION

Distribution . . Confined to the depressions and gentler slopes of the Kilbirnie Hills.

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

Dominant Series . Poorly drained.

Profile

As described in Annual Report 1950-51

Topography . . Varies between hilly and broadly rolling.

DREGHORN ASSOCIATION

Distribution . . Broad strip of low ground between Portencross and Hunterston.

Parent Material . . Raised beach sand.

Dominant Series . Freely drained.

Profile

As described in Annual Report 1950-51

Topography . . Varies between flat and very gently undulating.

KIRKLAND ASSOCIATION

Distribution . . Over greater part of the low ground and lower slopes of hills between West Kilbride and Largs.

Parent Material . . Till derived from sandstone of Old Red Sandstone formation with some quartz pebbles and basaltic stones.

Dominant Series . Imperfectly drained.

Profile

Horizon	*Depth*	
S	0-9 in.	Brown sandy loam; weak cloddy structure. Sharp change into
B_2	9-16 in.	Reddish brown sandy loam; weak cloddy structure; slight ochreous mottling. Sharp change into
B_3	16-28 in.	Reddish brown sandy clay loam; moderate ochreous mottling; a few pseudo:concretions of manganese. Merges into
C	28-36 in.	Reddish brown sandy clay loam; platy structure; slightly indurated.
Topography	. .	Undulating.

LINKS

Distribution . . Narrow coastal strip from West Kilbride to Largs.

Profile

As described in Annual Report 1950-51

Topography . . Generally flat.

ALLUVIUM

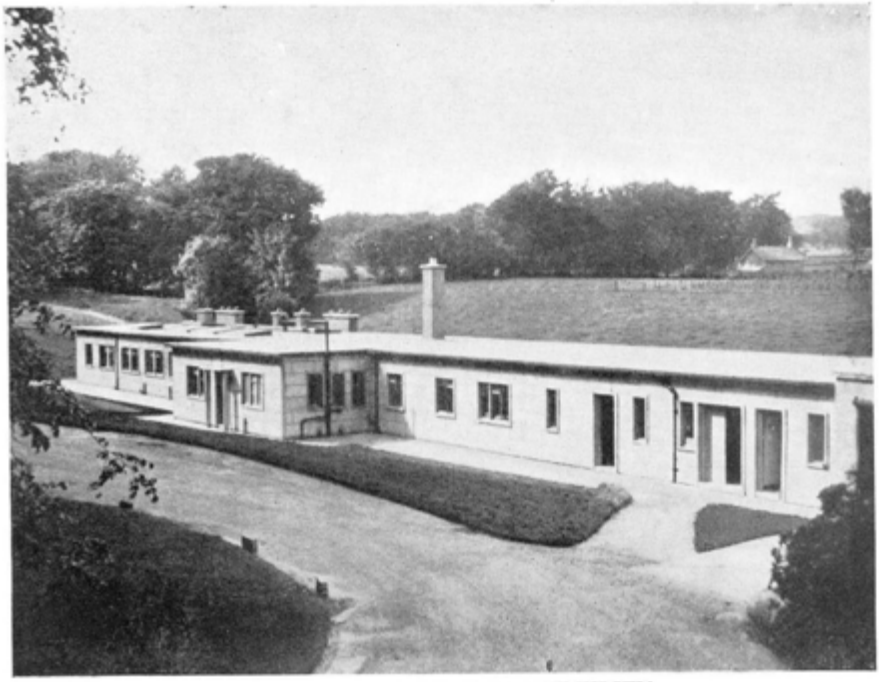
Small spreads of recent alluvium occur throughout the three areas surveyed.

HILL AND BASIN PEAT

Hill and basin peat has been mapped throughout the north-west and south-west areas.

SOIL HORIZON SYMBOLS USED BY THE SOIL SURVEY OF SCOTLAND

ELUVIAL HORIZONS		GLEYED ELUVIAL HORIZONS	
A	undifferentiated	A-G	gleyed A.
Subdivisions of Eluvial Horizons		*Subdivisions of Gleyed Eluvial Horizons*	
A_0L	undecomposed plant remains.		
A_0F	partially decomposed organic matter.		
A_0H	well decomposed organic matter.		
A_1	intimate mixture organic and mineral matter.		
A_2	grey silicious.	A_2-G	gleyed A_2.
ILLUVIAL HORIZONS		GLEYED ILLUVIAL HORIZONS	
B	undifferentiated	B-G	gleyed B.
Subdivisions of Illuvial Horizons		*Subdivisions of Gleyed Illuvial Horizons*	
B_1	iron pan, or humus concentration or both.		
B_2	diffuse deposition of sesquioxides or humus or both.	B_2-G	gleyed B_2.
B_3	indurated or compacted.	B_3-G	gleyed B_3.
PARENT MATERIAL		GLEYED PARENT MATERIAL	
C	undifferentiated	C-G	gleyed C.
GLEY HORIZONS			
G	undifferentiated		
CULTIVATED HORIZONS			
S	undifferentiated		



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