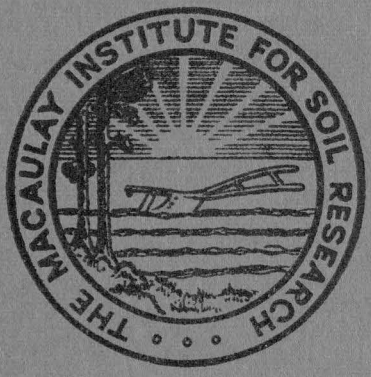
Irene A. Taylor

THE MACAULAY INSTITUTE FOR SOIL RESEARCH



FOUNDED 1930

ANNUAL REPORT 1957-1958

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THE MACAULAY INSTITUTE FOR SOIL RESEARCH

CRAIGIEBUCKLER, ABERDEEN

(Founded 1930)

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J. LOGAN.

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W. BICK.
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A. H. GORDON.

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	W. O. Binns, M.A.(Cantab.), B.Sc.(For.).
Statistics	R. H. E. Inkson, B.Sc., F.R.S.S.
	Mrs M. J. Macdonald, B.Sc.
Instrument Design	A. M. Fraser.
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	*Miss H. T. G. Donaldson.
Private Secretary to the Director	Mrs R. M. Simpson.
Librarian	Miss A. M. B. Geddes, M.A., F.L.A.

§Retired 31st March, 1958. §§Acting Director April-September, 1958.
*Appointed during the year. †Resigned during the year.
‡Seconded from Colonial Pool of Soil Surveyors. ††On leave of absence.

POST-GRADUATE RESEARCH WORKERS

E. Z. Arlidge (Massey Agricultural College, Palmerston North, New Zealand).
M. L. Berrow (Agricultural Research Council Training Grant).
B. M. Bishui (Central Glass and Ceramic Research Institute, Calcutta, India).
B. Bhattacharyya (Indian Bureau of Mines, New Delhi, India).
A. S. de Endredy (Department of Soil and Land Use Survey, Kumasi, Ghana).
Miss A. Kabata (Instytut Uprawy Nawozenia i Slebozmawstwa, Pulawy, Poland).
Lim Chin Hua (Department of the Government Chemist, Singapore).
H. A. Louw (Stellenbosch-Elsenburg Agricultural College, Stellenbosch, South Africa).
M. Marino (Centro Investigaciones Agronómicas, Maracay, Venezuela).
G. R. Suggett (Colonial Office, London).

CONTENTS

INTRODUCTION

On 31st March, 1958, the second Director of the Institute, Dr D. N. McArthur, C.B.E., who had been in charge since July, 1945, retired from the directorship. His successor is Dr A. B. Stewart, who until June, 1954 was Deputy Director and Head of the Department of Soil Fertility and since then Strathcona Fordyce Professor of Agriculture in the University of Aberdeen, and who will take up office in October, 1958.

In minuting their appreciation of Dr McArthur's services the Council recall with pleasure that when Dr McArthur was appointed Director of the Institute in 1945, he came not as a stranger but one of the original members of the Council of Management. To his new task he brought a wide knowledge of the problems confronting the soil scientist, and it was with characteristic energy and enthusiasm that he embarked upon his duties at Craigiebuckler. Quick to recognize the great complexity of plant-soil relationships and the need for fundamental research in this field, he proceeded gradually to enlarge the scope of the Institute's work, attracted an increasing number of scientists to his staff and established several important new departments. It is some measure of the growth of the Institute during his tenure of the Directorship that the scientific staff increased from fifteen to forty-four and the total staff to about one hundred and fifty. As the research programme developed and expanded, the importance of the practical application of the results of research was not overlooked, and a close connection arose between the laboratory and the field. In manifold ways Dr McArthur guided the work of the Institute along the most productive channels, and both government and private bodies at home and abroad made frequent calls for advice on matters pertaining to soil science and the improvement of soil fertility. Under his direction the Institute earned both a national and an international reputation, and he himself played a prominent part in contributing to the work, often as chairman, of numerous departmental and national committees concerned with the promotion and application of soil science in all its aspects. In the prosecution of his work one problem came to occupy his attention particularly—the need for new laboratories to provide adequate accommodation not only for an increased staff but for the steadily increasing number of overseas students and workers seeking admission to the Institute either for training or research. That a new building worthy of the Institute is in process of erection is in no small measure due to the tireless efforts of Dr McArthur, the final plans having been approved before he demitted office. In recognizing this notable achievement in particular, the Council wish also to record their appreciation of all his services to the Institute during the thirteen years he acted as Director and to express their hope that he and Mrs McArthur may enjoy a long and happy retirement.

As mentioned above, it is at last possible to record definite progress towards the erection of a new Institute building. During the year formal approval has been received from the Department of Agriculture for Scotland to proceed with the project, and a contract for the erection of the first stage of the building, for which the architect is Mr D. S. Macphail, O.B.E., A.R.I.B.A., has been placed with Messrs Alexander Hall and Son (Builders) Ltd. of Aberdeen. This section will accommodate the Departments of Pedology, Spectrochemistry and Biochemistry, together with Administration and Library, and should be ready for occupation during 1960.

In addition to the financial provision made for the maintenance of the research programme by the Department of Agriculture for Scotland, the Agricultural Research Council, and the Forestry Commission, the Council is indebted to several other bodies for grants, and particularly to the Rockefeller Foundation for the grant of 9500 dollars, reported last year, which has enabled the Institute to instal in the Department of Spectrochemistry direct reading equipment for the determination of soil and plant constituents.

The work of the Institute has proceeded on normal lines during the past year: the more important investigations are summarized in this report.

COUNCIL

Dr M. Macgregor and Professor R. G. White, who were elected to the Council of Management in 1943 and 1950 respectively as representatives of the Department of Agriculture for Scotland, have now retired. The Council record their appreciation of the services rendered by these two members and of the keen interest which they have always taken in the work of the Institute. They are succeeded by Dr A. G. MacGregor and Professor J. Monteath Robertson.

STAFF

Appointments—

Department of Pedology—

J. G. Cruickshank, B.Sc. (Soil Survey of Scotland).
K. Stringer, B.Sc. (Soil Survey of Scotland).
A. D. Walker, B.Sc. (Soil Survey of Scotland).
Miss E. Trimble (Soil Geology and Mineralogy).
Miss C. I. Dickson (Physical Chemistry).

Department of Spectrochemistry—

J. D. Russell, B.Sc.

Department of Soil Fertility—

J. Munro.

Cashier—

Miss H. T. G. Donaldson.

Resignations—

Department of Pedology—

J. B. Craig (Physical Chemistry).

Department of Soil Fertility—

Miss M. H. Brown.

Cashier—

Miss H. T. O. Whigham.

Members of staff again attended conferences and meetings bearing on the work of the Institute. On the award of a Fellowship by the Lalor Foundation Mr A. H. Knight studied for six months at the Kearney Foundation for Soil Science, California. Mr J. Smith spent the year in South Georgia with The Royal Society's expedition in connection with the Geophysical Year studies.

PUBLICATIONS

Twenty-eight papers published during the year are summarized in the report. Reprints can be obtained from the Librarian.

THESIS

The following thesis by a visiting research worker was accepted by the University of Aberdeen for the degree of Doctor of Philosophy:

Studies on the distribution and location of trace elements in soil profiles.
By Michael L. Berrow.

VISITORS

Throughout the year many visiting scientists both from this country and abroad were shown something of the work in progress and given opportunities for discussion with members of staff. Organized parties included members of the Association of Applied Biologists, the British Council Course on Nutrition of Farm Animals, the Science Masters' Association (Scottish Branch), the Society for Analytical Chemistry, and students from the Edinburgh and East of Scotland College of Agriculture and the University College of Wales.

POST-GRADUATE RESEARCH WORKERS

The facilities afforded for post-graduate study continue to attract many research scientists and during the year under review the following workers studied at the Institute:

Department of Pedology—

Soil Survey of Scotland—

G. R. Suggett (Colonial Office, London).

Soil Geology and Mineralogy—

E. Z. Arlidge (Massey Agricultural College, Palmerston North, New Zealand).

Physical Chemistry—

B. M. Bishui (Central Glass and Ceramic Research Institute, Calcutta, India).

A. S. de Endredy (Department of Soil and Land Use Survey, Kumasi, Ghana).

Department of Spectrochemistry—

M. L. Berrow (Agricultural Research Council Training Grant).
B. Bhattacharyya (Indian Bureau of Mines, New Delhi, India).
Miss A. Kabata (Instytut Uprawy Nawozenia i Slebozmawstwa, Pulway, Poland).
Lim Chin Hua (Department of the Government Chemist, Singapore).
M. Marino (Centro Investigaciones Agronómicas, Maracay, Venezuela).

Section of Microbiology—

H. A. Louw (Stellenbosch-Elsenburg Agricultural College, Stellenbosch, South Africa).

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 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 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*) Technical Committee on Fertilizers.
(*b*) Technical Committee on Mineral Deficiencies in Agricultural and Horticultural Crops.
(*c*) Technical Committee on Mineral Deficiencies and Excesses in Animals.
(*d*) Technical Committee on Research on Field Water Control.
(*e*) Soil Survey Research Board.

(4) *Forestry Commission—*

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

(5) *Colonial Office—*

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

30th September, 1958.

PEDOLOGY

SOIL SURVEY (SCOTLAND)

Prior to the last annual report in which three published soil survey memoirs were briefly summarized, it was customary to report on the soils surveyed during the current field season, giving in the appendix morphological descriptions of any new series established. This information continues to be included in the annual report of the Soil Survey of Great Britain published by Her Majesty's Stationery Office. In this report other completed soil survey sheets will be discussed and brief accounts of the areas under survey will be given.

Systematic soil surveys with field work on a scale of 2·5 inches to 1 mile, for publication on a scale of 1 inch to 1 mile, are now in progress in the following areas (see sketch map): Sheets* 94 (Cromarty), 48 and 49 (Perth and Arbroath), 39 (Stirling), 14 (Ayr), 7 and 8 (Girvan and Carrick), and 33 and 34 (Haddington and Eyemouth). Work on sheets 6, 10, 11 (Annan, Dumfries and Langholm), which was commenced in 1955, has been in abeyance pending the return of the surveyor at present on leave of absence to study glaciology in South Georgia as a member of the Royal Society's expedition in connection with the Geophysical Year studies. During the past year the soil map of sheet 95 (Elgin) has been published. The soil survey of sheets 25 and 26 (Kelso and Berwick-upon-Tweed) was completed in 1956 and the memoir is being prepared.

THE SOILS OF THE COUNTRY ROUND KELSO AND LAUDER

The area of 540 square miles covering northern Roxburghshire and the southern half of Berwickshire, together with parts of Selkirkshire, Midlothian and Peeblesshire, extends from the north-eastern end of the Southern Uplands southwards to the River Tweed, covering an altitudinal range from 1844 feet to sea level.

By comparison with areas in the south of Scotland described in last year's report, it has a particularly dry climate. Much of the lower ground receives only 25-28 inches of rain annually and the maximum yearly rainfall in the highest hills is only 40-45 inches or roughly that received by the west coast lowlands. Although also partly due to the nature of the parent materials, the high proportion of brown earths and the low proportion of gleys and peat in the soils is a reflection of the dry climate of the area.

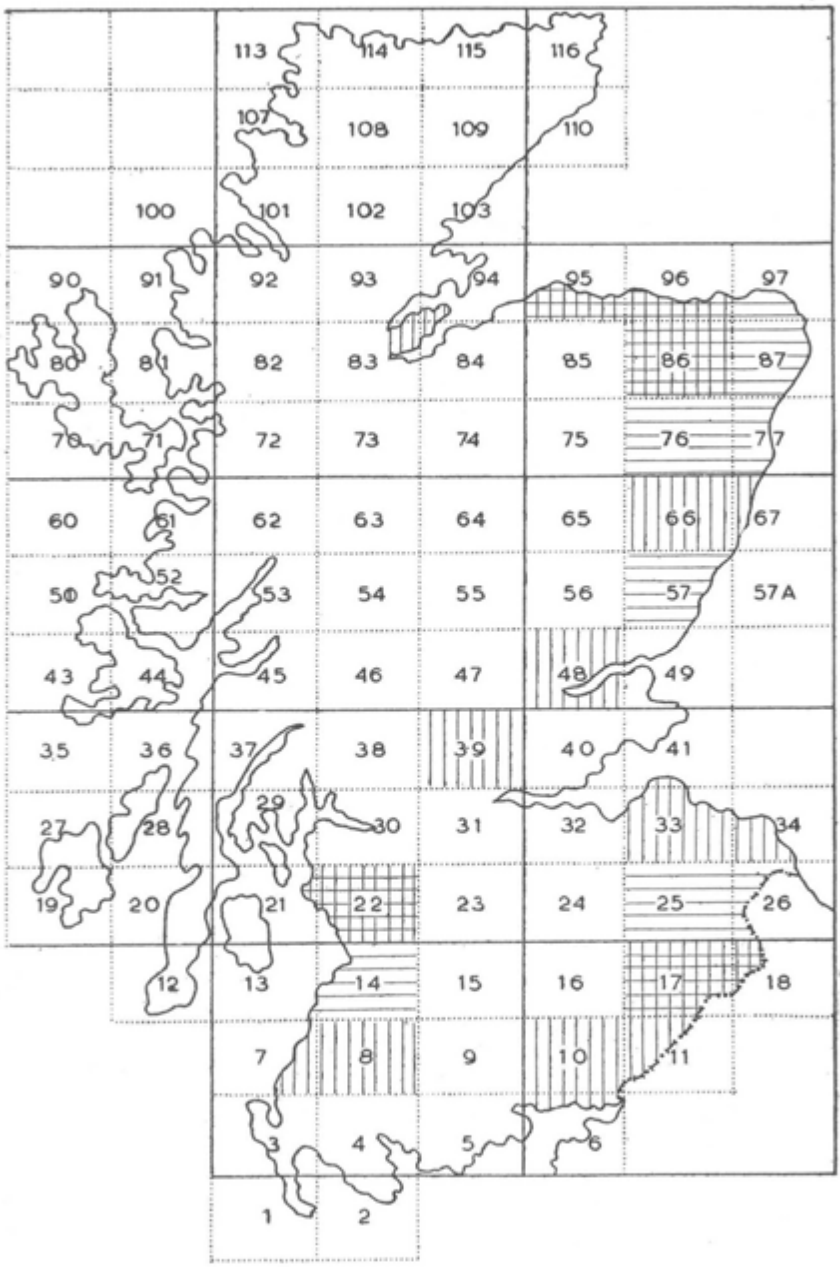
The Southern Uplands consist of Silurian and Ordovician rocks, greywackes and shales from which soils of the largest association, the Ettrick Association, are formed. Sandstones, marls, and conglomerates of the Upper Old Red Sandstone formation yield soils of the Hobkirk and Lauder

*Sheet numbers refer to 1 inch to 1 mile Ordance Survey (3rd edition) maps.

SOIL SURVEY OF SCOTLAND

Index to sheets

3rd edition 1" to 1 mile



SURVEY IN PROGRESS

SURVEY COMPLETED

PUBLISHED

Associations and sediments of the Calciferous Sandstone Series of Lower Carboniferous age give rise to the second largest soil association, the Whitsome Association of Lower Tweeddale.

The parent materials of most of the associations are of two types. The first, which covers just over half the area, is found mostly on high ground and consists of stony drifts and frost shattered rocks. The second, covering for the most part low lying ground, comprises tills of fine texture. The important feature of these deposits is that the former gives rise to freely drained soils and the latter to imperfectly and poorly drained soils. Apart from hill and basin peat, soils of three Major Soil Groups are found: (a) Normal brown earths, (b) Podzols, (c) Surface water gleys. The brown earths consist of two sub-groups: (a) brown forest soils of low base status, and (b) brown forest soils with gleyed B and C horizons. Brown forest soils of low base status are developed on parent materials of coarse texture (10-25% clay) typical of which is the Linhope series of the Ettrick Association. Exchangeable cations, calcium and magnesium, tend to show a decrease down the profile in these soils, while both total phosphorus and pH show an opposite trend. With the exception of the sandy Hobkirk series, much of the area of these freely drained soils is left as permanent grazing—semi-natural *Agrostis-Fescue* on the hills and reseeded mixed grasses with some rotational cropping elsewhere. Brown forest soils with gleyed B and C horizons are developed on parent materials of fine texture (25-50% clay) and are imperfectly drained. The base saturation and pH (base saturation 84-100% in B and C horizons; pH 6·6-8·6 in B and C horizons in Whitsome series) are higher in these soils than in the brown forest soils of low base status and the exchangeable cations, calcium and magnesium, generally show higher values. The dominant series of this sub-group is the Whitsome series which is utilized entirely for arable farming, due to its high natural fertility together with its favourable climate. In some instances it contains free calcium carbonate (1-10%) and a very high pH (>7·0) in the B and C horizons.

Except for slight variations in two brown forest soils of low base status the results of silica/sesquioxide analyses of the brown earths show constant values with depth. This lack of differentiation of sesquioxides is in accord with the definition of this Major Soil Group and is similar to the results already obtained for north-east and south-west Scotland. The distribution of the brown earths is largely determined by parent material and topography —the brown forest soils of low base status occur mainly on the uplands in the west and north, while the brown forest soils with gleyed B and C horizons are largely situated on the low ground in Tweeddale and Lauderdale.

Brown forest soils with gleyed B and C horizons have a higher clay content in the B horizon than in the surface and are identifiable with the grey brown podzolic soils of the U.S.A.

The podzols are represented by two sub-groups—(a) iron podzols and (b) peaty podzols with thin iron pan. The iron podzols are freely drained, but the peaty podzols are usually gleyed above the iron pan. Except for differences in morphology, these two sub-groups have similar chemical characteristics. Both are developed on parent materials of coarse texture and

are mainly confined to hill areas under a cold wet climate. Leaching is strong in the A horizons as indicated by the silica/sesquioxide ratios. Values for exchangeable cations in these soils are invariably low (< Ca 3·0 m.e.; Mg < 0·3 m.e. per 100 g.) with the exception of the raw humus H layer which shows a concentration of these radicals (Ca 2·7-4·3 m.e.; Mg 1·7-3·6 m.e.). Parallel with this trend the base saturation (< 20%), pH (< 5·0), and acetic acid soluble P_2O_5 (< 3·0 mg. per 100 g.) are also low. The agricultural value of the podzols is very poor, due to their low natural fertility and ericaceous vegetation. Heather, if well managed, can, however, provide valuable winter grazing for the hardy black-face sheep on these soils and is especially valued in snowy weather.

The surface-water gleys are represented by three sub-groups—(a) non-calcareous gleys, (b) calcareous gleys, and (c) peaty gleys. All the gleys are developed on tills of fine texture and are usually sited in basins, valleys, and low-lying places. The non-calcareous gleys are the most widespread of the three sub-groups and their main chemical characteristics are high pH (>6·0), base saturation (>60%) and acetic acid soluble P_2O_5 (>10·0 mg. per 100 g.) in the B and C horizons. The calcareous gley, which is a series within the Whitsome Association, shows similar features but with free calcium carbonate also present in the B and C horizons (10-12%). Where possible these strongly gleyed soils are drained artificially by clay tiles at 5 yard intervals and the land is put to arable use, but if artificial drainage is difficult they are left under permanent grass. The remaining sub-group, peaty gleys, is associated with the podzols in that it is usually found in the hill areas—mostly on the lower slopes of the Lammermuirs. By comparison with the other gleys the peaty gleys exhibit strongly leached A horizons. The H horizon, as with the podzols, shows maximum concentration of exchangeable cations (Ca 1·4-5·0 m.e.; Mg 1·7-5·7 m.e. per 100 g.). Reclamation of these soils for cultivation is almost impossible due to the thick humus layer and the difficulty of drainage. Their vegetation is poor, usually an Eriophoretum similar to that on hill peat. Cotton grass (*Eriophorum vaginatum*), which is the dominant species, provides early grazing for sheep in the spring and is rich in phosphorus, while the complementary heather (*Calluna vulgaris*) is known to be rich in calcium.

Clay mineral studies of these soils show that the clays are dominantly illitic; kaolin and montmorillonite are also found. Chlorite, a primary mineral in the Lower Palaeozoic greywackes, is found in most of the soils and, other than in the Ettrick Association, is attributed to glacial contamination by transported greywacke.

Within the arable region of East Lothian and the Tweed basin, below approximately the 500 foot contour in an area of generally low relief, are found the most favourable agricultural conditions in Scotland. The farming reputation is widely known. The extremely high acreage of arable land is indicated by the fact that the proportions of permanent grassland, rotational grass, oats, barley, wheat, turnips and potatoes are approximately the same.

THE SOILS OF THE COUNTRY ROUND ELGIN

The soils of the Northern Lowlands of Morayshire, Sheet 95 (Elgin), comprise an area of 132 square miles which includes the fertile stretch known as the Laich o' Moray. The region forms part of the coastal plain which follows the southern shore of the Moray Firth from Portgordon westward to Inverness; some two-thirds of it is less than 100 feet above sea-level. Much of this low-lying ground is formed of raised beach, river flood-plain and drained lake-bed, so that immature soils on estuarine alluvial and lacustrine deposits are of considerable importance. Podzol soils on coarse textured parent materials predominate over the remainder of the area.

The highest land (maximum elevation 980 feet) occurs in the south-east where the metamorphic Dalradian rocks of Banffshire have resisted erosion. These rocks include quartzites, quartz schists, and micaceous flagstones, and till derived from them forms the parent material of the soils of the Durnhill, Strichen, and Foudland Associations respectively. To the west the gently undulating Old Red Sandstone plain is relieved by a series of ridges running roughly parallel to the coast. These also are formed of more resistant rock, the Monaughty ridge having a core of crystalline schists while the Quarrywood-Spynie and Burghead-Covesea ridges contain hard Permo-Trias sandstones. The Middle and Upper Old Red Sandstone formations both occur in the area. The Middle Division east of the Spey consists of a thick basal conglomerate followed by beds of shale and sandstone all characterized by a bright red or purplish red colour. The Upper Division includes both coarse and fine-grained sandstones predominantly yellow or grey in colour. The glaciation of Moray involved three major ice-movements with various minor fluctuations and practically the whole area has a till cover, although this is largely obscured by an overlay of extensive fluvio-glacial deposits of sand and gravel.

The area enjoys a reputation for mildness of climate. The chief characteristic of the temperature figures is a low diurnal range (average annual difference, 12°F.) and the average annual temperature at Elgin is 48°F. Prevailing westerly winds account for the infrequence of snow-falls and lingering frosts, and sunshine hours are high, particularly in winter, compared with other parts of Scotland. Rainfall is low, averaging 26 inches per annum and being fairly evenly distributed throughout the year.

With the exception of certain lacustrine and alluvial deposits, the soil parent materials are coarse textured and acid in nature, being derived almost entirely from highly siliceous rocks. This, coupled with the low rainfall, results in a predominance of freely drained soils and the development of podzolic profiles. The series included in the Durnhill, Strichen and Foudland Associations have been described in detail in a published memoir and discussed in last year's annual report. Two other soil associations have been distinguished on till. The first of them, the Tynet Association, of which the Tynet series is dominant, is developed on till derived from the Middle Old Red Sandstone. The till is characterized by its bright red colour and abundance of small, well-rounded pebbles from the conglomerate. The uncultivated freely drained profile is a well-defined peaty podzol with a 3 to 6 inch

raw humus layer and a conspicuous grey A_2 horizon which contrasts sharply with the yellowishred B_2 below. A weak iron pan is sometimes present. It may be significant that the type locality for this soil is known as Whiteash Hill. Where cultivated, the soil provides good arable land, given adequate manurial treatment, but much of the area on the sheet consists of heather moor with scrub birch, some of which has been ploughed by the Forestry Commission and planted with Scots Pine.

The Elgin Association is developed on till derived from the Upper Old Red Sandstone rarely containing more than 15 per cent. clay. The till is pale reddish brown in colour and normally contains a fair proportion of sandstone fragments. It is found on the higher ground in the south and on the ridges but appears to underlie the other drifts in most of the area west of the Spey. The dominant Elgin series is a podzol with an intensely indurated B_3 horizon. On depressed sites and concave slopes this indurated layer is sometimes sufficient to impede the drainage and induce some gleying of the upper horizons and has been distinguished as the Rosebrae series; this series, however, is of very limited extent. The soils are strongly acid, with pH values rarely exceeding 5 when uncultivated, and notably low in nutrients. Exchangeable potassium seldom approaches 0·1 m.e. per 100 g. and total phosphate is generally of the order of 0·05 per cent. P_2O_5. In both these associations poorly drained non-calcareous gleys and peaty gleys occur only in patches too small to be of significance.

The Boyndie and Corby Associations, on fluvio-glacial and river terrace sands and gravels respectively, together account for some 50 per cent. of the total area. Since both have clay plus silt contents of about 10 per cent., the natural drainage is dominantly free and tends to be excessive in places where the topography is more moundy than usual. The normal profile on an uncultivated site is a well-developed podzol. A thin iron pan is common in the Corby, but a characteristic of both is a strongly humus-iron cemented B horizon, the notorious "Moray pan." Much of the Corby Association is uncultivated and is planted to Scots pine woodland. The Boyndie areas are more extensively farmed and, despite its natural poverty, this association gives reasonable yields when suitably treated.

Contrasting sharply with these acid soils in topography, texture and genetic soil types are the two associations developed on lacustrine clays. The Carden Association is represented by one series, the Carden series—a brown forest soil with gleyed B and C horizons. The parent material is a reddish brown silty clay probably deposited in a temporary lake during a late stage of the last glaciation. The soils are all cultivated and have an S horizon of loam to clay-loam texture on a slightly gleyed silty-clay B(g) horizon (45% silt, 45% clay) with strong prismatic structure and much fine ochreous and grey mottling. The values for exchangeable bases are high and base saturation is normally 100 per cent.

The Duffus Association is exceptional for the north of Scotland in that the dominant series, the Duffus series, poorly drained, is a calcareous gley. Developed on lacustrine clay deposited in the bed of a former extension of the present Loch Spynie, with a range of texture from silty clay loam to clay, the

soils are the only ones in the area to present any cultivation problems. Nevertheless they are noted for high yields of oats, barley and wheat. They are all calcareous with pH values up to 8·5 and, in some instances, free calcium carbonate in the surface horizons. In the more recently drained areas in the vicinity it is not uncommon to find thin beds of shell marl in the alluvium. Certain of the Duffus soils contain a moderate proportion of sand in the surface layer. This sand has been incorporated by cultivation since a disastrous sandstorm at the end of the 17th century which, in addition to creating the Culbin Sands, devastated wide areas of the coastal plain.

Recent alluvium is so extensive that it was considered advisable to make some differentiation within it. This has been done on the basis of texture and natural drainage. A wide range of texture, from gravelly loamy sand to clayey and peaty soil was found, and, with much of the land so nearly at sea-level, poor drainage due to the high water table presents some problem even in the light-textured soils. The agricultural potential of these immature alluvial soils shows a corresponding variation, and while some of the wetter areas afford only poor quality grazing, many excellent farms have been established on the better sites.

Other immature soils are found on raised beach deposits, generally sandy in texture but often containing interbedded fine sand and silt bands. They occur in flat sites with free to excessive drainage which are of little agricultural importance but are eminently suited to their present utilization as service airfields.

The coastal fringe contains fairly extensive stretches of links, storm-beach shingle and dune sands. The links soils are formed of raw blown sand on raised beaches and are now stabilized by a closed vegetation cover of dry heath. In the past their main use has been as golf-courses, but recently the Forestry Commission has established forests at Roseisle, Innes Links, and Speymouth, using Scots and Corsican Pine.

The farming economy of the area as a whole is based on the fattening of cattle and considerable quantities of oats and turnips are grown. Barley is a popular crop in view of the many distilleries on Speyside. Wheat is grown successfully on the better quality soils and occasional fields of rye may be seen on the thinner sandy soils. An important cash crop is seed-potatoes and Morayshire grows more carrots than any other county in Scotland. The few large dairy farms supplying local needs are, with one exception, located on the alluvial soils. Practically all the suitable land not cultivated is wooded. Policy woodlands and shelter belt plantations are common throughout the area, and the Forestry Commission has, in addition to the coastal plantations already mentioned, a well-established forest of some 4000 acres at Monaughty and an extensive planting programme in the Speymouth district.

SYSTEMATIC SURVEYS

Black Isle (Parts of Sheet 83 (Inverness), 84 (Nairn), 93 (Alness), and 94 (Cromarty).

This area has been selected for survey at this stage because of the occurrence of trace element problems on certain soils. The presence of cobalt deficiency

has been recognized for many years, and possibly the contents of other elements including copper and molybdenum are giving rise to plant and animal disorders.

The Black Isle is a narrow peninsula about 20 miles long between the Cromarty and Moray Firths. It is about 7 to 8 miles wide in the broadest part, narrowing to 4 miles near Rosemarkie and less than 2 miles near the tip of Cromarty. There is a central ridge of high ground rising to between 500 and 800 feet.

The underlying strata are largely sediments of Middle Old Red Sandstone age with buff and grey sandstones common at the western end, and redder beds more common in the east. The coastal ridge south-west of Fortrose is mainly of Middle Old Red Sandstone basal conglomerate whilst north-east of Fortrose it is of faulted blocks of granitic gneiss.

Pending further investigations the dominant soil series have not been named. The main types of parent material so far encountered are: (a) A sandy loam to coarse sandy loam, massive till, prevalent over the broad south-western part of the peninsula. The dominant soils are podzols, often with a strong indurated layer relatively close to the surface. A strong iron pan is often situated at the surface of the indurated layer. The semi-natural soils are peat podzols and iron podzols in which there is a limited development of the L and F layers with traces of the H layer below them. (b) A pink or red loam textured till usually overlain by a variable depth of sandy modified material. It appears in patches north and south of Mount Eagle forestry area and more generally over the eastern Cromarty tip.

Other soil parent materials include shallow till on the granite-gneiss ridges with much sandstone derived material; residual soils overlying red sandstone rock on Mount Eagle and along part of the coastal plain area to the north of it; upper and lower 25 foot raised beach sands with less shingle with a variable overlay of colluvium at the back of the beach; alluvium; isolated patches of morainic sand and gravel; and a little basin peat.

The land use pattern is one of small crofts at the western end, a mixture of moderate sized arable farms and crofts along the north and south sides of the central part of the Isle with the Forestry Commission extensively occupying the central hills. Moderate sized farms cover much of the Cromarty tip.

Rainfall is between 25 and 30 inches, being lowest round the coast. Difficulty was experienced with stock as a result of a seasonal water shortage prior to the laying down of the present piped water supply now in an advanced stage.

Sheets 48 (Perth) and 49 (Arbroath)

Approximately 100 square miles have been mapped in the area, south of the Rivers Tay and Earn and extending from the western to the eastern margin of Sheet 48 and in the coastal area from Tayport to Leuchars airfield.

The greater part of the region surveyed on Sheet 48 is underlain by andesitic lavas of Old Red Sandstone age with limited occurrences of lava till. The soils developed on till have been identified with those of the Sourhope Association previously mapped on Sheet 17 (Jedburgh). The Association

covers mainly hilly country where till is absent or very thin, and the soils are generally of a shallow residual nature.

Sandstone deposits of Lower Old Red Sandstone age overlain by glacial till occur in the south-west corner of Sheet 48 and a narrow band, bordering the alluvial deposits of the Firth of Tay, extends from Abernethy to Wormit. Soils developed on this till, generally of clay loam or sandy clay loam texture, have been identified with the Balrownie Association which is extensive on Sheet 57 (Forfar).

Bordering the Sourhope Association areas of the Mountboy Association have been mapped. This is developed on Old Red Sandstone parent material derived from sandstone with a high proportion of andesitic lava. Limited areas of Auchinblae Association developed on red or red-brown sands and gravels of Old Red Sandstone origin have been mapped throughout the areas.

The only new association found this season covers a limited area around West Dron farm immediately south of Bridge of Earn. The soil, a brown forest soil with gleyed B and C horizons, is heavy textured and imperfectly drained and is developed on a deep red till of clay or sandy clay texture derived from sandstone of Upper Old Red Sandstone age. It has not yet been identified with any other association and is at present unnamed.

Areas of the Carse Association, developed on estuarine clay, extend along the valley of the River Earn from Bridge of Earn to Abernethy. On the upper terraces, above the 50 foot contour, alluvial soils are found with mixed textures varying from silty fine sandy loam to gravelly loamy sand. These have been separated provisionally as an Upper Terrace Complex.

The Links Association, developed on stabilized blown sand, has been mapped in the Tentsmuir area bordering the coast. A narrow strip of Fraserburgh Association, developed on shelly sand, follows the coastline at the northern end of Tentsmuir. About two miles inland from the coast deposits of fine-textured alluvium cover an extensive area.

In the Midland Valley stretching from Coupar Angus west toward Dunkeld and south-west toward Moneydie the region, apart from the alluvial areas bordering the River Tay and its tributary the River Isla, is underlain by Old Red Sandstone deposits of which the Balrownie Association is the most extensive. Limited areas of the Laurencekirk Association on till derived from Old Red Sandstone marl have also been mapped.

South-west of Coupar Angus, bordering the recent alluvium of the River Isla, large areas of Boyndie Association developed on fluvio-glacial sand occur. The association merges on the north side into an area of the Corby Association on fluvio-glacial gravel. The dominant series in both associations is an iron podzol with free drainage.

Sheet 39 (Stirling)

Approximately 60 square miles have been mapped in the vicinity of Callander, Glen Artney, Dunblane and Cromlix, Longsidemuir and the Ochil Hills.

Only one new association has been encountered; this is developed on a mixed till derived from Old Red Sandstone sediments and Highland schists.

The dominant series is a freely drained podzol but on flatter sites it may be imperfectly drained above the B horizon. A typical profile is 2 inches of black fibrous and greasy humus over 3 inches of dark grey brown silty fine sandy loam over 8 inches of strong brown silty loam over 9 inches of yellow brown silty loam or olive grey till which is often quite stony. The association may be correlated with the Strathfinella, first established on Sheet 66 (Banchory).

Sheet 14 (Ayr)

Approximately 85 square miles have been surveyed, leaving some 40 square miles to complete the sheet much of which is non-arable land and includes large areas of hill peat.

The areas surveyed are in the south-east and south-west corners of the sheet. The eastern part is mostly hill country south of the Southern Uplands fault and the soils are dominantly various series of the Ettrick Association and peat. This is a high rainfall area devoted almost exclusively to sheep farming.

The western part lies between Maybole, Dailly, and the coast. The dominant soils belong to the Glenalmond Association on till derived from Old Red Sandstone with associated soils of the Maybole (moraine) and Darvel (gravel) Associations. Other soils include the Rowanhill (Carboniferous sediments) and Ettrick (greywacke) Associations. Mixed dairy and arable farming is practised, with early potato growing a feature of the coastal strip.

Sheets 7 (Girvan) and 8 (Carrick)

The soil survey of Sheets 7 (Girvan) and 8 (Carrick) was commenced this season. The area lies immediately south of Sheet 14 (Ayr) where surveying has already been in progress for some four years.

Most of the area is underlain by greywackes and shales of the Ordovician and Silurian systems, but in the east the Loch Doon granite occupies about 30 square miles and smaller areas of granite occur in the north-east and south-east corners of the sheet. In addition, about 40 square miles along the northern border of the sheet are underlain by Old Red Sandstone and Carboniferous sediments or andesitic lavas and felsites.

Preliminary surveys of soils developed on the Loch Doon granite have been carried out at the northern end of the outcrop at Loch Doon and at the southern end of the outcrop at Loch Trool. A more detailed survey of 40 square miles of the northern belt of the above area has been carried out. Soils developed on an Old Red Sandstone till have been referred to the Glenalmond Association which occurs in Sheet 14 (Ayr), whilst those derived from the Ordovician and Silurian greywackes and shales have been referred to the Ettrick Association of Sheets 17 and 18 (Jedburgh and Morebattle). The sands and gravels of terraces flanking the Water of Girvan between Dailly and Girvan have been grouped with the Darvel Association of Sheet 22 (Kilmarnock). A mixed sandstone till dominantly derived from Lower Carboniferous sediments forms a new association found also in the south of Sheet 14 and yet to be named. A further new association, provisionally named the Benan, is developed on soils derived from the Benan conglomerate

of the Ordovician system. In this case, although the parent rock is a sediment, most of the pebbles of the conglomerate are of basic igneous rocks. The soil thus resembles those of the Darleith Association of Sheet 22 (Kilmarnock) or the Insch Association of Sheets 86 and 96 (Banff, Huntly and Turriff).

Sheets 33 (Haddington) and 34 (Eyemouth)

Approximately 100 square miles have been surveyed this year, mostly in the western half of East Lothian. Many of the soils encountered are brown forest soils with gleyed B and C horizons derived from mixed tills similar to those already established in south-west Scotland. Until correlation has been attempted no soil series have yet been named on these parent materials.

SPECIAL SURVEYS

Isle of Rhum

The survey team from south-east Scotland made a detailed survey of the soils of the Isle of Rhum during the early summer. This survey was carried out for the Nature Conservancy and covered some 42 square miles of mountains and moorlands. A system of survey was evolved using air photographs on a scale of 1 : 10,000 which yielded an accuracy, even allowing for scale distortion on the photographs, which could only have been obtained otherwise by months of painstaking work. The survey gave an insight into techniques which will have to be used extensively in the Highlands of Scotland when these are surveyed. Although much of the island was peat covered, the soils identified were of undoubted interest. Among soils mapped for the first time in Scotland were alpine podzols on acid igneous rocks above 1,000 feet and a rendzina on a hard Triassic limestone. A map and preliminary report have been submitted to the Nature Conservancy.

Gartrennich Farm (Perthshire)

A survey of Gartrennich Farm, Aberfoyle, Perthshire, on a scale of 6 inches to 1 mile was made at the request of the Peat Division of the Department of Agriculture for Scotland. The farm comprises 620 acres; 140 are arable and the remainder peat.

Glen Turret Water Supply (Perthshire and Stirlingshire)

Information on the soils and parent materials along the line of the pipe from Glen Turret to Grangemouth was supplied to the civil engineers concerned who are interested in the prevention of pipe corrosion.

VEGETATION SURVEYS

Reconnaissance surveys of the vegetation of Sheet 14 (Ayr) and Sheet 39 (Stirling) have been carried out.

A greater number of records by plant sociological methods were taken with a view to bringing basic classification units of vegetation into line with those of the Nature Conservancy surveys.

Further specimens have been collected for the herbarium including bryophytes and lichens.

PEAT ECOLOGY

ECOLOGY

Ecological investigations directed towards the general improvement of upland grazings have continued and during the year two papers[3, 4] dealing with this aspect of the work have been published.

Recolonization studies on *Calluneta* and associated types of vegetation are still in progress at three centres and the results of the heather grazing experiment are being evaluated. The manurial trial designed to determine the response of various types of hill vegetation to low and high rates of lime and phosphate, such as might be applied by aircraft, has been extended at two out of the original four sites selected in 1952.

Considerable progress has been made at Coalburn Moss where, in collaboration with the Hill Farming Research Organization, the agronomic significance of water in peat is being investigated. On the unimproved series of plots where differential water tables have been successfully maintained, initial characterization of peat profiles and regenerating vegetation has been completed and levelling carried out at regular intervals. Following the establishment of a vigorous grass sward, a parallel series of plots is being established in order to determine the effect of different moisture regimes on the growth and development of the improved vegetation.

Another joint experiment designed to investigate the nature of run-off from areas of deep peat subjected to different surface treatments such as burning, surface seeding, and cultivation, is in a preliminary stage of development. During the current year a meteorological station has been set up and information obtained on the range of flow to be expected from the total catchment area and the most suitable methods of measurement.

POLLEN ANALYSIS AND QUATERNARY RESEARCH

Work has continued along the usual lines with the main emphasis on accumulating evidence on vegetational history from different parts of the country. A number of peat mosses on raised beaches in Argyll have been sampled for pollen analysis and a few sites, mainly of archaeological interest, are being investigated in the same area. Identification of both pollen and macroscopic plant remains from a buried organic horizon exposed during excavations by the North of Scotland Hydro-Electric Board in Ross-shire suggests that this plant bed is in all probability an Alleröd deposit (Zone 11). This is of particular interest as it is the first such site to be found in the north of Scotland. It is hoped that the Sub-department of Quaternary Research in Cambridge, which is collaborating in this investigation, will be able to ascertain a more accurate date for this material by the C^{14} method.

A paper[6] dealing with the pollen analysis of peats in Caithness and east Sutherland has been published, and a joint account of the vegetational history of an area in Wester Ross-shire is in preparation.

BOG CULTIVATION AND RECLAMATION

Investigations in this field are being carried out in association with the Scottish Peat Committee (Moss Survey Group) and the Department of Soil

Fertility. A number of non-fuel peat bogs representative of the range of types to be found in Scotland have been surveyed and their suitability for experimental cultivation assessed. Details of the cost of such schemes have been worked out and the social implications of the improvements examined. Close liaison is being maintained with the Department of Agriculture in Eire where a number of large-scale reclamation projects on both blanket bog and deep basin peat were inspected during the summer. A paper[10] reviewing some of the techniques used in bog cultivation has been published.

The grassland fertility trial has continued at Gardrum Moss, Stirlingshire. In addition to the three annual cuts taken to determine yield and chemical composition of the herbage, botanical analysis of the 109 plots has been completed on a separation basis. This will allow the percentage productivity of each of the five sown species to be determined. Any differential uptake of nutrients may also be assessed under the various manurial treatments.

A survey of the basal soils of Lochar Moss, Dumfries, has been completed.

LABORATORY INVESTIGATIONS

The routine analyis of samples submitted by the Department of Agriculture for Scotland (Peat Section) has continued. During the year over 1200 peat samples were received from the following areas: Lochar Moss, Dumfries; Kame Moss, Shetland; Gartrennich Moss, Aberfoyle; Lagan Moss and Monadh nan Cathag, Islay. Fibre estimations on an additional 20 samples from these deposits have been completed. Peat samples requiring special analyses have been received from Lancashire, Eire, and Pakistan, and routine chemical analyses of an increasing number of peat and herbage samples from field experiments have been completed.

Pot experiments to determine the suitability of different peat types for use in horticulture are still in progress in association with the Department of Plant Physiology.

SOIL GEOLOGY AND MINERALOGY

SCOTTISH SOILS

During the year the clay and fine sand fractions from representative soil profiles from the counties of Berwick, Roxburgh and Aberdeen have been examined by X-ray diffraction and optical methods. Chlorite and mixed-layer chlorite-vermiculite have been found in many of the soils from southern Scotland, but illite is invariably the dominant clay mineral. Mineralogical analyses of the fine sands have shown the mixed origin of the glacial drifts which form the parent material of most of the soils.

ROCK WEATHERING

The mineralogical study of weathering and soil formation on several basic igneous rocks in south-east Scotland has shown that some of the primary minerals had been affected by hydro-thermal alteration before coming under the influence of subaereal weathering. Resistance of the principal rock minerals to weathering in the soils has been found to increase in the order olivine, labradorite, augite, magnetite, ilmenite, haematite. The products

of alteration of the olivine crystals were found by X-ray diffraction methods to consist of an oriented intergrowth of haematite with a chloritic type of clay mineral. The mixture apparently corresponds to what has frequently been described as iddingsite in the past, where identification was made primarily on optical and chemical data. The clay minerals in the soil profiles were mostly vermiculite (or montmorillonite) and kaolin. The absence of illite has been related to the very low potassium content of the parent rocks.

PHOSPHATE FIXATION

Considerable progress has been made in the study of the nature and formation of synthetic and natural phosphates of iron and aluminium which may play a part in the fixation of phosphates in soils. A further series of pot experiments to test the availability to oats of the phosphate in these compounds has been carried out by the Department of Soil Fertility. In general the responses were very low, especially for the iron-containing phosphates. Experiments in the laboratory using soil minerals and pure minerals have shown that when these are kept in contact with solid soluble phosphate particles in a moist condition for periods up to three months insoluble phosphates are precipitated at room temperatures. It seems clear that similar reactions may occur in field conditions. The sorption of phytin—a major component of the organic phosphate in soils—on clay minerals and on soil clays at various pH levels has also been investigated.

OTHER INVESTIGATIONS

A number of soil clays from a forest nursery at the University of Istanbul have been examined. They contained a chlorite-vermiculite regularly interstratified mineral along with montmorillonite, illite, and kaolin.

In collaboration with the Section of Peat Ecology and the Scottish Peat Committee, a survey has been carried out of the basal soil material below the peat at Lochar Moss in Dumfriesshire, and the clay fractions of the profile samples have been analysed mineralogically. A considerable area of potentially very rich agricultural land on silty alluvial deposits could be brought into production here by removal of the peat and improvement of the drainage.

A number of samples have been examined at the request of other sections and departments. These included montmorillonites, illites, and oxides of iron and aluminium for the Section of Physical Chemistry, phosphate compounds for the Section of Microbiology, and samples of silt and clay fractions for the Department of Spectrochemistry.

Two papers[11],[12] on the clay and silt fractions of soils on basalts in Northern Ireland, mentioned in last year's report, have been published. An international conference on clay mineralogy held in Brussels in July was attended, and a paper on the mineralogy of Scottish soils was read at the meeting of the British Association for the Advancement of Science held in Glasgow.

PHYSICAL CHEMISTRY

The work described in last year's report has continued and may be considered under the same headings.

SEPARATION OF CLAYS

Only a limited number of soil-clay separations have been carried out during the year because of the number awaiting examination by X-ray and differential thermal methods.

DIFFERENTIAL THERMAL ANALYSIS

This technique, which involves measuring the temperature difference between a sample and an inert material as the two are heated under suitable conditions, enables a rapid qualitative and quantitative assessment of the mineralogy of a clay. An examination of the usefulness of the method as compared to others used for the study of clays has appeared in a paper[13] published during the year.

Normal Differential Thermal Technique

Soil clays from Aberdeenshire and Morayshire showed the presence of the usual suite of clay minerals, but a number of clays from Hong-Kong, Ghana, Kenya and other overseas territories gave curves which were in complete contrast. The latter had very high contents of kandite and sesquioxide minerals and it has been possible by using a combination of chemical and thermal techniques to determine quantitatively the kandite, goethite, and gibbsite content of the clay.[31] This method has now been widely tested and it is believed to give accurate results.

Minerals examined during the year included iron and aluminium oxides, phosphates, and montmorillonites. An intensive study of the effect of exchangeable ions upon the differential thermal curve of normal montmorillonite and upon the "fixation" of ions by normal montmorillonite has been carried out. By a combination of electron microscope, electron diffraction, X-ray, infrared absorption, and differential thermal methods it has been possible to elucidate the significance of the peaks on the differential thermal curves for iron oxide gels.[32] A similar set of experiments on alumina gels is almost complete.

The effect of chemical pretreatment of minerals upon their differential thermal curves has been further investigated, but no one useful method has yet been evolved. Papers upon the variability of the montmorillonite differential thermal curve[14], saponite[15], and illite[16] have appeared.

Controlled-Atmosphere Technique

The apparatus has been developed during the year by the addition of an inexpensive but very accurate programme controller, a new recording drum, and an additional furnace. It is now operating extremely satisfactorily. Because of the difference in emphasis of the two types of work performed by this apparatus it is best to consider it under two headings: (a) inert atmosphere, and (b) complete combustion.

Inert Atmosphere: Many minerals have been examined during the year in inert atmosphere, either because they gave rise to oxidation effects in air or because they were available in too small quantity for the normal apparatus.

The tendency has, indeed, been to use the controlled-atmosphere apparatus wherever practicable because the information obtainable is vastly superior to that provided by the normal apparatus.

Various iron oxide minerals, hydromica, chlorite, cronstedtite, nontronite, and interstratified minerals, in addition to several samples of illite associated with Old Red Sandstone deposits, have been examined. Calcium oxalate was thoroughly checked as it was believed differential thermal analysis might provide a method for detecting this in plants. Although as little as 0·5 mg. could be detected in mixture and although it was clearly observable in *bougainvillaea* leaves, the concentration in oat plants proved too small for detection. In collaboration with the Section of Soil Geology and Mineralogy much work has been done on phosphate minerals. Some preliminary investigations upon the dehydroxylation and rehydroxylation of normal and abnormal montmorillonite have also been carried out.

Soil clays from the localities mentioned in the previous section have been examined. The differences between the tropical and sub-tropical clays and those from Scotland was again very marked.

Complete Combustion: Peat samples of known botanical composition and degree of humification from mosses in Aberdeenshire, Caithness, Perthshire, Ross and Cromarty, and Wigtownshire have been examined. There appears to be a correlation between the characteristic double exothermic peak on the curve and both the botanical nature and degree of humification[17], but because the two are so closely linked it is difficult to disentangle the contribution of each. Examination of various peats showed a linear relationship between the calorific value of the peat and the area under the exothermic peak. In view of the complexity of the compounds in peat it has been decided that it would be useful to examine homologous series in an attempt to elucidate the full significance of the curve. This work has commenced using the higher solid paraffins. Organic matter separated from A horizons of soils has also been examined.

CHEMICAL STUDIES

Several clay minerals and clays have been analysed by semi-micro methods. In addition various iron and aluminium phosphates were analysed for the Section of Soil Geology and Mineralogy. The acid-dissolution technique for the estimation of octahedral and tetrahedral iron in smectites was applied to several montmorillonite samples, but some anomalies were observed.[33] Various new and modified methods have been tested for accuracy and rapidity on the semi-micro scale, and some have been found very satisfactory in both respects. An investigation into the mechanism of the photo-sensitive dissolution of iron oxides by oxalate solutions was carried out by Dr A. S. de Endredy of the Division of Soil and Land-Use Survey, Ghana, while working in the Section.

The density of water sorbed by montmorillonite has been discussed in a short note.[18]

SOIL ANALYSIS

Standard analyses of the soils collected by the soil surveyors during 1956 have been completed. During 1957, 525 samples (93 profiles) were taken and on those the following determinations have been completed: exchangeable bases, total carbon, total nitrogen, total and readily soluble phosphorus, and hydrogen ion concentration. Loss on ignition, mechanical analysis, and exchangeable hydrogen determinations have been completed on two-thirds of the samples.

Standard analyses have been carried out on 95 samples from Malta and 66 samples from Gozo in connection with a soil survey of these islands. In addition the calcium removed from these soils on extraction with ammonium oxalate was determined. Carbon dioxide determinations have been completed on 50 calcareous soils from Malta and south-east Scotland. Ultimate analysis of 123 samples (soils, soil separates, iron pans, etc.) and total silica, iron, and aluminium determinations on 30 clay samples have been carried out. About 100 miscellaneous samples of soil, clay, synthetic minerals, plant extracts, etc., have been analysed for various departments in the Institute and for the Hill Farming Research Organization.

SPECTROCHEMISTRY

Many results of analyses carried out in the Department of Spectrochemistry are recorded in the reports of other departments, and in order to avoid repetition these receive only brief mention here. This wide application of spectrochemical methods serves to underline the desirability of having such specialized items of equipment centralized, under the control of, and operated by workers experienced in their use, rather than having them scattered and duplicated throughout various departments where utilization might be spasmodic and less effective. This is probably true not only of spectrochemical equipment but of any type of equipment applicable to different problems which involves high capital outlay and specialized operation and maintenance.

In this connection it has become apparent that the use of physical methods for analysis on a serial basis tends to promote increased demands rather than to make time available for development in other directions. This is particularly true when the determinations are carried out by a service laboratory and not in the department producing the samples. It is therefore essential to have an efficient means of screening out unnecessary determinations at an early stage, if this has not been ensured by sound statistical planning. In direct reading spectrochemical work, as illustrated by the determination of magnesium by the porous cup solution spark excitation technique, in which the actual time of determination is little over one minute per sample, the cost of electrodes and the time involved in their preparation are factors which must be kept in mind. Experiments should be planned from the outset with the final analytical requirements in view. This has become particularly obvious where assistance in trace element studies is being given to external and overseas field workers, and where numbers of samples of the order of one quarter of the annual output of the department have been suggested for a single exploratory experiment. It is important to be sure that the cause of any problem requiring investigation does not lie in some straightforward and readily investigated factor before turning to more complex possibilities. It is not uncommon to be asked for trace element investigation before the major nutrient status of the samples in question has been checked and found to be in order.

During the past year collaboration with all departments within the Institute has continued. The most extensive work has been in conjunction with the Department of Soil Fertility, involving both trace element investigations and determinations of potassium, calcium, and sodium in fertility studies. Infrared and ultraviolet absorption has proved a valuable tool in biochemical and microbiological investigations as well as in certain pedological work. Collaboration has also been maintained with various N.A.A.S. centres, particularly where problems related to excess of trace elements arise, and with other British and overseas research organizations.

Visiting research workers who spent more than one month in the Department were Dr M. L. Berrow, A.R.C. Research Scholar, Mr Lim Chin Hua, Department of the Government Chemist, Singapore, Dr Manuel Marino, Centro Investigaciones Agronómicas, Maracay, Venezuela, Dr Alina Kabata, Institute of Soil Science, Pulawy, Poland, and Mr Biswanath Bhattacharyya, Bureau of Mines, New Delhi, India. Several other workers spent shorter periods studying specific methods. The demands for training facilities continue, and the accommodation available for long-term visitors has already been allocated for the forthcoming year.

Members of the staff of the department attended various scientific meetings during the year, including the International Colloquium on Spectroscopy in Liège, Belgium, the International Microchemical Conference in Birmingham, the Molecular Spectroscopy Conference of the Hydrocarbon Research Group in London, the British Association meeting in Glasgow, the Infra Red Discussion Group in Edinburgh, as well as such other discussion groups as the Inter-Services/D.S.I.R. Panel on Emission Spectroscopy and various committees of the A.R.C. and other government departments.

TRACE ELEMENTS IN SOILS, PLANTS, AND BIOLOGICAL MATERIALS

Soils and Soil Parent Materials

A comprehensive knowledge of the distribution of trace elements in rocks and minerals has been obtained in recent years, as a result of geochemical investigations carried out in a number of laboratories throughout the world, including this department. The original work of V. M. Goldschmidt has in general been confirmed and consolidated. The results have enabled an assessment to be made of the probable distribution of trace elements in soils and soil parent materials of different geological origins. The study of the total trace element contents of soils from the different associations and series examined by the Soil Survey of Scotland has shown that the nature of the parent material is of prime importance in determining the total soil content of such biologically important trace elements as cobalt, copper, manganese, molybdenum, and zinc, as well as such toxic heavy metals as nickel. The total content is not the only factor, as availability must also be kept in mind, but it gives an important lead in indicating possible deficiencies or excesses. During the year a number of soil profiles from the south-east of Scotland have been examined and findings in good agreement with profiles on similar parent materials in other districts have been obtained.

Such trace element information as has previously been available has, with few exceptions, referred to total or extractable contents in the whole soil, and the distribution in the different size fractions could only be inferred from knowledge of the mineral content of these fractions. A detailed investigation of the trace element content of the various particle size fractions of the different layers of freely and poorly drained profiles developed on the Countesswells and Insch Associations (granitic and basic igneous parent materials) has now been completed by a research student, and the results

presented in the form of a thesis which has been accepted for the degree of Doctor of Philosophy by the University of Aberdeen. In addition to the total contents of some 20 elements in each size fraction, separated by repeated sedimentation in distilled water, the amounts extracted by different soil extractants were determined. In general, good agreement was obtained between the results for whole soil and the sum of the contributions of the individual fractions. Interesting differences were obtained between poorly and freely drained profiles both in contents of individual size fractions and in variation with depth.

A brief report on the trace element contents of some soils and rocks from Macquarie Island has been published.[19]

Soil Status and Plant Uptake

The long-term experiments carried out in collaboration with the Department of Soil Fertility and mentioned in previous reports have been continued and extended. In studying the relationship between soil content and plant uptake there are two possible major lines of approach involving field work. One is to examine soils from different soil series over a period of years in order to ascertain what correlation, if any, exists between the plant content of the various trace elements and the amounts extracted from the soils by different extractants. In order to reduce the number of variables to a reasonable level, this investigation has generally been limited to the constituents of mixed pasture herbage sampled at the period of clover flowering in June. The analyses required by this investigation have now been carried out on plant samples taken during the past five years from typical soils of north-east Scotland. The examination of different soil extractants is still in progress, as it appears highly unlikely that any one extractant will prove suitable for the assessment of the availability of all important trace elements. It is possible that the results obtained in the investigation of the various size fractions reported above will prove instructive in the interpretation of the results of this investigation.

The second approach is to study the effect on plant uptake of addition of trace elements to the soil. This involves laying down replicated experimental plots and the analysis of samples of the crops over a number of years. If normal agricultural rotational practice is followed it is unfortunately not possible, except perhaps with pasture herbage, to study the change of content with time. Generally, also, the practical usefulness of this technique for subsequent diagnostic purposes is small, as the amount of trace element extracted from the soil in these experiments is composed of the amount originally present plus the addition, generally much more readily soluble. The relative amounts of these vary with different elements. Thus, with cobalt, an addition to the soil of 2 lb. cobalt sulphate per acre, or approximately one quarter of one part per million of cobalt in the soil, may increase the cobalt content of the herbage 5-10 fold over a number of years, but be very difficult to detect by soil extraction soon after addition. It is therefore essential to have all relevant information regarding previous soil treatment when the diagnostic assessment of the results of soil analysis is being made.

Such treatment appears to provide cobalt which is much more readily available to plants than that normally present in the soil. Experiments of this nature are useful in studying the most effective remedial dressings required to deal with trace element deficiencies or even to counteract excesses. Experiments along these lines are in progress, dealing chiefly with the uptake of copper, manganese, and cobalt under differing conditions of application.

During the past year further instances of molybdenum contents of herbage sufficiently high (*i.e.*, 5-10 p.p.m. or above) to produce disorders in stock have been encountered in various districts of north-east Scotland. As mentioned last year, the study of these occurrences has suggested a possible correlation with impeded drainage in certain instances: work is still in progress. It is desirable, however, to draw attention to such occurrences and to point out that, in general, in Scottish soils, the molybdenum level is at least adequate for crop production. The addition of fertilizers containing even small amounts of molybdenum (as little as a few ounces per acre) may be dangerous, particularly in areas where pasture herbages contain more than 1-2 p.p.m. Mo in the dry matter. Such areas may be quite localized and cannot readily be delineated, as many factors, including lime status, drainage, and organic matter content, affect molybdenum uptake. Addition should only be made if molybdenum deficiency has been diagnosed.

SPECTROCHEMICAL METHODS OF ANALYSIS

The determination of potassium, sodium and calcium in soil and plant extracts by flame photometry and of trace elements in plant materials, soil extracts and other related materials by arc excitation after chemical concentration, has been continued during the year. Demands have continued to increase and at the end of the year there were a considerable number of plant samples from experimental plots awaiting examination. This delay was caused in part by changes in the assistant (scientific) staff and in part by the introduction of new methods to include the determination of additional elements in each sample. A brief description of two items of equipment built in the department, a three-channel flame photometer and an electronic scanning microphotometer, has been accepted for publication.[34] The latter is at present being rebuilt in an improved form.

Direct Photometry

An eleven-channel Hilger Direct Reading Attachment for the Hilger Medium Quartz Spectrograph has been acquired by a grant from the Rockefeller Foundation. This instrument has been adjusted to provide direct analysis of zinc, silicon, boron, phosphorus, chromium, iron, magnesium, manganese, aluminium, lithium and copper, the intention being to employ chromium and lithium as internal standards. The design of the instrument, and the dispersion of the medium spectrograph, are such that there is some restriction in the choice of spectral lines available and the elements at present selected are those which it is hoped can be analysed directly in plant material or simple soil extracts without chemical concentration.

In the six months during which the equipment has been in service only porous cup solution spark excitation has been employed, and limits of determination in solution of from one-tenth to ten parts per million have been achieved, the most sensitive being copper and the least sensitive phosphorus. These values must be taken only as indications of performance, as such variables as the sensitivity of individual photomultiplier tubes, which may vary more than 10 fold from tube to tube, cannot be precisely assessed, and different elements vary differently with different parameters. Because of appreciable dark current in certain 1P28 tubes at full sensitivity, it has proved necessary to apply a correction for this to obtain accuracy at low contents.

The direct reader has been used mainly for the examination of EDTA, ammonium acetate and acetic acid extracts of soils, for the determination of copper and manganese. Excellent results have been obtained for the determination of copper in EDTA extracts.

A recently completed modification to the spark-stand will enable work to start on a rotating disk method. The modification involves the introduction of perspex and nylon fittings and a spring loaded carrier for the rotating disks.

The two-channel direct reading attachment to the Hilger Small Quartz Spectrograph for the determination of magnesium in acetic acid extracts of soils and other solutions has been in continuous operation during the year and has proved satisfactory and reliable. This instrument was designed and built in our workshop and a description[35] has been accepted for publication. The demands for magnesium determinations now amount to 400-600 per week.

In order to meet the increased consumption of electrodes an automatic cutter has been constructed in the Institute workshop. This can cut up a batch of 50 ten inch long carbon rods into predetermined lengths of about one inch accurately without attention. The cut end is satisfactory for use as the base of a porous cup without further machining. This has appreciably accelerated the production of electrodes.

ABSORPTION SPECTROMETRY OF SOIL CONSTITUENTS

Infrared studies on both organic and inorganic constituents of soils and peats have continued. Studies on the clay minerals talc, saponite, and hectorite, previously reported, have now been published,[20] and work has begun on the related micas of the phlogopite-biotite series. Their spectra have been found to vary with composition, due to substitution of ferrous for magnesium ions in the octahedral sites, and of ferric for aluminium ions in the tetrahedral sites in the crystal lattice. Other spectral differences which are not correlated with composition are thought to arise from variations in the stacking of the sheets. Work on phosphate fixation in the Section of Soil Geology and Mineralogy has made available a very full range of synthetic and natural iron and aluminium phosphates. Their infrared spectra have been found to provide information additional to that given by X-ray spectrometry, and a combination of these two techniques has led to a better understanding of the structure and interrelations of these minerals. One feature of the infrared spectra has been their ability to reveal the presence of amor-

phous material associated with the crystalline phosphates. Such amorphous material makes little contribution to the X-ray spectra.

The work of the Department of Biochemistry on organic matter of soil and peat has provided a wide range of fractions and chemical derivatives whose infrared spectra are yielding useful information. Co-operative studies with the Section of Microbiology and the Department of Biochemistry have continued. Work previously reported, leading to the characterization of 6-0-acetyl-D-glucopyranose and some related compounds has been fully described,[36] as has work on the effects of ring substituents on the β-oxidation of phenoxybutyric acids.[21] Co-operative work on the metabolism, by some wood-rotting basidomycetes, of compounds related to lignin is being actively pursued. Analytical techniques have been developed to follow the course of metabolism, using both ultraviolet and infrared spectrometry.

BIOCHEMISTRY

The study of the nature of soil organic matter has been carried on for some years along two main lines: by direct chemical investigation of materials extracted from soil, and by a study of the products of metabolism of soil bacteria.

The direct approach has shown that sugars, amino-acids, and lignin-like substances are present. In some cases, as with lignins, reported last year and now published in full,[22] the materials present in the soil have some recognizable relationship to the plant residues from which they probably originated. This work has been supported by new studies, in co-operation with the Department of Spectrochemistry, of chemically modified humic acids from *Phragmites* peat. Their infrared spectra are well defined and have a distinct relationship to that of lignin preparations from *Phragmites* itself.

In other cases the soil constituents provide no clue to their origins. Thus analyses just completed have shown a general similarity in the proportions of individual amino-acids in a variety of soil samples, for example several from vegetation substitution plots with bracken and *Calluna* at Glensaugh, Kincardineshire, and from grass plots receiving different manurial treatments at West Fingask, Aberdeenshire.

Early work on the sugars contained in soil organic matter showed only a few which were already known to occur widely in plants, animals, and micro-organisms, but later studies have shown that smaller amounts of unknown sugars are also present. These are of particular interest because in recent years a great number of sugars of unusual structure have been found in the cell walls and other products of bacterial metabolism. It has been necessary to refine the analytical techniques, and the first result of this has been to show that the samples of partly methylated sugars from soil polysaccharides studied a few years ago were probably mixtures. During the year a new method for the separation of simple sugars has been investigated and reported to the April 1958 meeting of the Biochemical Society.

The search, in collaboration with the Section of Microbiology, for unusual sugars among the products of metabolism of soil bacteria has led to some interesting discoveries. Full accounts[23], [36], [37] have now been written of the formation and breakdown of 6-0-acetylglucose by *B. megaterium*. These include proof of structure and information about the infrared spectrum obtained in collaboration with the Department of Spectrochemistry. It has now been found that *Nocardia opaca*, which has been the subject of several publications on the mechanism of fatty acid oxidation, including one[21] this year, produces considerable amounts of sedoheptulose, ribulose, and dihydroxyacetone from glucose when growing in a medium containing calcium carbonate. Five years ago no explanation would have been forthcoming for this, but it is now known that these sugars constitute part of the "pentose

pathway," an alternative route of carbohydrate metabolism in plants, bacteria, and animals. The reasons for their excretion by *N. opaca* are unknown, but there appears to be no specific effect of calcium carbonate; if the pH is prevented from falling by other modifications of the growth medium they appear almost as abundantly. A point of interest is that ribulose is known to exert a specific stimulatory effect in the extension growth of roots, but whether the organism would produce these sugars in the soil is at present an open question. This work was reported to the June 1958 meeting of the Biochemical Society, and a further account is being prepared for publication.

PLANT BIOCHEMISTRY

Work on the trisaccharide fraction of monocotyledons, reported last year, is almost complete.

A spectrophotometric method, using 0·5 g. samples, has been developed for the measurement of the enzyme aconitase in leaves. Preliminary results show considerable variations in the aconitase content according to species and age of leaf. In collaboration with the Department of Plant Physiology, the method is being applied to leaves of iron-deficient plants. An account of the method was given to the IVth International Congress of Biochemistry in September, 1958.

Some of the analyses of amino-acids and organic acids in leaves made in collaboration with the Department of Plant Physiology are being published in full[38], [39], and others have been reported to the International Congress of Biochemistry.

PLANT PHYSIOLOGY

Investigations have proceeded on much the same lines as in the previous year. Mr A. H. Knight spent six months at the Kearney Foundation for Soil Science, Berkeley, California, during tenure of a Fellowship from the Lalor Foundation.

PEAT UTILIZATION

Work in collaboration with the Section of Peat Ecology has continued. Peat from Alt-na-breac, which was reputed to be toxic to plants, has been found in greenhouse tests to be as good a medium for plant growth as granulated peat supplied for horticultural use. Tomatoes have shown luxurious growth in almost pure peat provided a satisfactory nutrient solution was applied at regular intervals. Experiments have also been started on growth of rye grass on peat to determine whether early or late application of nitrate gives the better "take."

MINERAL BALANCE

An experiment to study the interaction between calcium, iron, phosphorus, and potassium in the ash of leaves of mustard has been completed and a highly significant correlation obtained between the phosphorus-iron and potassium-calcium ratios. Further experiments have been carried out to compare the amounts of iron extractable by normal hydrochloric acid with the total iron in plant leaves.

The effect of supplying nitrogen as the ammonium or nitrate ion to mustard plants has been studied in nutrient culture and results of these studies presented to the IVth International Congress of Biochemistry in Vienna. Work on the amino and organic acids of various plant leaves has been carried out in collaboration with the Department of Biochemistry and two papers[38, 39] have been accepted for publication.

CHANGES IN METABOLIC PROCESSES CONSEQUENT TO AGEING

A study[24] of the stimulatory effect of heavy metal inhibitors on the oxygen uptake of mature leaf tissue, in which it appeared that the response of the tissue to the inhibitor was a function of its iron status as measured by the phosphorus-iron ratio, has been published and a more detailed study of the changes in cyanide sensitivity of the leaves of *Heracleum giganteum* has been made during the past summer. Mineral analyses and amino and organic acid estimations have been carried out together with the respiratory measurements. The great size of the leaves of this plant allows regular sampling of the same leaf throughout the growing season and because of this it is possible to compare changes due to ageing in any one leaf throughout the growing season with those exhibited by a series of leaves present on the plant at any one time.

The investigation of the metabolism of disks of storage tissue has continued with emphasis on the changes in amino and organic acids. Two papers[40], [41] embodying the results of earlier studies have been accepted for publication.

CATION EXCHANGE CAPACITY OF PLANT ROOTS

The method outlined in the last report has continued to be used and its application to dried root material has been studied. Saturation of the dried roots with hydrogen rather than with calcium or potassium, as has been proposed by some workers, appears to yield exchange capacities more comparable with those of fresh material.

It has been suggested that the groups which contribute most to cation exchange in plant roots are the free carboxyl groups of pectin in the roots. Decarboxylation of dried root material using the classical method of Lefevre and Tollens, and latterly a micro-method due to Tracey, have shown good quantitative agreement between the cation-exchange capacity, determined on the fresh roots by acid-washing, and the amount of exchangeable hydrogen calculated from the decarboxylation results. Similarly, the increases in the exchange capacity of oat roots due to excess nickel appear to be accompanied by increases in their pectin content. There are indications that the increase in root exchange capacity brought about by an increase in nitrogen supply can also be explained in terms of an increase in the pectin content of the root. A paper[42] dealing with the effects of heavy-metal toxicity on the cation-exchange capacity of the roots of various plant species has been accepted for publication.

RADIOACTIVITY

Due to Mr A. H. Knight's absence at the Kearney Foundation for Soil Science, work in the section was devoted to the completion of outstanding projects; papers on the investigation of rooting systems of plants in the field by radioactive means[44], [45] and on the toxic effects of nickel on plants studied by autoradiography have been prepared for publication.

SOIL FERTILITY

Investigations involving concurrent field, pot, and laboratory studies have been continued on the significance of pedological factors and soil properties in relation to crop production and manurial practice. The first step is characterization of the nutrient status and field behaviour of different soil types, and of the fertilizer requirements of the common agricultural crops, by means of field and pot experiments. The 1958 field programme comprised over seventy experiments distributed over ten soil associations and including cereals, swedes, turnips, potatoes, grass, and hay. Several influences of parent material and drainage conditions have been noted, particularly on phosphorus relationships, and laboratory investigations into the nutrient status and other relevant properties of the soils have been extended to examine the pivotal factors involved. Importance continues to be attached to practical application of results, and consultative activities, including lectures to agricultural and horticultural bodies, contributions to the agricultural press and soil testing work in collaboration with the North of Scotland College of Agriculture have been continued. Collaboration has also been maintained with other research organizations and technical committees, particularly the Grassland and Field Trials Committees of the Scottish Agricultural Improvement Council. In conjunction with the Section of Statistics an account[46] of co-operative experiments on the effects of times of application of nitrogen on oats, carried out under the aegis of the latter committee, has been submitted for publication. Contact has also been maintained with the Agricultural Research Council Unit of Statistics in relation to developments in the surveys of fertilizer practice being carried out by the Scottish Colleges of Agriculture.

CROP RESPONSES TO MAJOR NUTRIENTS

Further factorial experiments, distributed over five major soil groups, have been carried out on swedes and potatoes to measure the responses to and the two-factor interactions of nitrogen, phosphate, and potassium. In collaboration with the Section of Statistics an account[47] of earlier experiments on potatoes, including farmyard manure and three levels of each nutrient, has been accepted for publication. As mentioned in last year's report, the mean responses to all three nutrients are fairly large, and the response to potassium is reduced by about two-thirds in the presence of dung, whereas the responses to nitrogen and phosphate are not appreciably affected. There is also a general trend for both nitrogen and potassium to show a small positive interaction with phosphate, but there is practically no interaction between nitrogen and potassium. The nitrogen and potassium contents of the tubers show appreciable effects from the application of nitrogen, potassium, and dung, but the phosphate contents show little or no effect of treatment. An account of corresponding results for swedes and turnips is in preparation.

METHODS AND TIMES OF FERTILIZER APPLICATION

Results from a series of experiments extending over eight years on comparisons of broadcast and band applications of fertilizers for swedes and turnips grown in ridges are summarized in a paper[48] submitted for publication, and further work is in progress to examine the effects of placement for different forms of phosphate. Further experiments are also being carried out on cereals to study the effects of combine-drilling of nitrogen, as sulphate of ammonia and Nitro-Chalk, and of concentrated compared with ordinary NPK mixtures. In another experiment on oats undersown with grass, the effects of different times and methods of applying phosphate, including combine-drilling, are being examined from the point of view of the establishment and subsequent development of the grass sward.

As mentioned earlier, an account[46] of co-operative experiments on times of application of nitrogen for oats has been submitted for publication. Some of the trials concerned were carried out by the three Scottish Colleges of Agriculture, thereby extending the coverage. The results emphasize the importance of applying adequate nitrogen to oats following a cereal or root crop and show that there is no advantage in late or split applications. All the nitrogen considered necessary for oats should be applied at seed-time. Top-dressings applied up to 8-10 weeks after seeding can, however, be expected to be practically equally effective, but they should normally be used only where it has not been possible to apply a full dressing at seed-time, or where a need for more nitrogen becomes apparent during growth. Similar experiments on times of application of nitrogen to barley are in progress.

TRACE ELEMENTS

Field and pot investigations have been continued and extended on the effects of copper, cobalt, manganese, boron, and molybdenum on the yield and composition of crops, including grass. In the latter case, particular attention is being paid to uptake by individual species and to the effects of lime, nitrogen and phosphate. The analytical work on the soils and crops is carried out by the Department of Spectrochemistry, and in collaboration with the Animal Diseases Research Association attention continues to be given to implications in relation to animal health.

MAGNESIUM

Field and pot experiments covering varying rates and forms of application of magnesium for different crops and soils have been continued, but so far no clear yield response has been obtained, even on soils with relatively low contents of readily-soluble magnesium.

NITROGEN

Crop response measurements under field and pot conditions have been extended to widen the basis for examining the usefulness of laboratory incubation procedures for characterizing the nitrogen status of soils, and a further field experiment has been started on the role of clover in the nitrogen relationships of a mixed sward, using varying levels of applied nitrogen and

two frequencies of cutting. Progress has been made in laboratory studies but further work is necessary before any definite conclusion can be drawn as to the usefulness of soil nitrogen values as criteria of nitrogen status.

PHOSPHATE INVESTIGATIONS

Inorganic Phosphorus

Over twenty long-term field experiments, distributed over six soil groups, are in progress to measure residual effects of phosphate in the presence and absence of lime and to examine the influence of frequency of application. Field work has been continued on comparisons of autumn and spring applications of superphosphate, the significance of cultivations in relation to positional availability, and the effectiveness of different forms of phosphate for different crops. The latter subject has also been studied in pot experiments, with particular reference to the availability of superphosphate residues from field plots compared with that of various synthetic iron and aluminium phosphates prepared and characterized by the Section of Soil Geology and Mineralogy. In the latter connection, further pot experiments have also been carried out in collaboration with the Section of Microbiology to examine the influence of microbial activity on phosphate availability.

Laboratory investigations have been continued. An account[28] of relationships between soil properties and phosphate sorption, mentioned in last year's report, has appeared, and a paper[49] on the influences of parent material and drainage conditions on soil phosphorus relationships was presented at an International Symposium on Pedological and Biochemical Aspects of the Phosphate Nutrition of Plants, held in the Island of Elba, September, 1958. Accounts of the numerous influences of drainage conditions have already been published and are summarized in a previous report (1954-1955). Comparison of mean properties for groups of freely-drained soils derived from basic igneous, slate, granitic, and Old Red Sandstone glacial drifts showed that there are major differences attributable to parent material, the outstanding feature being the more extreme properties of the basic igneous soils. The slate group has a higher ratio of soluble iron to aluminium than the other three groups, but in several respects it is intermediate between the basic igneous group and the Old Red Sandstone and granitic groups, which have generally similar properties. There is a clear association between soluble aluminium, phosphate sorption capacity, total phosphorus, and total organic phosphorus in the soils. In the parent-material groups all these values fall in the sequence:

basic igneous > > slate > Old Red Sandstone and granite.

Similarly, irrespective of parent material, they are all higher in freely-drained compared with poorly-drained soils. These sequences are not consistent for the inorganic phosphorus contents of the soils. Considerable proportions of the soil inorganic phosphorus, especially in the poorly-drained soils, appear to be present in acid-soluble form in the coarser fractions, particularly the fine sand, whereas phosphate sorption, soluble aluminium, and organic phosphorus content depend very largely on the clay. A particularly interesting feature is that despite some large differences in sorption capacity and phosphate content, the four parent-material groups have very similar degrees

of saturation with phosphate. On the average the total phosphorus content in each group is of the order of 17-20 per cent. of the maximum phosphate retention capacity. It seems highly probable that this similarity is a broad expression of the fact, shown by pot experiments, that they have a similar average phosphate status. In this case, an appropriate measure of the degree of saturation with phosphate might well be a good criterion of the phosphate status.

Another interesting finding, which has emerged from the work on fertilizer placement for turnips and swedes, mentioned earlier, is that the relative superiority of placed compared with broadcast phosphate on the four parent-material groups also falls clearly in the order:

basic igneous > slate > Old Red Sandstone and granite.

Since placement produces a high local degree of saturation with phosphate it seems reasonable to interpret these varying effects in terms of the parallel variations in sorption capacity. The behaviour of the slate soils, however, is probably conditioned partly by their higher ratio of soluble iron to aluminium. Soluble aluminium is the dominant factor governing the magnitude of phosphate sorption, but soluble iron is probably important in determining solubility and availability. As shown by earlier work, the more extreme properties of the basic igneous and slate soils are also reflected in generally poorer correlations between readily-soluble phosphorus values and crop responses, particularly in the case of neutral NH_4F-soluble phosphorus. Finally, it appears that irrespective of parent material the freely-drained soils contain a fairly constant proportion of about 50-60 per cent. of the total phosphorus in organic form. The organic phosphorus, therefore, satisfies about 10 per cent. of the phosphate retention capacity. The limited data available indicate that although they contain lower proportions of organic to total phosphorus, this is also true for the poorly-drained soils. In so far as the degree of saturation is important in relation to phosphate status, the organic phosphorus would therefore appear to be fulfilling a useful function in this respect, even if it makes no other contribution to the crops. This and other aspects of the results are being investigated further.

Organic Phosphorus

Detailed investigations on the nature, distribution, and stability of organic phosphorus compounds in soils have been continued. An account[50] of the isolation and identification of the purine and pyrimidine bases characteristic of deoxyribonucleic acid (DNA), which have been found to be present in soil humic acid, is in press. The bases were released by hydrolysis with perchloric acid, purified by ion exchange and paper chromatography, and their identity confirmed by ultraviolet spectrometry. In one soil examined in detail guanine and cytosine were in excess of adenine and thymine, and 5-methylcytosine was not detected, indicating that the DNA, which accounted for 0·6 per cent. of the soil organic phosphorus, was of microbial rather than plant origin.

Further collaborative studies have been carried out with the Section of Soil Geology and Mineralogy on the fixation of inositol hexaphosphate by clays,

and investigations have been continued on the identification and estimation of other categories of soil organic phosphorus.

CONSULTATIVE WORK

Soil testing has been continued and over 12,000 samples have been examined. Most of these were taken from agricultural and horticultural land by staff of the North of Scotland College of Agriculture, but a substantial number from forest nurseries were also included. A considerable number of soil and produce samples were again received from areas with special problems concerning crop production and animal health, and as in the past these were dealt with in collaboration with the Departments of Spectrochemistry and Plant Physiology. The continued occurrence of animal health problems associated with magnesium has resulted in an appreciably increased demand for examination of the magnesium status of soils and crops. There appears, however, to be no clear relationship between the soil and crop values and the incidence of these disorders.

Classification of the soil data according to lime and nutrient status has also been continued. As noted in last year's report the results show appreciable improvements in the lime and potash status of the arable land in the North of Scotland College area. The estimated amount of lime required to correct outstanding deficiencies shows a drop from 1,434,000 tons CaO in 1950 to 1,170,000 tons in 1958, an improvement of over 250,000 tons. Some farmers who have been applying lime regularly for a considerable number of years may have to guard against the possible dangers of overliming, but it is clear that most of the land in the north of Scotland still requires lime, not only for maintenance purposes but also to correct outstanding deficiencies.

MICROBIOLOGY

The main lines of investigation reported last year have been continued and collaboration with the other departments mentioned has been maintained.

Members of staff attended the VIIth International Congress for Microbiology in Stockholm, the Symposium on Soil Fungi sponsored by the University of Liverpool, and the British Association meeting in Glasgow.

ACTINOMYCETES

Paraffin- and Fat-decomposing Soil Nocardias

The study on the influence of chemical structure on the β-oxidation of the fatty acid side chain of certain ω-aryl and ω-aryloxy-n-alkylcarboxylic acids (hormonal herbicides) by *Nocardia opaca* has been published[21]. In this work it has been shown that the following affect the process: (a) an oxygen bridge between the fatty acid and the ring; (b) ring substitution particularly in the 2-position; (c) nature and number of the ring substituents (*e.g.*, chlorine and/or methyl groups); (d) kind of ring structure to which the fatty acid is attached (phenyl, indolyl, and naphthyl); (e) position of attachment of the fatty acid as with ω-(1-naphthyloxy)- and ω-(2-naphthyloxy)-propionic and -butyric acids. These effects are most marked when the fatty acid side chain is short as in propionic and butyric acids. It was also found by the Department of Spectrochemistry that β-hydroxy acid intermediates accumulated with all the ω-aryloxy-butyric acids tested. The results obtained with the well-known herbicides 2:4-DB and MCPB in this investigation are of particular interest since it has been suggested that two plants might respond differently to these compounds because the β-oxidizing enzymes were unable to operate in the unaffected plant. By analogy with *N. opaca* it is suggested that the β-oxidizing system of plants which are resistant to 2:4-DB and MCPB may be more sensitive to ring substituents than that of susceptible plants and therefore unable to convert these substances to the corresponding herbicidal acetates. The herbicides and related substances used in this work were obtained through the courtesy of Professor Wain (A.R.C. Unit of Plant Growth Substances and Systematic Fungicides), Dr Heywood (Chemical Division, May and Baker), and Dr Byrde and Dr Woodcock (Long Ashton Research Station).

Work has continued in collaboration with the Department of Biochemistry on the hexose monophosphate pathway (H.M.P.) in *N. opaca* and other saprophytic soil nocardias and mycobacteria. Small and large scale growth experiments with a variety of different substrates have been set up and it was found that the ion exchange resin IR4B could be used to control pH changes taking place in the medium during growth. It was necessary to wash and then to saturate the resin with the culture medium before inoculation. A joint communication on the H.M.P. work has been presented to the

Biochemical Society. A study of the trace element requirements of *N. opaca* has been started.

Thermophilic Actinomycetes from Composts

The investigation on the growth of the thermophilic actinomycete *Micromonospora vulgaris* in a defined medium has been brought to a conclusion and a paper[51] on the results obtained has been accepted for publication.

FUNGI

An account of the work carried out in the section on the physiology of fungi decomposing lignin and related substances was presented by invitation at the Liverpool University Symposium on Soil Fungi.

A detailed investigation has been made of the metabolism of benzoic, mono-methoxybenzoic, 3-4-dimethoxybenzoic and β-naphthoic acids by *Polystictus versicolor*, a white rot fungus. In general these acids were reduced and the formation of the corresponding aldehydes and alcohols was detected by spectrochemical analysis of the culture solutions at intervals and of extracts prepared from the culture solutions. This fungus therefore differs from the micro-fungi previously studied which demethoxylated methoxybenzoic acids to yield the hydroxybenzoic acids which were subsequently decomposed. Paper chromatography revealed that the demethoxylation system did exist in *P. versicolor* but it was insignificant in comparison with the reducing system. An extracellular dehydrogenase produced by this fungus is also being studied.

Experiments designed to study the importance of trace elements in the metabolism of phenolic compounds, using mats of *Aspergillus niger* grown in the absence of these elements, have shown that iron is required. This is in agreement with previous findings of other workers using *Pseudomonas* sp.

A survey of the nuclear condition of several fungi which form mycorrhizal associations with orchids was made on behalf of the Botany Department of Aberdeen University using the new fluorescence equipment recently obtained. It was found to be very satisfactory and useful for such studies.

MICROBIOLOGY OF THE ROOT REGION

Work on the bacteriology of the root region with special reference to organisms dissolving certain insoluble phosphate fertilizers and related compounds has been continued. Suitable Mitscherlich pot experiments were set up in collaboration with the Department of Soil Fertility for this purpose. Improved methods for separating and estimating the general and phosphate-dissolving bacterial flora clearly demonstrated the existence of a bacterial flora closely associated with the root surface. Evidence was also obtained that the phosphate-dissolving bacteria are increased in numbers in the root region, although this group is not preferentially stimulated. In agreement with past experience, fertilizer treatment only affects the bacterial numbers indirectly through their effect on plant growth. About 150 isolates of phosphate-dissolving bacteria have been obtained in pure culture. An intensive study has been made of their morphology and physiology, parti-

cularly with regard to the mechanism by which they solubilized various forms of mineral phosphates. A number of organisms with good ability to dissolve gafsa rock phosphate were given special attention. Using paper chromatography, it was shown that the isolates produced organic acids and that the nature of the latter influenced the ability of the organisms to dissolve the different types of insoluble phosphate.

OTHER WORK

The investigation on the metabolism, by strains of *Bacillus megaterium* and other soil organisms, of a new metabolite—6-0-acetylglucose—has continued. A joint paper[37] with the Department of Biochemistry on this work has been accepted for publication.

FOREST SOILS

FOREST FERTILIZER TRIALS

Use of Fertilizers on Sand Dunes

The trial of inorganic fertilizers at Culbin Forest, Morayshire, has continued. The small height response of Corsican pine to phosphate applied in 1954, first observed in 1956, was maintained in 1957, although by this time no significant differences in foliage nutrient content due to the fertilizer were detectable.

In the NKMg trial laid down in April 1956, the nitrogen treatments had produced a considerable increase in height growth by the end of the second growing season. Increased uptake of nitrogen and potassium in plots receiving these fertilizers was still appreciable, but was not so great as in the previous year. Foliage phosphate content was increased by the nitrogen treatment; this was in marked contrast to the results obtained in the first year, when nitrogen applications caused an apparent reduction in phosphate content, due to the "diluting" effect of increased needle dry weight. The magnesium treatment again had no effect on either magnesium uptake or height growth.

It would appear that trees growing on the dunes would benefit from added nitrogen, but that the usual commercial nitrogen fertilizers are leached from the sand too rapidly to make their application economically attractive.

Fertilizer Trials on Deep Peat

The NKMg factorial experiment laid down in April 1957 in P.46 *Pinus contorta* at the Lon Mor, Inchnacardoch Forest, resulted in a significant reduction in height growth in all fertilized plots by the end of the first growing season, probably due to a check to spring growth by high salt concentrations in the soil solution. The potash treatment caused a large increase in the potassium content of the needles, and nitrogen content was increased by the nitrogen application.

Similar increases in foliage N and K contents were observed in the P.29 Sitka spruce plots subjected to the same treatments. Measurements of height response were not made in these plots since diameter increase is considered to be of more practical importance in these larger trees, and this is being measured by dendrometer.

Two new experiments were laid out in April 1957 to test aqueous ammonia, calcium cyanamide, and granite dust as possible slow-acting sources of N and K on deep peat.

TREE GROWTH ON DEEP PEAT

The study of the effects of *Pinus contorta* and Scots pine on peat at the Lon Mor has continued. All field sampling has now been completed, and analysis of the material from the Scots pine experiment is in progress.

Use of the pressure membrane apparatus to investigate the tensions at which moisture is held in the peat under trees suggests that, although a reserve of available moisture still exists in the relatively dry peat under the largest trees, temporary moisture shortage may be experienced during a dry summer.

An investigation has been started on the marked effect of plough ridge depth on the early growth of *Pinus contorta* and Sitka spruce on peat at Wauchope Forest, Roxburghshire, where growth on the deep ridges from single mouldboard ploughing has been noticeably better than on shallow ridges thrown up by the double mouldboard. Since needle analysis in 1957 showed higher nitrogen levels in the larger trees, monthly determinations of moisture, ammonia-N, and nitrate-N in the peat from the rooting zones in both types of ploughing were made during the 1958 growing season, and these showed consistently higher values for moisture and ammonia-N in the deep ridges.

GROWTH OF NORWAY SPRUCE ON MINERAL SOILS

In the autumn of 1957, foliage samples and height measurements were taken in 34 stands of 20-year Norway spruce growing in Forestry Commission plantations on a wide range of sites in the East Conservancy (Scotland), with a view to determining height growth-foliage nutrient content relationships in trees of this age. A strong correlation was found between height growth and foliage nitrogen content in Quality Classes II-IV, while foliage P, K, Ca, and Mg contents were not related to height. Wide variations in foliage nutrient content were found between different sites, and the relationship of these differences to soil properties is now being studied.

ADVISORY AND COLLABORATIVE WORK

Fertilizer recommendations for both Forestry Commission and private nurseries, based on analyses carried out by the Department of Soil Fertility, have continued. Analyses of the second year's samples from the Commission's Long Term Fertility Demonstrations at Newton and Teindland nurseries are in progress.

STATISTICS

The work of the section is principally concerned with the field experiment programme of the Department of Soil Fertility. Co-operation is given in the design of the experiments and field plans are produced. The significance of the results is assessed by the appropriate methods of statistical analysis. A count of the number of analyses of variance arising from the field experiment programme during 1957-1958 shows that approximately one half have been concerned with soil analysis results, one quarter with crop composition, and one quarter with crop yield measurements.

Almost half of the total number of field experiments have been continued from previous years. The designs of these include randomized blocks, Latin squares and each of these with split-plots, a complex Latin square, lattice squares, factorials and confounded factorials, some of which have fractional replication.

Among the 37 experiments commenced in 1958 there are several randomized block designs, some with split-plots, Latin squares, and factorial designs with confounding. When several times or methods of application or forms of a fertilizer are being tested, lattice square designs are often used and the comparisons are based on the hypothesis of proportional response.

As mentioned last year, a report was prepared for the Field Trials Sub-Committee of the Scottish Agricultural Improvement Council on the results of a series of experiments on seed-time and late dressings of nitrogen for oats. In collaboration with the Department of Soil Fertility a modified version[46] of this report has been submitted for publication.

The results from a series of NPKD factorial experiments are being evaluated. Information is provided on the responses to and the interactions between nitrogen, phosphate, potash, and dung on a number of crops grown in north-east Scotland. The first report[47] in this series, dealing with the potato crop, has been prepared in collaboration with the Department of Soil Fertility and has been accepted for publication. This work also had the practical objective of providing information on suitable fertilizer dressings for potatoes grown in the absence and presence of dung. An account[28] of correlation and regression analyses, investigating the linear relationship between phosphate sorption values and various soil characteristics has been published.

A considerable amount of preliminary work has been done in evaluating the parameters, A, b, and c, for field and pot experiment results, from the Mitscherlich nutrient-yield equation $y=A[1-10^{-c(x+b)}]$ where y is the yield obtained with an added amount of nutrient x, A measures the maximum yield obtainable with unlimited use of the nutrient, c is a measure of the efficiency of the fertilizer, and b represents the soil content of the nutrient in the control plots in a form assimilable by the crop.

Nutrient content and yield measurements on plant materials from two experiments designed to test the effects and interactions of the factors Fe, K/Ca, and P/N have been analysed on behalf of the Department of Plant Physiology. In further experiments which were designed in this series catalase, an enzyme which destroys hydrogen peroxide, was examined. The results are expressed in terms of the rate of reaction, k, which is proportional to the activity of the enzyme. k is estimated by fitting the regression equation $y=a+b.10^{-kt}$ where y is the reading at time t and $a+b$ represents the true value at time $t=0$. In an investigation of the dependence of cation-exchange capacity on the percentage of nitrogen in the roots of oat plants, analyses of covariance were carried out on pot experiment results. Also in collaboration with the Department of Plant Physiology, the effect of varying concentrations of different inhibitors on the respiration of old and young tomato leaves was studied as the difference between control (C) and inhibited (I) respiration rates and as the ratio I/C.

Experiments continued from previous years by the Section of Forest Soils include one on phosphate manuring and one, of factorial design, on N, K, and Mg manuring. Needle nutrient content and height increment measurements from these and from two later NKMg factorial experiments, and soil nutrient content measurements from long-term fertility demonstrations have been examined and the significance of the results assessed. Further work has been done on the relationship between tree height and needle nutrient content. Multiple regression analyses showed that the calculated tree height of Norway spruce at 20 years is dependent on the nitrogen content of the needles and that the prediction of height from needle nitrogen content is not significantly improved by taking account of the content of other nutrients in the needles. A design was produced for a factorial experiment to test the effects and interaction of nitrogen and granite dust on annual height increment.

Heather analysis results from a factorial experiment were examined on behalf of the Section of Peat Ecology.

During the 1957-58 programme of seminars held in the Department of Statistics of the University of Aberdeen, each senior member of staff of the section presented a paper. A course of introductory lectures on statistical science in agriculture and forestry was given to second year students at the University of Aberdeen.

CONSULTATIVE WORK

As mentioned in last year's report a group of three NPK factorial experiments on potatoes was designed in collaboration with the Department of Soil Fertility for the Crop Husbandry Department of the West of Scotland Agricultural College. Yield measurements and other results from these have been examined. A further group of four experiments on the same subject has been planned for the 1958 potato crop.

The Section co-operated with the Department of Agriculture of the University of Aberdeen in the analysis of yield and botanical composition results from a series of Latin square experiments concerned with the response of

grass to nitrogen and in the design and analysis of a series of lamb feeding trials in a pasture evaluation study.

Collaborative work with the North of Scotland College of Agriculture has included the analysis of a series of barley variety trials and of seed-rate and nitrogen trials. Further randomized block experiments, with and without split-plots, were designed to test various materials for the control of carrot fly and wheat bulb fly. The analysis of the results of one of these experiments was complicated by a lack of orthogonality due to the substitution of some treatments.

The Section is at present accommodated in the Department of Statistics of the University of Aberdeen. Acknowledgement is made to the University of Aberdeen, and in particular to Dr D. J. Finney, F.R.S., for the courtesies shown.

PUBLICATIONS

(A) *Published—*

1. The Soil Survey of Scotland. By R. Glentworth. (*Scot. Agric.*, **37**, 72-75, 1957).

   A brief account of the principles of soil classification and soil mapping is followed by a statement of the progress made to date in the mapping of the soils of Scotland. The practical importance of the work of soil survey for advisory purposes is pointed out.

2. The effect of various factors on soil formation in south-west Scotland, with particular reference to the influence of man. By B. D. Mitchell and R. A. Jarvis. (*Agrochimica*, **2**, 107-126, 1958).

   The principle soils of North Ayrshire have been equated to the five soil-forming factors—climate, relief, parent material, vegetation, and age—and an attempt has been made to estimate the influence of man on normal soil development. His main efforts have been directed to overcoming the problem of excessive moisture in the surface-water soils and to enhancing the base status of the soil with a view to improving the grazing value of the vegetation which it supports. His activities as evidenced from the soil profile have not been constant in certain areas, particularly those designated "marginal land." Nevertheless by his efforts he has influenced the major soil group pattern of the area.

3. Heather management. By R. A. Robertson. (*Scot. Agric.*, **37**, 126-129, 1957).

   The importance of heather (*Calluna vulgaris*) in the diet of mountain sheep is widely recognized. *Calluna*, however, exhibits a remarkable tolerance to a wide variety of environmental conditions which is reflected by its dominance in a number of plant communities which differ substantially in structure and status. The reaction of these types of Calluneta to varying intensities of burning, drainage, and grazing is seldom taken into account in management practices. Some of the factors which influence the distribution, growth and regeneration of heather and heather communities are briefly discussed in order to show that a more ecological approach might enable hill farmers to adopt a system of management compatible with the maintenance of productive heather swards.

4. Some observations on the ecology of an upland grazing in north-east Scotland, with special reference to Calluneta. By I. A. Nicholson (Hill Farming Research Organization) and R. A. Robertson. (*J. Ecol.*, **46**, 239-270, 1958).

   The physical features, climate, geology, soils, and vegetation of the area are described in some detail. In the course of mapping the soils and vegetation, which was undertaken using aerial photographs in conjunction with ground survey, several variants of Callunetum were clearly recognized. The differences are defined on the basis of floristic composition and structure which, taken together, not only provide a means of characterization but also enable the probable effects of biotic influence to be more accurately assessed. The four inter-related factors which affect the development of heather communities after burning on any soil type are briefly discussed.

5. Certain aspects of vegetational history in north-east Scotland. By S. E. Durno. (*Scot. geogr. Mag.*, **73**, 176-184, 1957).

   The influence of climatic and biotic factors on the vegetation of the north-east of Scotland is shown in the pollen analyses of a number of peat mosses in the area.

6. Pollen analysis of peat deposits in eastern Sutherland and Caithness. By S. E. Durno. (*Scot. geogr. Mag.*, **74**, 127-135, 1958).

   Five pollen diagrams from peat deposits in Caithness and the eastern part of the county of Sutherland are presented and discussed.

7. The dating of the Forth Valley Carse clay: a note. By S. E. Durno. (*Scot. geogr. Mag.*, **74**, 47-48, 1958).

   The pollen analysis of Flanders Moss East provides further evidence for the dating of the Forth Valley Carse clay.

8. The occurrence of pollen of *Fraxinus* in northern Scottish peats. By S. E. Durno (*Trans. Proc. bot. Soc., Edinb.*, **37**, 221-222, 1958).

   A note recording the identifications of pollen of *Fraxinus* in peat deposits in the north of Scotland and suggesting that this may be of significance in assessing the status of this tree in the north of Britain.

9. Identification of fossil fruits of *Najas flexilis* in Scotland. By S. E. Durno. (*Trans. Proc. bot. Soc., Edinb.*, **37**, 222-223, 1958).

   A note reporting the find of fossil fruits of *Najas flexilis* in lacustrine mud from Kilbirnie Loch, Ayrshire.

10. Peat reclamation. By R. A. Robertson. (*Trans. roy. Highl. agric. Soc. Scot., 6th series*, **2**, 38-54, 1957).

    A brief review of the nature of Scottish peat deposits and previous reclamation attempts is followed by a discussion of modern techniques now in use in many northern European countries. The need for further scientifically controlled experiments is stressed whereby the new equipment now available could be thoroughly tested and the economics of bog cultivation in general accurately assessed under Scottish conditions.

11. Studies on the basaltic soils of Northern Ireland. IV. Mineralogical study of the clay separates. By D. M. McAleese (University of Cambridge), and W. A. Mitchell. (*J. Soil Sci.*, **9**, 76-80, 1958).

    The clay separates ($<2\mu$) isolated from the horizons of ten basaltic soil profiles are shown by X-ray analysis to have a mixed mineralogical composition; the type and amount of each mineral present is dependent on the drainage conditions within the profile. Kaolin, the end product of weathering, generally predominates in surface horizons. Vermiculite is formed in well-drained profiles, but where gleying symptoms are evident vermiculite is replaced by montmorillonite, the amount of which increases with increased degree of waterlogging. Illite occurs in only two profiles to any appreciable extent. It is inferred that soil separates other than clay are contributing to the cation-exchange capacity of these soils.

12. Studies on the basaltic soils of Northern Ireland. V. Cation-exchange capacities and mineralogy of the silt separates (2-20μ). By D. M. McAleese (University of Cambridge) and W. A. Mitchell. (*J. Soil Sci.*, **9**, 81-88, 1958).

    X-ray and chemical studies of silt separates (2-20μ) from basaltic soils were made to determine the origin of the rather high cation-exchange capacities (C.E.C.) found for these separates. The silts consisted in the main of quartz and feldspars with variable amounts of clay minerals which occurred as aggregates. These aggregates were of two types: (a) Composed of clay-size particles, *i.e.* $<2\mu$, cemented or bound into silt-size aggregates by "free" sesquioxides of which the basaltic soils have a high content. The aggregates were disrupted by reduction and the clay particles subsequently released. (b) "Pseudo-aggregates" which were shown to be individual particles of silt-size dimensions and having a flaky appearance. These particles were either vermiculitic (under good drainage conditions) or montmorillonitic (under poor drainage conditions), and it is suggested that they form intermediate products in the weathering of primary rock minerals to clay minerals. Whilst the major contri-

butor to the C.E.C. of the silts was undoubtedly the "pseudo-aggregates" and to a lesser extent the true clay aggregates, most of the silt separates had a much higher C.E.C. than implied by their mineralogical composition.

13. Modern methods for studying clays. By R. C. Mackenzie. (*Agrochimica*, **1**, 305-327, 1957).

The methods employed in any clay investigation depend upon the information desired, but generally some knowledge of the mineralogy of the clay is essential. The minerals likely to occur in clays are discussed, and their constitution and the reasons for their complexity established. The application of chemical and optical methods, electron microscopy, X-ray and electron diffraction, and thermal and infrared absorption techniques are considered in turn, with special reference to the type of information these methods yield and to recent developments in each field. It is concluded that while use of two distinct techniques, such as X-ray diffraction and differential thermal analysis, may give a reasonable picture of the constitution of any clay, it is essential that *all* available methods be applied as each can give valuable data complementary to those supplied by others.

14. The montmorillonite differential thermal curve. I. General variability in the dehydroxylation region. By R. C. Mackenzie. (*C. R. Groupe franç. Argiles*, **9**, 7-15, 1957).

The various types of curves given by montmorillonite samples are discussed and compared; possible reasons for differences are considered. The exchangeable cations, and the fixation of cations, affect not only the hygroscopic moisture region but also the dehydroxylation region of the curve. The reasons for this can at present only be surmised, but the eventual solution would undoubtedly lead to clarification of the true montmorillonite structure.

15. Saponite from Allt Ribhein, Fiskavaig Bay, Skye. By R. C. Mackenzie. (*Miner. Mag.*, **31**, 672-680, 1957).

A full description is given of this saponite which is closely associated with zeolites. Its chemical constitution is derived by a new method of calculation which enables one also to determine with reasonable accuracy the temperature at which all the sorbed water is expelled. The saponite is of excellent purity and free from interstratification. Chemical, thermal, X-ray, and electronoptical data are given.

16. The illite in some Old Red Sandstone soils and sediments. By R. C. Mackenzie. (*Miner. Mag.*, **31**, 681-689, 1957).

An illite separated from an Upper Old Red Sandstone sediment was examined by chemical, optical, X-ray, and electronoptical methods. It differs from "normal" illite in having two peaks (one at 550°C and one at 600°C) on its differential thermal curve. Possible reasons for the variation in the temperature of the illite peak are discussed.

17. Differential thermal characteristics of peat. By B. D. Mitchell. (*Nature*, **180**, 1414-1415, 1957).

The controlled-atmosphere differential thermal analysis technique has been used to obtain the complete-combustion differential thermal curves of several peats. Variations in the thermograms can be related to the botanical origin of the peat and additional results suggest that they may also be influenced by the degree of humification of the peat.

18. Density of water sorbed on montmorillonite. By R. C. Mackenzie. (*Nature*, **181**, 334, 1958).

The use of density measurements in determining the structure of interlayer water in montmorillonite is critically discussed and it is concluded that such measurements can as yet yield no useful information upon the configuration of the initially adsorbed water.

19. The trace-element content of some soils and rocks from Macquarie Island, South Pacific Ocean. By D. J. Swaine. (*Australian National Antarctic Research Expedition Reports, Series A*, Vol. III, 1957).

The soils of Macquarie Island are predominantly peaty, although some are derived from morainic material. This paper gives the trace-element contents of four samples of peaty material, two of morainic material, and one of rock. The samples of peaty soils and morainic material had pH values of 4·6-6·9, with ash values of 15-61% for the former and 92%, 97% for the latter. Mineralogical examination of the morainic materials indicated that they are probably doleritic. The sample of basaltic rock has lower potassium and phosphorous contents than an average Pacific Islands basalt and Daly's average basalt. In keeping with their basic character, the rock and morainic materials are low in Zr, Pb, Ba, and Rb. The peaty soils seem to have concentrated Mo and Cu appreciably and Mn, Ag, and Sr slightly. The trace-element contents of the peaty soils have been compared with other peat samples from Finland, Norway and Scotland.

20. The infra-red spectra of talc, saponite, and hectorite. By V. C. Farmer. (*Miner. Mag.*, **31**, 829-845, 1958).

The absorption spectra of talc, saponite, and hectorite between 4000 and 400 cm.$^{-1}$ are closely related, although the bands of the smectites are more diffuse as a result of isomorphous substitutions in the talc structure. Using oriented specimens, vibrations in which the change of dipole moment is perpendicular to the sheets of the minerals are identified; and the results compared with theoretical predictions. Three bands arising from the stretching vibrations of interlayer water molecules in the smectites are distinguished, one of which corresponds to a very weak hydrogen bond. Spectral changes arising from vigorous grinding are discussed.

21. The influence of chemical structure on β-oxidation by soil nocardias. By D. M. Webley, R. B. Duff, and V. C. Farmer. (*J. gen. Microbiol.*, **18**, 733-746, 1958).

Studies of the β-oxidation of the fatty acid side chain of certain ω-aryl and ω-aryloxy-n-alkylcarboxylic acids by soil nocardias show that γ-phenyl-and γ-(1-naphthyl)- are more rapidly oxidized than γ-phenyoxy- and γ-(1-naphthyloxy)-butyric acids. Further the rate of β-oxidation of 3-, 4-, and 2-isomers decreases in that order and substitution in position 2 has by far the greatest effect. Chlorine exerts a bigger influence than a methyl group in all positions. These effects of the oxygen bridge and nature and position of ring substituents are most marked when the fatty acid side chain is short. It has also been found that ω-(2-naphthyloxy)-butyric and propionic acids are more rapidly oxidized than the ω-(1-naphthyloxy) compounds and that the rate of β-oxidation of γ-phenyl-, γ-(3-indolyl)- and γ-(1-naphthyl)-butyric acids decreases in that order. It has been shown too that β-hydroxy acid intermediates are formed from ω-aryloxybutyric acids.

22. The alkaline nitrobenzene oxidation of soil organic matter. By R. I. Morrison. (*J. Soil Sci.*, **9**, 130-140, 1958).

The yields of syringaldehyde, vanillin, and *p*-hydroxybenzaldehyde obtained by the alkaline nitrobenzene oxidation of soil organic matter are of interest in indicating the extent to which lignin-derived material occurs in soil organic matter. Methods are described for performing the oxidation on a micro-scale and for the separation and determination of the aldehydes. Results are given for a number of soils, peats and peat fractions. These are discussed in the light of present knowledge of lignin and soil organic matter.

23. Esterification of the primary alcoholic groups of carbohydrates with acetic acid—a general reaction. By R. B. Duff. (*J. Chem. Soc.*, 4730-4734, 1957).

The primary alcoholic group of various carbohydrates is selectively esterified by 50% acetic acid at 100°. The crystalline acetylglucose obtained in this way is shown to be identical with the 6-*O*-acetyl-D-glucopyranose obtained from cultures of

Bacillus megaterium grown on glucose media. Crystalline 6-*O*-acetyl-D-galactopyranose, an unstable syrupy xylopyranose acetate, and a syrupy di-*O*-acetylglucose have also been prepared. An estimation is made of the total esterification (*i.e.*, including di- and tri- as well as mono-acetates) obtained with various carbohydrates including laminarin, glycogen, and amylose.

24. The stimulation of leaf respiration by respiratory inhibitors. By I. R. MacDonald and P. C. DeKock. (*Physiol. Plant.*, **11**, 464-477, 1958).

Iron-deficient leaves have been shown to be more sensitive to cyanide inhibition than normal leaves and iron-toxic leaves to be less sensitive. Similar patterns have been found in young and old leaves of various plants in the presence of a variety of respiratory inhibitors. It is suggested that the iron status of the tissue may have an effect on its sensitivity to heavy metal inhibitors and stimulation of respiration observed in older tissues may be due to complexing of some metal such as iron which accumulates in ageing tissue.

25. Observations on the pedology and fertility of some krasnozems in northern New South Wales. By J. D. Colwell. (*J. Soil Sci.*, **9**, 46-57, 1958).

Eight krasnozem (red-earth) profiles representing a wide range of environments have been studied. Contrasting features of the soils can be explained by differences in parent material, climate, vegetation, and land use. The main effects corresponding to those variations are seen in the relative contents of total and readily soluble aluminium, organic carbon, nitrogen, organic phosphorus, and of exchangeable metal cations. Land utilization appears to have led to losses in organic carbon, nitrogen, organic phosphorus, exchangeable cations, and "available" manganese. These losses suggest the possibility of a potassium deficiency and are in agreement with observed nitrogen deficiencies. The cation-exchange capacity of the organic matter is much greater than that of the inorganic matter, and in some soils extrapolation suggests that losses of organic matter threaten the capacity of the soils to retain cations.

26. Some effects of thinning on the soil of a Norway spruce plantation. By T. W. Wright. (*Forestry*, **30**, 123-133, 1957).

Describes the effect of thinning on the litter fall, the decomposition of the forest floor, and the chemical and physical properties of the surface soil in the sample plots of Norway spruce (*Picea abies* Karst) established by the Forestry Commission at Bowmont Forest, Roxburghshire.

27. The nutrient content of Scots and Corsican pines growing on sand dunes. By T. W. Wright and G.M. Will. (*Forestry*, **31**, 13-25, 1958).

A study has been made of the amounts of N, P, K, Ca, Mg, and Na in the needles, branches, bark and wood of three age classes of Scots and Corsican pine (*Pinus silvestris L.* and *P. nigra* var. *calabrica* Schneid) growing on sand dunes at Culbin Forest, Morayshire. Variations in these amounts were ascribed to season, dominance of the tree, and differences in the rate of bark and heartwood formation between the two species. The amount of nutrients immobilized by the crop, and the amounts removed by exploitation, were calculated for each age class.

28. Soil properties and phosphate sorption. By E. G. Williams, N. M. Scott, and Margaret J. McDonald. (*J. Sci. Fd. Agric.*, **9**, 551-559, 1958).

Relationships are given for freely drained, acid surface soils representing four parent materials. Sorption in all groups depends mainly on soluble aluminium, especially that extracted by the Tamm acid-oxalate method. There are also significant correlations with acid-oxalate soluble iron, and with organic carbon and loss on ignition, suggesting that the active aluminium and iron are intimately associated with organic matter.

(B) *Submitted for Publication—*

29. The geography and soils of north-east Scotland. By R. Glentworth. (To appear in *Agric. Progr.*).

30. The basic igneous soils of Aberdeenshire. By J. Muir and R. Glentworth. (To appear in *J. Soil Sci.*).

31. Recent research on Sasumma clay. By R. C. Mackenzie. (To appear in *Proc. Instn. Civil Engrs.*).

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