

THE MACAULAY INSTITUTE
FOR SOIL RESEARCH

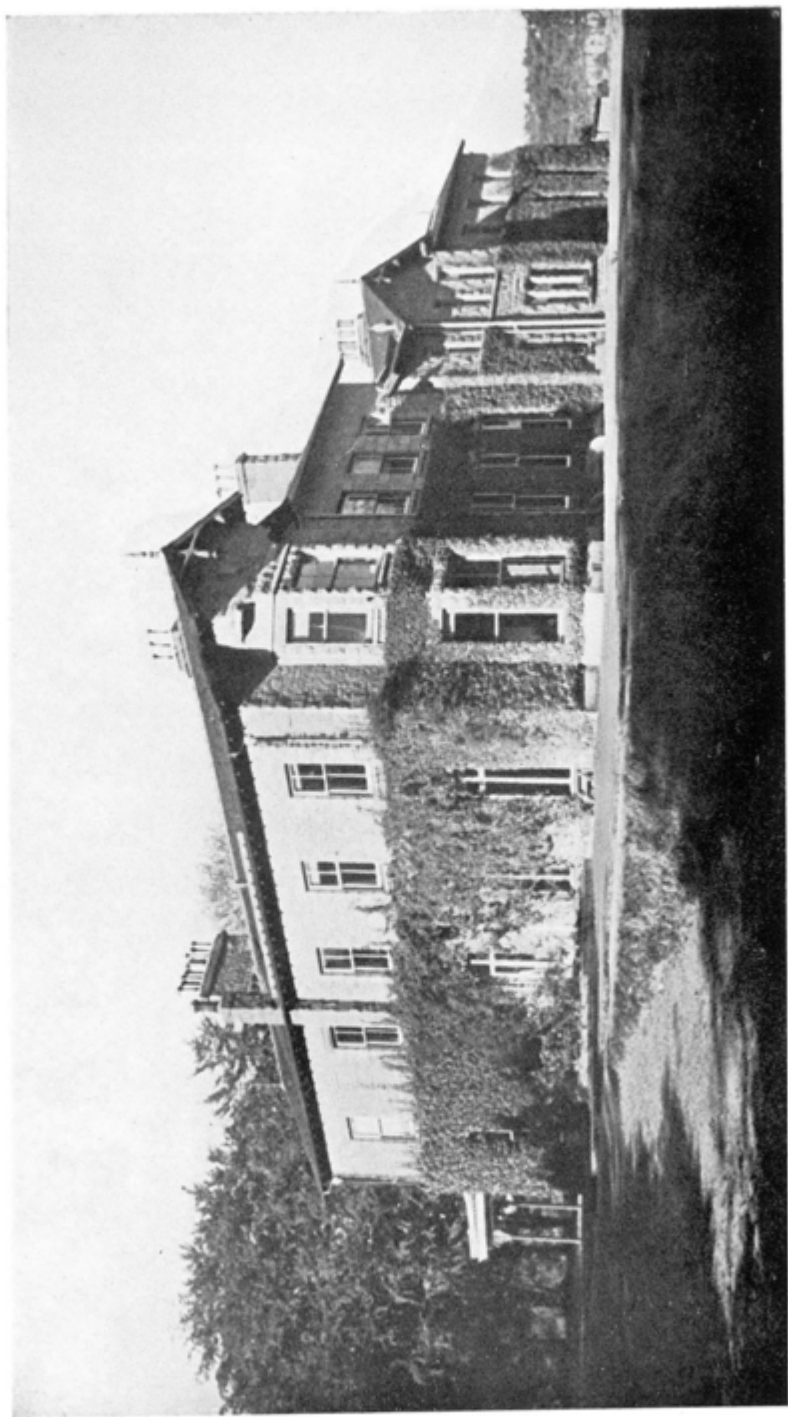
REFERENCE ONLY



ANNUAL REPORT
1947-1948

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

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THE MACAULAY INSTITUTE

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CRAIGIEBUCKLER, ABERDEEN

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1947-1948

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* Appointed 1948.

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THE MACAULAY INSTITUTE FOR SOIL RESEARCH

ANNUAL REPORT

1947-1948

THE Council of Management of The Macaulay Institute for Soil Research record with deep regret the death of Sir Robert Greig—Chairman of the Council since 1942—which occurred in London on 29th November, 1947. It was due to his foresight and to his interest in the soil that the foundation of the Institute became possible. Later, when he joined the Council and in due course became Chairman, that interest became intensified. By his rich experience, by his gifts of leadership and by his humanity, The Macaulay Institute was specially favoured.

Professor J. R. Matthews—a member of Council since 1937—was appointed to succeed Sir Robert Greig as Chairman of the Council. Sir William Hamilton Fyfe, consequent upon his retirement as Principal of the University of Aberdeen, resigned from the Council of Management. The Council record their appreciation of the services rendered by Sir William and their gratitude for the interest which he always showed in the welfare of the Institute. Lieut.-Col. G. B. Duff has been appointed as one of the representatives of the North of Scotland College of Agriculture in succession to Sir William Hamilton Fyfe.

Dr. W. G. C. Forsyth, Biochemist in the Department of Soil Organic Matter, resigned upon acceptance of an appointment to the staff of The Microbiological Institute, Trinidad, and Dr. R. I. Morrison has been appointed as his successor.

Mrs. D. J. Eastwood, B.Sc. (Hons.) joined the staff of the Microbiological Unit of the Department of Soil Organic Matter on 1st April, 1948.

Dr. J. D. Ovington was appointed and seconded to the Soil Organic Matter Department to specialize in the study of the physico-chemical relationships of soils upon which tree canopy is being formed. This appointment was made in terms of the grant received for this purpose from the Forestry Commission.

Mr. J. C. C. Romans, B.Sc. (Hons.) and Mr. B. D. Mitchell, B.Sc. (Hons.) were appointed to the staff of the Soil Survey Department. Considerable difficulty is being experienced in the recruitment of suitable personnel for the authorized established strength of this department.

Mr. A. M. Ure, B.Sc. (Hons.) joined the staff of the Department of Spectrochemistry on 1st September, 1948.

Mr. J. R. Devine, B.Sc. (Agr.) was appointed to the Soil Fertility Department as Field Experimental Officer and Mr. R. H. E. Inkson, B.Sc. (Hons.) as Statistician.

Dr. E. G. Williams was granted leave of absence for one year to enable him to accept a Swedish Fellowship to carry out post-graduate study in the Department of Pedology under the direction of Professor S. Mattson, College of Agriculture, Uppsala, Sweden.

During the past year numerous visitors from overseas have been welcomed to Craigiebuckler.

Arrangements have been made to accommodate research workers from various parts of the British Commonwealth, and the scheme was inaugurated by workers from East Africa and Southern Rhodesia who spent several months studying the methods used in the Department of Spectrochemistry in the Institute.

It is gratifying to be able to report that permission has been obtained for the erection of new laboratories and a modern scientific greenhouse. When these buildings have been completed it is hoped to restore the facilities previously afforded to overseas post-graduate workers.

The Council has pleasure in reporting that the Spectrochemistry and X-ray Units have now been equipped with the latest modern instruments necessary for the prosecution of specialized work.

The policy of the Institute is to study the soil in all its aspects—its origin and its properties—with a view to the maintenance and improvement of soil fertility. With this object a survey of the soils of Scotland is in progress and a study of the fertility of the various types is being made. Fundamental investigations are in progress upon the trace element content of rocks, soils and plants, the structure and properties of clays, the nature of soil organic matter, and soil-plant relationships. The Macaulay Institute has collaborated with the other Research Institutes and Colleges of Agriculture in Scotland in so far as the fundamental properties of the soil are related to problems of crop production and animal health.

Representation of the Institute has been maintained on the Agricultural Research Council Conferences dealing with

- (a) methods of fertilizer application to agricultural and horticultural crops,
- (b) mineral deficiencies in agricultural and horticultural crops,
- (c) land drainage,

and on

- (a) the Soils Sub-Committee of the Committee for Colonial Agricultural, Animal Health and Forestry Research,
- (b) a Forestry Commission Sub-Committee dealing with nutritional problems in Tree Nurseries.

The Council of Management tenders thanks to the Department of Agriculture for Scotland, to the Agricultural Research Council and to the Forestry Commission for grants received and to other benefactors for their generous support.

September, 1948.

PEDOLOGY

SOIL SURVEY (SCOTLAND)

The reconnaissance soil survey of Kincardineshire has been continued from the boundary reached in the previous season which ran east and west from Crawton to Strathfinella Hill, through the area known as the Howe o' the Mearns, to a line drawn east and west about one mile south of Laurencekirk.

Topographically the area consists of a broad plain at about 150-250 feet altitude running in a north-east—south-west direction. It is bounded by hill features on its north-western side rising to about 1500 feet. This area is underlain by the Dalradian schists immediately north of the Highland Boundary Fault, while south and east of this, on the Old Red Sandstone formation, the plain is bounded by the Garvock Hills which rise to approximately 860 feet.

Of the area surveyed, approximately 200 square miles, only about 24 square miles, extending south-west from Cairn o' Mount, are dominantly hill ground. The bulk of this hill land on the steeply sloping ground is heath, and is covered by an ericaceous vegetation. Above 1200 feet the summit areas consist of hill peat, while the fringes of this region bordering the arable ground are planted with conifers. The survey has been conducted in an intensively farmed arable region which has been mapped, with as much detail as the scale of mapping (2.5 inches to 1 mile) permits, on the basis of a survey of sample areas on the scale of 6 inches to 1 mile.

THE SOILS OF THE HOWE O' THE MEARN'S REGION. Two soil associations not previously distinguished have been separated—Strathfinella and Auchinblae—while extensive alluvial spreads, mainly composed of Old Red Sandstone material, have been separated but meantime left unnamed. The associations of Foudland, Corby, Stonehaven, Laurencekirk and Ury, previously described, have been extended.

The bulk of the area falls into the Stonehaven and Laurencekirk associations, with Strathfinella and Foudland next in extent.

The descriptions given for the soils of the Foudland and Stonehaven associations in the *Annual Report, 1946-1947*, are applicable to the present area, the Foudland association being an extension to the south-west of the area previously reported.

The *Stonehaven association* has also been extended southwards along the line of the Garvock Hills. It is still composed mainly of relatively heavy textured soils, stony clay loams, on stony clay loam or stony clay till. While the parent material contains rock material of varied Old Red Sandstone strata, including many conglomerate pebbles and lava pieces, the andesitic lava becomes dominant in certain localities, and gives rise to loam textured soils of free drainage. This may be seen around the Barras farms (3 miles north-east of Arbutnot). The separation of these localized areas could only be effected by detailed survey.

Strathfinella Association. This association is developed on till derived mainly from Old Red Sandstones. The solid rock may be seen on the south side of the Glen of Drumtochty at a quarry a little east of Drumtochty Castle. The soils of this association are morphologically more podzolic than those of the Stonehaven association, and are of lighter texture, being loams to sandy loams on sandy loam till. The dominant soil is freely drained, unlike the Stonehaven association, which is gleyed. The area covered by this association forms an irregular belt stretching from Strathfinella Hill along the north-east side of the region in line with the Highland Boundary Fault.

It is probable that this association is in many respects comparable with the Cuminstown association (see *Ann. Rep.*, 1942-1943).

The *Ury association* extends as areas of locally mixed drift of Dalradian and Old Red Sandstone origin along the margin of the Foudland association running along the line of the Highland Boundary Fault.

The *Laurencekirk association* becomes extensive on the smooth to flat ground between Glenberrie and the North Esk river. The parent material of this association is a bright red glacial till generally of clay texture but sometimes slightly lighter in texture (clay loam). The till is derived from a fine grained mudstone which contains marl strata. In localized areas, notably to the south of Fordoun station, the glacial till is thin and the solid, horizontally-bedded mudstone forms the parent material of the soil. No freely drained soils have been found in this association. The greater part of the area consists of slightly-poorly drained soils. A brownish-red to reddish-brown surface horizon of nutty to cloddy structure overlies a B-G horizon which is predominantly red, although close inspection reveals a considerable amount of ochreous mottling which tends to be obscured by the colour of the parent material. The substrata have a prismatic cloddy structure. The poorly drained soils have a somewhat paler surface colour. Underlying the surface is a blotchy red and grey horizon, an inch or two in thickness, which passes into the bright red basal colour of the parent material. In both the slightly-poorly drained and poorly drained soils there is a considerable amount of black staining believed to be due to manganese.

From the agricultural viewpoint this association covers some of the best land in Scotland.

Undifferentiated Alluvium. Broad spreads of alluvium occur throughout the Laurencekirk association from the Bervie Water to the North Esk. The textural range is from sandy loam to clay, generally of slightly poor drainage. While no flooding of these areas is now reported, the soils are immature and show no definite profile development. They appear similar to the Kemnay association (*Ann. Rep.*, 1945-1946), except that their geological composition is more particularly of Old Red Sandstone origin—the soils generally have the typical reddish colour.

The *Corby association*, developed on fluvio-glacial and morainic gravel, is found near Auchinblae, where it overlies Strathmore till, and quite extensively on the north side of the North Esk river. The separates consist of subangular to rounded fragments of quartz schist and quartzite with various pieces of metamorphosed argillaceous schists—predominantly from the western or Dalradian region. It is suspected that some of the finer material may be of Old Red Sandstone origin. Where the topography is

flat, as in the terraces along the North Esk, a high standard of farming prevails despite the light textures—gravelly loamy-sands to gravelly sandy-loams.

The dominant soil is freely drained, while excessively drained soils are associated with the mounded topography of the moraines. The soil profile of the virgin soils tends to be lacking in the thin iron pan below the A_2 horizon which is less strongly developed.

Gravel is found extensively to the north and west of Catterline, but here it has a considerable admixture of Old Red Sandstone material, and the surface texture of the soils is often loam to stony sandy loam.

Auchinblae Association. This association is developed on stratified fluvio-glacial sands and gravels of Old Red Sandstone origin, and can be seen to the east of Drumlithie. The topography is dissected, and the soils are mainly freely drained, having the brownish-red surface horizon overlying a B horizon which is recognizably stained by iron. The extent of the area is small.

ANALYTICAL INVESTIGATIONS. Routine analyses on forty-six soil profiles have been completed, with the exception of the mechanical analyses which have been delayed owing to lack of equipment. Six of the profiles were collected from long-term experimental areas, the remainder being characteristic of the various hydrologic sequences encountered on the various associations.

Clay fractions have been supplied to the X-ray and Physical Chemistry Sections for fuller characterization, while work is proceeding on the determination of the amorphous sesquioxides of certain profiles which appear to vary with the drainage status of the soil.

SOIL GEOLOGY AND MINERALOGY

South-west Scotland. Pining in sheep, due to cobalt deficiency, occurs in certain areas in south-west Scotland, and the survey of parent materials and soils of suspected areas on the borders of Kirkcudbrightshire and Dumfriesshire was continued. During a series of traverses soil samples were collected for further investigation in the laboratory. In this area, in contrast to those previously surveyed in the south and west of Kirkcudbrightshire, where there is an extensive development of igneous rocks, the rocks are mainly sedimentary, consisting of shale, grit, greywacke and sandstone. The soils can be grouped on the following basis: residual soils on sedimentary rocks; soils on glacial drift mainly derived from sedimentary rocks; soils developed on glacial drift of mixed rock origin, both sedimentary and igneous rocks being involved. The incidence of the disease does not appear to be so marked in this area as in the igneous rock areas or in the areas where the glacial drifts are largely derived from igneous rocks. A paper is in preparation discussing the results of this study.³³ The survey is to be extended to neighbouring areas.

Central Scotland. The glacial drifts forming the parent materials of the soils on a farm for the proposed Horticultural Research Centre were differentiated and a detailed soil map on a scale of 6 inches to 1 mile was prepared at the request of the Department of Agriculture for Scotland.

The estates of Bush and Dryden, Midlothian, were also surveyed and assistance was given in delineating the drift deposits. Detailed maps on the

scale of 6 inches to 1 mile, showing the soil types and their parent materials, were prepared for the Edinburgh and East of Scotland College of Agriculture.

North-east Scotland. Field work was carried out in connection with the soil surveys of Aberdeenshire and Kincardineshire and the soil parent materials examined to determine the soil associations. The soil types and parent materials in various areas of these counties where experimental plots were being laid down were also examined. A mineralogical examination was made of the fine sand fractions of soils and their parent materials obtained during the soil surveys. These soil parent materials are mainly glacial drifts of mixed lithological composition and the determination of the mineral character of the matrix of the drift serves to determine the soil association.

A study is also being made of the clay material formed from a decomposed granite in Aberdeenshire. The optical properties of the mineral were determined, and it was shown to have the characteristics of illite and to be an alteration product of the felspathic material in the granite. A paper is in preparation discussing this material.²²

X-RAY INVESTIGATIONS

The work of the X-ray Section is centred on the elucidation of the mineralogical nature and mode of origin of the clay fractions of soils. Other issues enter from time to time, but they are of interest only in so far as they contribute towards the development of the main theme. The soils examined are selected very largely from those sampled in the field by the Survey Officers, but samples from other parts of the world are occasionally included for the purposes of comparison.

Prior to the advent of X-ray diffraction there was no adequate method for determining the mineralogical composition of soil clays and, since its inception, the relative importance of the clay fractions of soils has been increasingly recognized among soil scientists. The technique is, however, a comparatively recent development and one of the greatest hindrances at the present time is the lack of an X-ray camera designed specifically for clay mineral work. In order to obviate some of the technical difficulties involved in adjusting and modifying cameras made for other purposes, a camera has been designed in collaboration with Hilger and Watts Ltd. of London, who are at the present time constructing a trial model. Two 9-cm. and one 19-cm. new-type cameras are on order, and the Hilger HRX Diffraction Unit with which they will be used has already been installed at the Institute. This X-ray apparatus permits the simultaneous examination of four specimens and, used in conjunction with the present machine, should increase the output of the Section.

The Soil-Clays of North-east Scotland. Before general rules can be formulated governing the conditions under which soil minerals form, it is necessary to examine a large number of soil-clays, and it is perhaps as yet a little early to draw definite conclusions. It does appear, however, that soils derived from basic and ultrabasic parent material tend to contain montmorillonitic clay minerals under wet conditions and vermiculitic and kaolinitic types under free drainage conditions. In soils derived ultimately from acid and intermediate rocks, on the other hand, drainage appears to

have little influence in conditioning the types of clay minerals present. These are normally kaolinites, illites and vermiculites.

The study of the decomposition of biotite by natural processes²¹ was a necessary preliminary to the elucidation of the mineralogical nature of the soil-clays, where a corresponding breakdown of a clay mineral similar to biotite takes place. The "clay biotite" which usually occurs in mixed-layer structures with its decomposition products is widely distributed as such in the soil clays. A description of the new mineral and its decomposition product is being prepared for publication.²² Under free drainage conditions, the "clay biotite" breaks down to form vermiculite, whereas in poorly-drained areas the product is a trioctahedral montmorillonite; and both of these products break down further to give a member of the kaolinite group of minerals. The kaolinites, which are ubiquitous, show a general tendency to increased development towards the surfaces of the profiles, and there is a certain amount of evidence that they sometimes form mixed-layer structures with the "clay biotite" and its decomposition products.

Non-crystalline hydrated oxides of iron and aluminium are important constituents of some of the soil-clays of the area. The coatings formed on the surfaces of the crystalline particles by this amorphous material lead to heavy background fogging on the X-ray photographs, and hence to increased difficulty in their interpretation. Although various chemical treatments are available for the removal of these amorphous coatings, alterations in the positions and intensities of certain diffraction lines were found to occur after treatment, and anomalous results obtained in this way were a source of some difficulty in the early stages of the work.

Vermiculites. The above investigation led to an independent study of the vermiculites, a somewhat neglected group of minerals best known for their property of expanding or exfoliating when heated. The high cation exchange capacity of many of the soil-clays is traceable to these minerals, and it appears probable that the high exchange capacity shown by the silt and sand fractions of many soils in the north-east area is caused by vermiculites, which possess this property to a marked degree even in comparatively large crystals.

In natural vermiculite, the exchange positions are filled by Mg^{++} ions, and, although their replacement by other ions can be effected easily, corresponding modifications to the structure of the water layers in the mineral take place.²³ Because they are large enough for single-crystal X-ray work, vermiculites may prove useful for studying the ways in which exchangeable ions are bound in crystals, and hence the availability of these ions to plants. A chapter on vermiculites²⁴ is in course of preparation for inclusion in a monograph on Clay Minerals shortly to be produced by the collaboration of some half dozen clay mineralogists in Britain, France and America; and further work at the Institute on these interesting minerals is envisaged.

PHYSICO-CHEMICAL INVESTIGATIONS

The differential thermal analysis study of soil clays has continued. During the year about sixty pure minerals and mixtures, and seventy soil clays have been examined. The routine investigation of soil clays outlined in last year's report has been somewhat slow because of the unsuitability of the apparatus for the determination of more than one curve per day.

However, the reconstruction of the apparatus with a view to obtaining a much greater output of results is under consideration, and it is hoped that at the same time some data on the most satisfactory method of automatic control may be obtained. Recommendations for standardization of differential thermal analysis techniques are at present under consideration by an international group on which the Institute is represented.

The thermograms obtained for soil clays have been of special interest because of the light they shed upon the nature of the free iron oxides present in the soil. Two types of iron oxides have been observed, namely goethite and cold-precipitated ferric hydroxide, the latter having been checked against the pure material prepared in the laboratory. In this connection it is noteworthy that the temperature of precipitation of the iron hydroxide modifies its thermogram very considerably. A third type of iron oxide may be present in some of the clays examined, but the evidence for this is rather scanty. These iron oxides appear to be amorphous. Professor G. I. Finch of the Imperial College of Science and Technology kindly examined some of these clays by electron diffraction and found no evidence of any crystalline iron oxide. Thus it would seem that differential thermal analysis is, at present, the only means of distinguishing them. Correlation of the type of iron oxide with conditions of soil formation is being attempted, but the investigation is not yet complete. Preliminary results would, however, seem to indicate that there may be some correlation with drainage conditions, but a considerable amount of work is still necessary to prove or disprove this hypothesis. Apart from the iron oxides, practically all the clays examined show the presence of variable amounts of a halloysite mineral.

A clay occurring in an altered granite near Ballater, Aberdeenshire, has been examined by differential thermal analysis and chemical methods. X-ray and microscopic examination of this clay showed it to have the characteristics of illite, with a small amount of montmorillonite (< 0.5 per cent.) as an impurity. The montmorillonite, as might be expected, was concentrated in the finer fractions. The chemical analysis of this clay, as well as its cation exchange capacity, was in accordance with its being classed as illite. Its thermogram, however, is quite distinct from that of the type illite, and is of considerable interest. A paper on this mineral was presented at the Clay Minerals Group meeting held in conjunction with the XVIIIth Session of the International Geological Congress, and is now in preparation for publication.³²

A differential thermal analysis study of the diatomite occurring at Loch Cuithir, Skye, has been completed. No sign of any extensive impurity was observed, but it was found that CaCO_3 and pyrites, which were present in small quantity, were concentrated in the finest fraction (< 0.4μ e.s.d.). Quartz was not detected in any fraction, and, if present, must occur in a quantity less than 1 per cent. (the limit of detection).

In collaboration with the X-ray Section, differential thermal analyses of vermiculites and hydrobiotites are being carried out. So far it has been observed that the exchangeable cation present has a very considerable effect on the type of thermogram obtained, and this work is being pursued.

Methods for the removal of free iron oxides from soils and clays are still being studied. The sodium hydrosulphite method, while not yet completely satisfactory for clays, is believed to be capable of further

development. The method was found to be very effective for soils, and comparison with Tamm's method for a wide range of soils has led to the conclusion that it should be a very effective rapid routine method.

An investigation into the composition of the ethylene glycol-water-montmorillonite complex has been referred to previously (*Ann. Repts.*, 1944-1945, 1945-1946), and a paper dealing with the determination of the glycol and water contents and the interrelationships between glycol content, water content and (001) spacing of this complex has now been published.¹⁵

SPECTROCHEMISTRY

THE work of the Department of Spectrochemistry is developing along several distinct lines. The primary object is to provide data on the qualitative and quantitative composition of soils, soil extracts, plant materials, fertilizers, soil parent materials, and animal products. It is possible to obtain, on a routine scale, determinations of alkali and alkaline earth metals by means of the Lundegårdh flame technique, and of a number of the more important trace constituents by means of the cathode layer arc method of excitation. Routine methods can in general be applied only to the specific materials for which they were developed, and examination of other substances, as for instance seaweeds, may involve considerable preliminary investigation before the most suitable technique is found.

The development of new methods, to cover an extended range of elements and to suit samples other than those normally dealt with, occupies most of the research time devoted to spectrographic methods. This includes the study of new and modified equipment, and it is hoped that this side of the work will soon be facilitated by the precision workshop for which accommodation is now being provided.

The interpretation of the results of spectrographic analysis is often a more difficult problem than the determinations themselves. The uncertainty which can arise in the assessment of determinations of such nutrients as phosphate or potassium in the soil, from the results of either soil or plant analysis, is widely recognized, but nevertheless the impression is widespread that a single trace element determination on a soil or plant can establish the trace element status completely. For certain elements, such as cobalt, the possibility of deficiency can generally be recognized thus, provided that factors such as soil pH value and previous treatment are kept in mind, but this is not the case for all elements. Considerable investigation of the normal contents of soils, plants and biological materials is necessary before the best possible use can be made of spectrographic methods as a diagnostic tool. This type of work is being carried out in collaboration with other departments of the Institute and with external research institutions, particularly the Animal Diseases Research Association, the Rowett Research Institute and Rothamsted Experimental Station.

The department has, during the year, secured additional accommodation, enabling the apparatus detailed below to be put into operation, together with the new medium and small quartz spectrographs previously acquired.

Amongst visitors who have come for training are the workers who are to carry out the spectrographic determinations at the East and West of Scotland Colleges of Agriculture, as well as workers from China, Kenya, Chile and Holland. There is a steady demand on the services of the spectrographic unit for training purposes and a considerable amount of time is devoted to these and other long or short period visitors. Members of the staff have attended the meetings of such bodies as the Spectrographic Discussion Group and Absorptiometric Panels in Glasgow, the Industrial Spectroscopy Group of the Institute of Physics and the International Con-

ference mentioned elsewhere in this section, thereby maintaining adequate scientific contact with workers in associated fields.

During the year under review grants from the Agricultural Research Council and the Department of Agriculture for Scotland have been available for development work. New equipment obtained by means of these has included a Knorr-Albers Recording Microphotometer, a Beckman Spectrophotometer, a Hilger Wavelength Spectrometer, and equipment for the direct photometry of spectral lines. A Technical Communication dealing with the application of spectrographic methods to soils, plants and related materials, giving an extensive bibliography and describing the methods employed at the Macaulay Institute, has been published,¹⁶ together with two shorter summarizing accounts of the work being carried out.^{5, 17} A third paper on these lines, given in 1947 to the XIth International Congress of Pure and Applied Chemistry, is still awaiting publication.¹⁹

FLAME EMISSION METHODS

The Lundegårdh flame is a particularly stable source, and as such is suitable for the application of methods of direct photometry. An investigation of the possible applications of these to the determination of the alkalis and alkaline earth metals extracted from soils and plant materials is in progress. The initial work has been done using E.E.L. Selenium cells and Ilford 207 Infra-red filter for the determination of potassium by means of the lines at 7665 and 7699A. It would appear that reasonable freedom from the calcium interference reported by earlier workers can be obtained, provided certain precautions are taken, although the sensitivity is not all that could be desired. Applications of this method to other elements, and the uses of photomultiplier tubes and vacuum photocells are being studied, using a spectrometer to isolate the desired spectral lines.

The normal determinations made by the ordinary Lundegårdh flame technique have been carried out as in previous years, a second flame burner unit having been set up for the above investigations in order to avoid interference with the routine determinations. These have included easily soluble soil constituents, exchangeable bases, and alkali and alkaline earth metals in plant materials, as well as some determinations on extracts of rocks and minerals.

ARC EMISSION METHODS

Determinations after excitation in the cathode layer carbon arc are being made of trace elements in concentrates from soil extracts, plant materials, biological materials and animal products. A preliminary chemical concentration with organic reagents is employed to obtain a matrix suitable for spectrographic purposes as well as to extend the limit of determination. The reagents normally employed are 8-hydroxyquinoline, tannic acid and thionalide, and two accounts^{3, 25} of the technique have been prepared, that presented to the International Congress on Analytical Chemistry at Utrecht not yet having been published. Investigations on the use of dithizone as an extractant for certain types of material high in iron and aluminium, such as rocks and minerals, are in progress and appear promising for certain elements.

A study of the effects of electrode dimensions and sample quantity on the absolute and relative intensities of trace element and internal standard

lines is nearing completion, and seems likely to provide useful information on the ranges of variation which are permissible with different elements without loss of accuracy.

TRACE CONSTITUENTS IN SOILS, PLANTS AND BIOLOGICAL MATERIALS

The programme of work envisages the study of the contents of trace elements in all materials related to soil and the growth of plants and animals. The ultimate source of these trace elements is the rock, and geochemical investigations on rocks and minerals have been continued. An account of the distribution of trace elements in the rocks and minerals of the Caledonian plutonic rocks of the west of Scotland has been published,⁴ and a paper on similar lines dealing with the behaviour of chromium, vanadium, nickel, cobalt and copper during the fractional crystallization of a basic magma has been presented to the XVIIIth International Geological Congress.²⁶

The total content of trace element in a soil is of less interest than the amount which can be taken up by the plant, and the study of the amount soluble in different extractants is the best approach to this. Dilute acetic acid (2.5 per cent.) has been found to be a useful extractant, and is being employed for the study of the surface layers of arable soils and the different layers of soil profiles developed from the same parent material under differing site and drainage conditions. Variations in certain trace elements similar to those found by the Soil Survey Unit for some of the major constituents have been observed and these investigations are being continued.

Much of the work on the trace element uptake of plants is being carried out in collaboration with the Animal Diseases Research Association, and covers investigations into animal disorders which are possibly due to trace element deficiency or excess. Thus the determinations carried out in 1946-1947 on the individual species comprising two hill grazings in Sutherland have been repeated on samples taken in 1947 and 1948, in connection with investigations on yellowosis. Other work on this problem has been done on samples from Glen Finglas. The samples taken in different years show good agreement between the trace element contents of corresponding samples of the different species at different sampling times. Other samples examined have been from areas on which lactation tetany, swayback or teart occurs.

Cobalt investigations have included determinations on soils, plants, urine and faeces of sheep (from the Animal Diseases Research Association) and rumen fractions of sheep (from the Rowett Research Institute). From the latter, it would appear probable that rumen bacteria play an important part in cobalt deficiency diseases of ruminants,¹³ and investigations on the trace element status of bacteria are being continued. Samples for cobalt determinations have been received from various sources, including Iceland. Trace element determinations have been made on numerous samples from Commonwealth sources, including herbage samples from areas on which toxæmic jaundice of sheep occurs in Australia, and sisal leaves affected with banding disease, from Kenya. The latter disorder would appear to be due to potassium deficiency and not to a trace element.

Plant samples have been examined for molybdenum on behalf of the Botany Department of the Rothamsted Experimental Station, and other plant, soil and fertilizer samples have been received from various sources in England as well as Scotland.

SOIL ORGANIC MATTER

THE general principles, scope and results of the study of soil organic matter have been described in a paper read at the joint meeting of the British Society of Soil Science and the British Ecological Society in London in April of this year.

CHEMICAL INVESTIGATIONS

Investigations into the chemistry and chemical properties of humus have been continued. A note has been published¹ dealing with the purification of humus by freezing, a process which has been of considerable value in the preparative work entailed in the investigations. Some progress has been made in fractionating the "humic acid" complex. Even when freed of co-precipitated and absorbed contaminants, this may contain up to 25 per cent. of a fraction which is not humic acid in the stricter meaning of the term, since it can be hydrolysed with dilute acid and appears to have a polyuronide constitution.

During the year attention has been concentrated on the soluble carbohydrates present in the soil. A paper has been read illustrating the probable contributions of plants and of micro-organisms to the soil carbohydrate complex.¹² It would appear that the polysaccharides present in soil may originate from the polyuronide hemicellulose fraction of plants or from microbial synthesis. The relative contributions from these two sources is not yet known, but it seems likely that in mineral soils at least microbially synthesized polysaccharides predominate. Carbohydrates are present in soils as free sugars and as constituents of glucosides, polysaccharides and nucleic acids. In connection with this work a new application of the use of phenolic reagents to paper chromatography has been devised for the detection and identification of individual sugars in complex mixtures.⁷ By the standard procedure these can be identified only with difficulty, because of the similarity of their R_F factors, and the consequent inefficient spatial separation on the paper. By the use of resorcinol and naphtha-resorcinol they can be identified by colour tests supplementary to chromatographic separation. The value of this method has been demonstrated in the study of bacterial metabolism. It has been found possible to estimate each sugar in a mixture of sugars in a bacterial substrate at any interval during growth, without affecting culture conditions. As a foundation for a comprehensive study of the carbohydrate metabolism of soil, the carbohydrate constituents and products of plants—in particular of mosses—of micro-organisms and of soils are being investigated.

Some progress has been made in the study of the nature of the more complex nitrogenous compounds found in soils. Using paper chromatography, the various fractions of soil organic matter (Forsyth, *Biochem. J.*, **41**, 176, 1947) have been tested for proteins after hydrolysis to amino-acids. The soluble protein appears to be confined to the fulvic fraction D, and to that part of D which is retained in the centre compartment during electro-dialysis. That part which moves to the anode is "nucleic acid" in

character. The soils studied yield similar chromatograms with more definite quantities of leucine, norleucine, isoleucine, valine and proline, and smaller amounts or traces of tyrosine, alanine and glycine.

MICROBIOLOGICAL INVESTIGATIONS

A note ⁶ and a paper ² on the bacteriology of composting have been published during the year. In addition a paper was read before a joint meeting of the Society of Applied Bacteriology and the Microbiological Panel of the Food Group of the Society of Chemical Industry. Using the same raw materials and conditions for composting as were previously used, the mycological aspects of composting have been studied in some detail. With lawn mowings the fungi present on the fresh material are destroyed in the mass of the material during the high temperature phase. Subsequently, those which survive toward the outside of the mass do not re-establish themselves to any great extent; the numbers do not rise above 20 per cent. of the original. Fungi appear to play little part in the decomposition of the lawn mowings. It is suggested that factors such as the compaction and alkalinity of the material inhibit fungal development. With barley straw, on the other hand, it is clear that fungi play an important role in decomposition. Following the high temperature phase, their numbers increase rapidly and are maintained over the rest of the period of composting. Dominant organisms are being isolated and investigations are being made into their physiological activities with particular reference to cellulose breakdown.

Counts of fungi occurring in the composts have been made, using the technique standardized for soil work. It is recognized that this method has serious limitations—it gives no indication of the condition of the organisms. Examination has been made of a technique reported in the literature for distinguishing between mycelium and spores in soil by subjecting the soil to vacuum desiccation. This method was applied to cultures of compost and soil organisms. It has been found that although fragmental mycelium is completely destroyed, up to 25 per cent. of the spores are also killed, the young spores apparently being unable to withstand desiccation. Hence absolute numerical data for mycelial fragments and for spores cannot be obtained by the suggested method. Bacteriological and mycological investigations of soil and soil-plant problems are now in progress.

Much of the microbiological work has a chemical aspect, as is indicated in a published note ¹¹ dealing with the carbohydrate metabolism of bacteria. The techniques referred to above ⁷ have been applied to the study of the mechanism of synthesis of bacterial polysaccharides from sucrose. For example, using strains of *Leuconostoc mesenteroides*, which are capable of synthesizing dextran from sucrose, a complete balance sheet has been worked out for the speed of disappearance of sucrose and the rate of appearance of fructose and glucose in the medium. In the past it was suggested that this organism, when growing in the presence of sucrose, utilizes the glucose half of the molecule for synthesis of dextran, leaving the fructose half in the medium. With the technique now used it has been demonstrated that, in addition to fructose, glucose is present in the culture medium although in smaller amounts. Similar detailed studies are being made into the polysaccharides synthesized by type culture bacteria as well as by bacteria isolated from a variety of soils.

ROUTINE AND CONSULTATIVE WORK

Routine consultative work and experiments have continued, chiefly in connection with peat and other organic soil ameliorants. Part II of the Wartime Pamphlet on the Peat Deposits of Scotland has now been published,⁹ as well as a general paper on British peat.¹⁰ At the request of the Department of Agriculture for Scotland, expert evidence has been given concerning the utilization of peat, and on behalf of the Department routine examination of peat samples is being carried out at the Institute.

FORESTRY INVESTIGATIONS

At the request of the Forestry Commission an investigation is now in progress into the changes which take place in soil when canopy is being formed. From several forest areas visited, Culbin Forest was chosen for preliminary work and testing of field techniques upon which other investigations will be based. At Culbin, soil and crop conditions vary sufficiently to allow the selection of a series of comparable sites having a good range of crop ages, the trees being *Pinus silvestris*, *P. laricio*, and *P. contorta*. Preliminary investigations of the water relationships have given interesting results.

PLANT PHYSIOLOGY

THE study of the soil-plant relationship has been continued. This has involved laboratory and field work concerned with the absorption, translocation and utilization of nutrients by plants and with the use of plants in assessing soil conditions. Furthermore, the actual technique employed in such investigations has been under review.

PLANT NUTRITION

The studies in plant nutrition have dealt with both agricultural and fruit crops. Field experiments have been established using oats, swedes and potatoes, and samples collected from these throughout the season. Samples obtained from the previous season's experiments have also been analysed. Long-term field experiments have been laid down on the nutrition of soft fruit (strawberry, raspberry and gooseberry) and the preliminary investigations completed. These experiments are designed to obtain information on the following: ion antagonism; the distribution of nutrients throughout the plant; and the effect of soil treatment on yield, tissue composition and the incidence of nutritional and parasitic diseases.

In addition, sand culture experiments have been used to study the factors which affect the absorption of magnesium—particularly the carbohydrate and ion antagonism aspects of the problem.

Experiments have been carried out on the absorption of magnesium by tomato plants growing on soils of high salt content and characterized by a high potassium-magnesium ratio, conditions which had reduced the magnesium status of the plants to deficiency levels. The experiments have confirmed the beneficial effects of heavy dressings of peat worked into the top soil.

Research has been continued on bracken nutrition. Further samples have been collected and examined, and samples previously accumulated have been analysed. A paper is being prepared dealing with the uptake of nutrients by this plant.³⁷

PLANT-ANALYSIS TECHNIQUE

The plant-analysis technique has been used in determining the nutrient status of plants, and in studying the soil conditions affecting their growth. Simultaneously, the fundamentals of the plant-analysis technique itself have been examined.

Factorial field experiments, similar to those of the previous season, have supplied material which will be used to show the effects and interactions of deficiencies of nitrogen, phosphorus and potassium on oats, swedes and potatoes. Both actively metabolising tissue (leaf laminae) and conducting tissue (stems and petioles) of growing, fully developed, and senescent types have been sampled and the determination of various fractions of the nutrients therein has been started.

The plant-analysis technique has also been used in the routine determination of the nutrient status of plants submitted by advisory officers and research workers.

When investigating a case of poor crop growth, two samples are usually taken. One sample consists of the abnormal plants or parts of these plants ; the other is a similar sample but is taken from normal, or at least more nearly normal, plants of the same variety and from the same field. The two samples are taken to the laboratory where their nutrient status is determined with regard to nitrogen, phosphorus, potassium, calcium, magnesium and manganese. In the case of nitrogen, this is done by a direct tissue test on the mature stems or petioles using a diphenylamine reagent. In the case of phosphorus, potassium, calcium and magnesium, the laminae of the fully expanded leaves are used ; absorptiometric methods are employed to analyse extracts of these obtained by macerating them in a Waring Blender with sodium acetate-acetic acid buffer solution (pH 4.8). The dry matter is used for manganese determinations.

ANALYTICAL METHODS

Analytical technique has necessarily received considerable attention. The methods used in the actual determination of the nutrient composition of the extracts, etc., are based on the Spekker Photoelectric Absorptiometer, and are either original or are adaptations of published techniques. The degree of accuracy obtained is satisfactory, being within ± 5 per cent. These methods are relatively rapid ; even in the case of potassium, which takes the longest time, about sixty determinations can be made in a day.

SOIL FERTILITY

SOIL FERTILITY INVESTIGATIONS

Field, pot and laboratory studies, of both long-term and short-term character, have been developed on the general lines detailed in previous annual reports. Field experiments are in progress at over forty centres, which were selected as being representative of particular soil associations on the basis of information supplied by the soil surveyors. Laboratory examination of samples of soil and produce from the experimental areas, and pot experiments on a selection of the soils are being carried out to provide supplementary information. In these investigations particular attention has been given to (1) methods of assessing the nutrient requirements of soils and crops, (2) increasing the effectiveness of fertilizers, especially phosphate, and (3) the effect of pedological factors on soil productivity and on the nutrient requirements of soils. In connection with the last-mentioned objective a set of soil substitution experiments has been commenced in small field plots at Craigiebuckler. For these substitution experiments bulk samples of soil, representing seven of the main soil associations in the north-east of Scotland, have been transported for comparison with the Craigiebuckler soil under uniform drainage and climatic conditions.

General Manurial and Liming Experiments. These include investigations on (1) the responses to and interactions of nitrogen, phosphate and potash in various combinations, (2) the nutritional requirements of crops, (3) the effect of soil type on the lime and fertilizer needs of a range of soils, (4) the crop-producing capacities of different soils. For a start, special attention is being given to soils derived from Old Red Sandstone, granitic and gneissic, basic igneous and slate parent materials. Experiments have also been commenced to study the effect of farmyard manure on the responses to nitrogen, phosphate and potash individually and in combination. In the experiments comparing the values of a range of liming materials, further yield data have been obtained. These support the previous conclusion that differences in the effectiveness of the various materials are small and unimportant relative to the over-all beneficial effect of liming.

Phosphate Relationships of Soils. Investigations on various aspects of this problem, particularly phosphate fixation, have been continued with special reference to (1) the interaction of calcium carbonate and calcium sulphate with phosphate on different soil associations, (2) the comparison of infrequent heavy and frequent light dressings of phosphate, (3) the use of fertilizers in powder and granular forms. A paper on the relative effectiveness of different phosphatic fertilizers has been published during the year.⁸

Dr. Williams, who has been mainly responsible for the detailed work on phosphate fixation, had the honour of being offered a Swedish Government Fellowship for one year from 1st October, 1947. He has, therefore, during the past year been making a special study of this problem under the direction of Professor Mattson in Uppsala.

The comprehensive examination of samples of soil and produce from experimental plots at Craibstone, the North of Scotland College of Agriculture Farm, referred to in previous reports, has been completed. The results obtained have been described in a thesis submitted for the degree of Doctor of Philosophy and accepted by the University of Aberdeen. In a long-term rotation experiment, in which different fertilizer treatments have been given throughout a period of nearly twenty years, the benefits of suitably balanced complete fertilizer supplements are clearly shown. As a source of phosphate, ground mineral phosphate has given good results with turnips, swedes and pasture, but the highest yields have usually been obtained from complete fertilizer dressings containing superphosphate as the source of phosphate. In many of the experimental areas it has proved extremely difficult to obtain accurate information on the phosphate status of the soils, because of the complicating influence of variable drainage conditions. The poorly drained soils show distinctly higher contents of readily soluble phosphate than the freely drained soils of the same type. Although the over-all yield level is lower than in the well-drained areas, the poorly drained soils nevertheless respond markedly to additions of phosphate. The effects of lime in increasing crop yield and in increasing the readily soluble phosphate contents of the soils have been quite pronounced in these experiments.

From other results of general interest in the main experimental programme on phosphate problems, it appears that, because of the high fixing power of practically all soils, it is probably sounder policy to apply moderate dressings of phosphate for each crop than to attempt to build up a phosphate reserve in the soil by applying single heavy dressings at infrequent intervals. The experiments with fertilizers in granular form indicate that these are *at least* as effective as those in powdered form.

Fertilizer Placement. Experimental work on the placement of mineral nutrients in soils has been continued with the aid of a further grant from the Agricultural Research Council, to whom a report on the 1947 experiments has been submitted. A leaflet reviewing fertilizer application and placement for arable crops is being prepared for the Department of Agriculture for Scotland.²⁹

The results of the 1947 experiments on cereals show that combine-drilling of sulphate of ammonia does not affect the response to combine-drill applications of superphosphate. With potash there has been little difference between combine-drilling and broadcasting, and chief interest attaches to the observation that muriate of potash can be combine-drilled with oat seed at rates up to 1 cwt. per acre without any injurious effects. The results also show that higher yields can generally be obtained from combine-drilling NP and NPK mixtures than from similar dressings applied broadcast.

Further experiments on turnips and swedes have been carried out with a New Zealand machine—a Storrie-Willett, combine seed-fertilizer, two-row, ridge drill. These experiments indicate that with turnips and swedes placement of superphosphate in bands near to, but not in contact with, the seed is likely to be superior to broadcast application. The fertilizer delivery mechanism of the above machine is, however, too erratic for the accuracy desired in this work, and a special experimental drill for ridge work is meantime being made with the help of the National Institute of Agricultural Engineering.

TABLE I
 GROUPING OF ADVISORY SOIL SAMPLES FROM ROTATION LAND IN ABERDEENSHIRE (1941-1947) ACCORDING TO THEIR CONTENTS
 OF LIME, PHOSPHATE AND POTASH

The figures under the various heads are percentages of the samples examined

Parent Material Group.	Soil Association.	No. of Samples Examined.	Lime.			Phosphate.			Potash.		
			* S.	S.L.	L.	S.	S.L.	L.	S.	S.L.	L.
All Groups		7874	2	50	48	7	44	49	14	72	14
A. Acid Igneous Boulder Clays	All Associations . . . Countesswells Association Strichen Association	2020 1698 294	2	45	53	9	55	36	7	72	21
B. Intermediate and Basic Igneous Boulder Clays	All Associations . . . Insch Association . . . Tarves " . . . Maud/Arnage Association	2364 396 1622 267	2	58	40	9	50	41	13	75	12
C. Old Red Sandstone Boulder Clay	All Associations, i.e. Cruden Association . . .	414	3	76	21	21	54	25	11	70	19
D. Slate Boulder Clay	All Associations . . . Fouldland Association . . .	1848 1810	2	54	44	7	51	42	14	75	11
E. Water Sorted Sediments	All Associations . . . Corby Association . . . Kemnay " . . .	874 691 111	1	56	43	3	42	55	16	78	6
F. Old Red Sandstone Boulder Clays, Medium and Light Textured	All Associations, i.e. Haddo Association . . .	273	4	68	28	6	42	52	42	53	5
G. Siliceous Deposits	All Associations . . . Skelmuir Association . . .	81 80	1	45	54	2	23	75	18	73	9
			1	45	54	2	22	76	18	73	9
			2	49	49	9	54	37	9	71	20
			1	48	51	7	57	36	6	72	22
			4	59	37	21	34	45	18	68	14
			1	44	55	1	25	74	10	78	12
			—	25	75	—	19	81	3	90	7
			—	25	75	—	19	81	3	90	7

* S. = satisfactory. S.L. = slightly low. L. = low.

During 1948 further experiments have been laid down to compare the effects of broadcast and drill or placed applications of nitrogen, phosphate and potash on cereals and on turnips and swedes.

ADVISORY WORK

In collaboration with the North of Scotland College of Agriculture advisory work has been continued and extended. During the year analyses have been carried out on over 7500 soil samples, and relevant advisory reports issued on the treatment likely to be most suitable for the areas sampled. Most of these samples were drawn from ordinary agricultural land, but soils from horticultural land, forest nurseries, aerodromes and sports grounds have also been examined. As in previous years, materials such as limestones, calcareous sands, wood ashes, compost and various by-products likely to be of value on the land, have been analysed as and when required.

In the 1946-1947 report reference was made to the grouping of advisory soils from Aberdeenshire in terms of the various associations recognized in the reconnaissance soil survey. Analytical data for soils examined during the years 1941-1947 have now been recorded. In Table I these are grouped as satisfactory, slightly low, or low, according to their contents of plant foods in relation to the needs of a common rotation of cereals, roots, hay and pasture. Although the numbers of samples in some of the groups are as yet too small to permit of definite conclusions being drawn, certain trends are evident. In all associations deficiencies of lime and phosphate are widespread. Although potash deficiency is relatively less pronounced, dressings of potash may nevertheless be regarded as desirable for the maintenance and improvement of the fertility of most of the soils. In regard to individual soil associations lime deficiency appears to be slightly less pronounced on soils of the Inch and Cruden associations than on the others, while phosphate deficiency is somewhat less pronounced in soils of the Inch and Kemnay associations. Soils of the Cruden association are rather higher in readily soluble potash than the others, while soils of the Countesswells, Inch and Corby associations are relatively low in potash.

COLLABORATIVE WORK

THE ANIMAL DISEASES RESEARCH ASSOCIATION

Collaboration has been continued on problems of the interrelationships of soil and herbage upon animal health. Spectrographic determinations have been made on samples of soils, plant materials, animal organs and excreta, and foodstuffs in connection with joint investigations on cobalt deficiency, yellowsees and lactation tetany.

THE ROWETT RESEARCH INSTITUTE

Numerous samples, in particular samples of bacterial fractions separated from sheep rumen, have been analysed for trace elements in connection with investigations into the action of cobalt in ruminants. Other trace element determinations on various materials used for the production of artificial diets have also been carried out.

Differential thermal analysis examinations of bone-salt and various calcium-phosphorus compounds are being carried out with a view to elucidating the nature of bone-salt.

THE HANNAH DAIRY RESEARCH INSTITUTE

Problems arising in the manuring of grass have been studied and the necessary experimental work undertaken.

THE SCOTTISH COLLEGES OF AGRICULTURE

The Macaulay Institute and the Colleges of Agriculture have collaborated in the application of experimental findings to practical agriculture.

FORESTRY COMMISSION (RESEARCH BRANCH)

Co-operative work with the Research Branch of the Forestry Commission on various aspects of the nutrition of forest tree seedlings has been continued.

THE DEPARTMENT OF AGRICULTURE FOR SCOTLAND AND THE AGRICULTURAL RESEARCH COUNCIL (STRAWBERRY DISEASE INVESTIGATION AND SCOTTISH RASPBERRY INVESTIGATION)

Experiments on strawberries, raspberries and gooseberries to correlate soil treatments with vegetative development, fruit yield, tissue composition and disease resistance, have been established.

CONSULTATIVE COMMITTEE ON THE DEVELOPMENT OF SPECTROGRAPHIC WORK

The Consultative Committee—constituted by the Agricultural Research Council and the Department of Agriculture for Scotland, with the Director

of the Macaulay Institute as Convener—represents all the Research Institutes in Scotland, the Scottish Colleges of Agriculture and the Research Division of the Ministry of Agriculture of Northern Ireland. The parent committee reviews the various aspects of pure and applied spectrochemistry, while a technical sub-committee representative of the active workers in this field of investigation has been appointed to deal with detail.

PUBLICATIONS

(A) Issued during the year—

1. "Freezing as an aid in the drying and purification of humus and allied materials." By W. G. C. Forsyth and G. K. Fraser. (*Nature*, **160**, 607, 1947.)

When precipitated humus gel is frozen solid and then allowed to thaw, the colloidal properties are destroyed and it is readily filtered as irregular microscopic flakes of low moisture content.

2. "The microbiology of composting." By D. M. Webley. (*Proc. Soc. Appl. Bact.*, No. 2, 83-79, 1947.)

The behaviour of the aerobic mesophilic bacteria of composts made under standard conditions has been studied. Two types of material, barley straw and lawn mowings, were used for composting. Inorganic nitrogen was added to the straw but no addition of any kind was made to the mowings.

The aerobic mesophilic bacterial flora of both types of compost behaved in a similar general manner during the composting period. Thus there was a reduction in the numbers at the high temperature phase of the process (65-55° C.) followed by a striking increase when the temperature fell below 40° C. Sampling error could not account for this phenomenon.

3. "Concentration methods in spectrographic analysis. II. Recovery of trace constituents in plant materials and soil extracts by mixed organic reagents." (*J.S.C.I.*, **66**, 330-336, 1947.)

A concentration method, employing precipitation by means of a mixture of 8-hydroxyquinoline, tannic acid and thionalide, is described for the simultaneous recovery of Co, Ni, Mo, Cr, and V (2-50 µg.); Be, Ge, Sn, Pb and Ti (5-100 µg.); and Zn (0.2-4.0 mg.). Details are given for the application of the methods to the determination of trace constituents in plant materials and soil extracts.

4. "The geochemistry of some Caledonian plutonic rocks." By S. R. Nockolds (University of Cambridge) and R. L. Mitchell. (*Trans. Roy. Soc. Edin.*, **61**, Pt. 2, 533-575, 1948.)

Trace element contents (determined spectrographically) are given for typical Caledonian plutonic rocks and their constituent minerals. The rocks vary from ultrabasic (dunites and periodites) to acidic (granites and aplites) and the geochemical significance of the data is discussed.

5. "Trace constituents in soils and plants." By R. L. Mitchell. (*Research*, **1**, 159-165, 1948.)

A short review of the spectrographic methods employed at the Macaulay Institute and of the results so far obtained.

6. "Aerobic mesophilic bacteria in composts." By D. M. Webley. (*Nature*, **161**, 174, 1948.)

A preliminary account is given of the behaviour of the aerobic mesophilic bacteria in composts. It was shown (a) that during the high temperature phase of composting there is a marked reduction in the number of bacteria present in the original material, (b) that when the temperature of the compost falls below 40° C. there is a very striking increase in the aerobic mesophilic flora.

7. "Colour reagents for the paper chromatography of sugars." By W. G. C. Forsyth. (*Nature*, **161**, 239, 1948.)

The qualitative identification of sugars in complex mixtures is readily obtained by spraying chromatograms with resorcinol and naphtharesorcinol solutions which gives characteristic coloured spots.

8. "The relative effectiveness of phosphatic fertilizers." By E. G. Williams and J. W. S. Reith. (*Emp. J. Expt. Agric.*, **16**, 1-13, 1948.)
Field and pot experiments have shown no marked difference in the effectiveness of phosphate other than mineral phosphates, calcium metaphosphate and Semsol. Granulation did not alter effectiveness of triple superphosphate or steamed bone flour. There is no indication of any marked variation in the relative effectiveness of the different phosphates in soils of various geological origin. Even with responsive crops on very deficient acid soil there is generally little or no increase in yield obtained with dressings higher than about 80-100 lb. P_2O_5 per acre. Mitscherlich pot experiments with P_2O_5 additions of 0.1-0.2 g. P_2O_5 per pot give a useful indication of the field effectiveness of the different phosphates.
9. "Peat deposits of Scotland. Pt. II. Peat mosses of Aberdeenshire, Banffshire and Morayshire." (*Geol. Survey Wartime Pamphlet No. 36*, 1948.)
Contains introductory matter, distribution of major peat deposits, notes on types of peat and their stage of development, notes on local utilization, and details of the deposits of the north-eastern area of Scotland, including, for each deposit, name, locality, elevation, depth of peat and type, together with other points of interest or of importance in relation to the utilization of peat.
10. "British peats." By G. K. Fraser. (*J. Min. Agric.*, **55**, 71-78, 1948.)
A general description of the mode of formation and of accumulation of peat in this country; of the major types of peat deposits and their extent and distribution in Great Britain and Ireland; of the principal types of plants which go to form the abundant kinds of peat; of the cutting and drying of peat and its uses, including some notes on reclamation of peat ground.
11. "A method for studying the carbohydrate metabolism of micro-organisms." By W. G. C. Forsyth and D. M. Webley. (*Nature*, **162**, 150, 1948.)
An application of the method described in (7) to the study of carbohydrate metabolism of bacterial synthesis of polysaccharides from sucrose. With strains of *Leuconostoc mesenteroides* which are capable of synthesising dextran from sucrose a complete time/reaction balance sheet can be obtained of the disappearance of sucrose and the appearance of fructose and glucose in the medium.
12. "Carbohydrate metabolism in the soil." By W. G. C. Forsyth. (*Chem. & Ind.*, pp. 575-579, 1948.)
A general description of the present position of the origin, character, and transformations of carbohydrate materials in relation to soil organic matter, reference being made to carbohydrates of higher plants and lower plants and to the decomposition of these in soil. Bacterial polysaccharides are described in some detail, and reference made to fungal. The relation of these substances to the carbohydrate content of those fractions of the soil organic matter separated by Forsyth (*Biochem. J.*, **41**, 176, 1947) and the function of soil carbohydrates are described.
13. "Concentration of cobalt by micro-organisms and its relation to cobalt deficiency in sheep." By J. Tosić (Rowett Research Institute) and R. L. Mitchell. (*Nature*, **162**, 502, 1948.)
It is shown that in a cobalt deficient sheep over 80 per cent. of the total cobalt in the rumen contents is in the rumen bacteria. After dosing with cobalt this drops to 60 per cent. The cobalt content of the rumen liquid of undosed animals is very low. Possible relationships between the cobalt content of rumen bacteria and cobalt deficiency in sheep are suggested.
14. "Complexes of clays with organic compounds. I. Formation between the clay minerals montmorillonite and halloysite and organic liquids." By D. M. C. MacEwan. (*Trans. Faraday Soc.*, **44**, 349-367, 1948.)
Adsorption complexes, formed by montmorillonite and halloysite with a variety of organic compounds have been studied by X-ray methods. The organic molecules enter between the structural sheets of the clay minerals and arrange themselves in parallel layers. Up to three such layers have

been found in montmorillonite complexes but only one layer has been found in halloysite complexes. The effect of the structure of the adsorbed compound on the adsorption complex is discussed. Deductions may be made as to the molecular configuration of the adsorbed molecules.

15. "Complexes of clays with organic compounds. II. Investigation of the ethylene glycol-water-montmorillonite system using the Karl Fischer reagent." By R. C. Mackenzie. (*Trans. Faraday Soc.*, **44**, 368-375, 1948.)

The composition of specially prepared ethylene glycol-water-montmorillonite complexes has been studied by means of the Karl Fischer reagent. Details are given of the application of this reagent to the determination of alcohols in the presence of clays. The relationships between the composition of the complexes and X-ray data are described and discussed.

16. "The spectrographic analysis of soils, plants and related materials." By R. L. Mitchell. (*Commonw. Bur. Soil Sci., Tech. Comm. No. 44*, pp. v, 183, 1948. Price 12/6.)

A review of the literature on spectrographic methods of analysis relevant to the investigation of soils, plants and related substances, such as soil parent materials, fertilizers and animal products, together with full details of the methods employed at the Macaulay Institute. Tables for the evaluation of spectral line intensities, and photographs of spectrograms with the trace element lines indicated are included together with some 750 references.

17. "Applications of spectrographic analysis to agricultural problems." By R. L. Mitchell. (*Brit. Sci. News*, **1**, No. 11, 13-16, 1948.)

A brief account of the work in progress at the Macaulay Institute.

(B) *In Preparation*—

18. "Placement of mineral nutrients in soils." By A. B. Stewart. (To appear in *Trans. XIth International Congress of Pure and Applied Chemistry*.)

19. "The trace constituents of the soil." By R. L. Mitchell. (To appear in *Trans. XIth International Congress of Pure and Applied Chemistry*.)

20. "The association or hydrologic sequence in certain soils of the podzolic zone of north-east Scotland." By R. Glentworth and H. G. Dion. (To appear in *Brit. J. Soil Sci.*)

21. "The weathering of biotite in the soil." By G. F. Walker. (To appear in *Min. Mag.*)

22. "A new mineral occurring in soil clays." By G. F. Walker. (To appear in *Brit. J. Soil Sci.*)

23. "Water layers in vermiculite." By G. F. Walker. (To appear in *Nature*.)

24. "Vermiculites and some related mixed-layer minerals." By G. F. Walker. (*Monograph on Clay Minerals*, Chap. 7. To be published by the Oxford University Press.)

25. "Applications of chemical concentration by organic reagents to spectrographic analysis." By R. L. Mitchell and R. O. Scott. (To appear in *Spectrochimica Acta*.)

26. "The distribution of chromium, vanadium, nickel, cobalt and copper during the fractional crystallization of a basic magma." By L. R. Wager (University of Durham) and R. L. Mitchell. (To appear in *Trans. XVIIIth International Geological Congress*.)

27. "Studies on the more soluble complexes of soil organic matter. 2. The Polysaccharides." By W. G. C. Forsyth. (To appear in *Biochem. J.*)

- ✓ 28. "Polysaccharides synthesised by aerobic mesophilic spore forming bacteria." By W. G. C. Forsyth and D. M. Webley. (To appear in *Biochem. J.*)

29. "Fertilizer application and placement for arable crops." By A. B. Stewart. (To be published by the Department of Agriculture for Scotland.)

- ✓ 30. "The microbiology of composting. II. A study of thermophilic bacterial flora developing on grass composts." By W. G. C. Forsyth and D. M. Webley. (To appear in *Proc. Soc. Appl. Bact.*)

31. "The absorptiometric determination of magnesium." By J. G. Hunter.
32. "Illite occurring in decomposed granite at Ballater, Aberdeenshire." By R. C. Mackenzie, G. F. Walker and R. Hart.
33. "Soils and their parent materials in the sheep pining area of Galloway." By R. Hart.
34. "The mineralogical composition of soils from northern Aberdeenshire." By R. Hart.
35. "The synthesis of polysaccharides by bacteria isolated from soil." By W. G. C. Forsyth and D. M. Webley.
36. "A modified hydrometer method for mechanical analysis of soils." By A. Muir and G. Robertson.
37. "The composition of the bracken frond and rhizome." By J. G. Hunter.

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