THE MACAULAY INSTITUTE FOR SOIL RESEARCH

ANNUAL REPORT

1940-41

STAFF 1940-41

Director	W. G. Ogg, M.A., B.Sc. (Agr.), Ph.D.
Soil Fertility and Advisory Work	A. B. Stewart, M.A., B.Sc., Ph.D. Miss A. J. Preddy, M.A. E. G. Williams, B.Sc., Ph.D. H. G. M. Hardie, A.I.C.
Soil Survey	A. Muir, B.Sc., Ph.D. R. Glentworth, B.S.A. (Manitoba), Ph.D.
Peat and Soil Organic Matter	G. K. Fraser, M.A., B.Sc. (For.), D.Sc. M. R. F. Ashworth, B.A., B.Sc., Ph.D.
Geology	R. Hart, B.Sc., Ph.D.
Spectrographic Department	R. L. Mitchell, B.Sc., Ph.D. Miss A. M. M. Davidson, M.A., B.Sc. R. O. Scott, B.Sc., A.R.T.C., A.I.C.
Lysimeter Studies	H. D. Welsh.
Secretary	Miss E. J. Dey.
Librarian	Miss I. M. Anderson, M.A.

THE MACAULAY INSTITUTE FOR SOIL RESEARCH

Craigiebuckler, Aberdeen.

ANNUAL REPORT

1940-41

No major alterations have been made during the year in the war-time programme of work. As before, attention has been directed chiefly to advisory work and to problems of immediate practical importance. These have included fertility experiments with lime and phosphate, studies on phosphate fixation, storage and time of application of fertilizers, crushed biotite schist as a source of potash and cobalt manuring in relation to pining in stock.

The analytical work in connexion with the survey of lime resources in Scotland has been continued and assistance again given on the forestry side in the war-time felling research scheme.

Some progress has been made with soil survey, but if soil surveys are to be used in post-war planning and development, immediate steps should be taken to train additional surveyors. Several enquiries which have been put to the Institute during the past year could not be satisfactorily answered because of the lack of a soil survey. Attempts are being made in various quarters to classify land, assess its productivity and plan its utilization without the necessary basis of information, and it is felt that maps and data of this kind will prove useless or misleading.

Satisfactory progress has been made by the spectrographic department and increasing use is being made of this work in problems connected with minor elements, and also in the routine analytical work of other departments.

The compost investigations have been continued but Dr. Ashworth, who was taking part in this work, left during the year to join the Navy. A beginning has been made with an investigation into the use of peat, with suitable addition of fertilizers, as a substitute for

farmyard manure.

Miss A.M.M.Davidson, a Carnegie Research Scholar who was working in the spectrographic department, has left to take a post elsewhere and Mr.D.M.C.Macewan has obtained a grant from the Agricultural Research Council to recommence the X-ray work which had been suspended for some time.

Miss E.J.Dey has been appointed secretary in place of Miss E.C.Forrest and Miss I.M.Anderson has been appointed librarian.

As in previous years there has been close collaboration with other institutions, particularly the North of Scotland College of Agriculture, the Animal Diseases Research Association, the Forestry Commission and the Geological Survey.

SOIL FERTILITY AND ADVISORY WORK

Advisory Work

The Institute undertakes the testing of soils for manurial and lime requirements, and can provide the farmer with information on the following lines:

1. Degree of acidity and lime requirement measurements indicate whether lime is required and, if so, how much should be applied.

2. From determinations of the readily soluble phosphate and potash in the soil, advice can be given regarding the amount and kind of fertilizer to be used.

3. An approximate measure of the amount of organic matter in the soil is given by loss-on-ignition determinations; this has a bearing on the amounts of farmyard or other organic manures and artificial fertilizers likely to be necessary.

Leaflets with instructions on the sampling of soils and forms for field notes are available on request, and full particulars may be obtained from the Secretary of the Institute.

The major portion of the actual soil sampling work has been done by members of the staffs of the Institute and the North of Scotland College of Agriculture but, during the year, a scheme of voluntary sampling has been started with the aid mainly of rural schoolmasters; the latter are voluntarily undertaking soil sampling work in their own districts and are of great assistance to the Institute.

During the year, 3675 samples of soil have been examined and relevant advisory reports issued on the treatment likely to be most suitable for the fields in question. These samples have been drawn mainly from ordinary arable rotation land and from old grassland which is being ploughed up. In addition, advisory and experimental work has been continued on the liming and manuring of plots under various seedling species in certain Forestry Commission nurseries.

Problems of liming and manuring with special reference to war-time needs have been discussed by W. G. Ogg and

A. B. Stewart (1), and the latter has read a paper on the manuring of oats at a Farmers' Conference arranged by the North of Scotland College of Agriculture.

From results obtained on advisory samples during 1940, a comparison has been made of the lime, phosphate and potash supplies in arable rotation land and old grassland in the North of Scotland. The soils have been grouped as satisfactory, slightly low, and low according to their contents of lime, phosphate and potash, when considered from the point of view of a rotation of the common crops in the district, viz: oats, barley, turnips, potatoes, hay and pasture. A crop such as sugar beet which, for instance, would require a higher lime status in the soil than any of the above crops, is not grown to any great extent in the North of Scotland and has consequently not been taken into account in the arbitrary grouping. Separate grouping of the soils has also been made according to the parent rocks from which they were formed, and some of the results are given in Table I where "R" indicates arable rotation land and "G" indicates old grassland. The figures under the various heads are percentages of the samples examined.

The numbers of samples in the quartz-rich group and, to a smaller extent, in the group of slates and shales are too small for definite conclusions to be drawn, but have been included to give some indication of the deficiencies to be expected in soils formed from these rocks. From Table I it will be seen that the general position with regard to distribution of deficiencies in the various groups is briefly as follows:

Lime: Only a very small percentage of the soils, some 3%, has satisfactory lime contents and this applies to both rotation land and grassland in all the geological groups. As could be expected, however, the percentage of soils in the basic igneous group with low or very low contents of lime is considerably less than in the others. The lime position appears to be most unsatisfactory in the soils derived from slates and shales and quartz-rich rocks.

Phosphate: Phosphate deficiency, unlike lime deficiency, is much more pronounced in old grassland than in arable rotation land; in the former only some 15% of all the samples have satisfactory phosphate contents and over 50% are low or very low; the corresponding figures for rotation land are 26% satisfactory and 28% low or very low. Phosphate deficiency is considerably less widespread in

TABLE I. Grouping of advisory soil samples according to their contents of lime, phosphate and potash.

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

Geological origin	No. of samples examined		Lime						Phosphate						Potash					
			S*		SL		L		S		SL		L		S		SL		L	
	R.	G.	R.	G.	R.	G.	R.	G.	R.	G.	R.	G.	R.	G.	R.	G.	R.	G.	R.	G.
All formations	1740	541	3	3	70	65	27	32	26	15	46	33	28	52	17	35	68	55	15	10
Acid igneous rocks	752	282	6	3	65	66	29	31	28	6	41	36	31	58	21	37	62	54	17	9
Basic igneous rocks	729	156	1	2	82	81	17	17	41	34	46	40	13	26	13	21	72	62	15	17
Slates and shales	212	80	2	0	45	43	53	57	2	8	35	12	63	80	15	53	80	46	5	1
Quartz-rich rocks	49	23	2	4	61	39	37	57	8	9	35	21	57	70	10	52	69	43	21	5

* S = satisfactory; SL = slightly low; L = low or very low.

soils of basic igneous origin than in the others and appears to be very widespread in the slates and shales and quartz-rich groups.

Potash: There is again a marked difference between the arable rotation land and grassland soils, but the picture for potash is the opposite of that for phosphate. Old grassland soils are generally richer in potash than soils from rotation land, and in both classes of land potash deficiency is much less widespread than phosphate deficiency. Although only 17% of the rotation and 35% of the grassland soils have satisfactory potash contents, the majority are only slightly low and the percentage figures for soils with low or very low potash contents are, except for those of basic igneous origin, considerably less than the corresponding figures for soils with low or very low phosphate contents. It will be seen that soils of basic igneous origin are more liable than the others to be deficient in potash and very few of the slates and shales group have low potash contents.

General Soil Fertility Investigations

Land Fertility Scheme Experiments with Lime and Phosphate: In connexion with the Government Land Fertility Scheme three liming experiments (two in Aberdeenshire and one in Kincardineshire) and three phosphate manuring experiments (one in Aberdeenshire, one in Morayshire and one in Ross-shire) were laid down in the spring of 1939 on land in arable rotation. In these the principal aims were to study the effects of lime and phosphates, particularly basic slag, on the yield and composition of ordinary rotation crops and on soil properties. These experiments have been continued and the general position to date in so far as crop yields are concerned is summarized in Tables II and III, where the mean yields for each treatment are given for the three crops which have been grown since the experimental dressings were applied. The yield figures are all expressed as cwt. per acre and refer to fresh weights of turnips, dry weights of grain plus straw for the cereals and dry weights of hay.

In the liming experiments the initial pH values of the soils at the three centres were 5.4, 5.7 and 5.6 respectively and basal dressings of nitrogen, phosphate and potash were applied on the basis of preliminary analyses of the soils. From the yield figures it will be seen that, in the season following its application, the lime

TABLE II. Liming Experiments. Yields as cwt./acre.

Treatment	Centre (1) Aberdeenshire. Drift soil of Diorite origin			Centre (2) Aberdeenshire. Drift soil of Gneiss origin			Centre (3) Kincardineshire. Drift soil of Gneiss origin		
	1939 Turnips	1940 Barley	1941 Hay	1939 Turnips	1940 Barley	1941 Hay	1939 Turnips	1940 Oats	1941 Hay
No lime	313	40	34	311	47	35	212	48	41
Light lime	352	52	41	350	56	43	222	52	48
Medium lime	349	57	42	350	61	46	215	54	50
Heavy lime	349	60	43	352	63	45	206	59	53

TABLE III. Phosphate Experiments. Yields as cwt./acre.

Treatment	Centre (1) Aberdeenshire. Drift soil of Gneiss origin			Centre (2) Morayshire. Drift soil from schists and Gneiss			Centre (3) Ross-shire. Drift soil of Old Red Sandstone origin		
	1939 Turnips	1940 Barley	1941 Hay	1939 Turnips	1940 Barley	1941 Hay	1939 Turnips	1940 Oats	1941 Oats
No phosphate	234	39	41	185	45	34	255	43	32
Light basic slag	315	49	41	238	50	35	311	52	34
Medium basic slag	342	54	41	252	57	39	300	46	34
Heavy basic slag	358	57	45	274	64	39	354	53	39
Light superphosphate	341	48	43	262	51	38	300	48	32
Medium superphosphate	359	52	45	283	58	39	307	50	32
Heavy superphosphate	381	56	44	290	60	38	370	51	33

gave an appreciable increase in yield at two of the centres but was without effect at the third; in the second season yield increases of from 20 to 50% with barley and of some 10 to 20% with oats followed the application of lime. In the third season there are again marked increases of the order of 20 to 30% in the hay crop and it is evident that the increases in yield in these soils not only pay for the lime dressings applied but provide a substantial profit. Analyses of the produce and of soil samples from the experimental plots have not yet been completed but the results so far obtained indicate that there is a marked increase in the lime content of the produce with increases in the dressings of lime applied. Other results show that, for a rotation of turnips or potatoes, oats or barley, hay and pasture, such as is common in the North of Scotland, reduction of soil acidity by liming to a pH value of about 6.2 is very suitable.

In the phosphate experiments basal dressings of lime, nitrogen and potash were applied where necessary to all the areas, and the experimental phosphate dressings were 2, 4 and 8 cwt. of 21% superphosphate per acre respectively and equivalent amounts of phosphate in the form of high soluble basic slag. From the yield figures (Table III) it will be seen that with turnips, yield increases over the control of anything up to 60% have been obtained as a result of the application of phosphate, and there is ample justification for the application of heavy phosphatic dressings. In the first season superphosphate appears to be slightly superior to basic slag; in the second season both fertilizers show marked residual effects and basic slag is, if anything, slightly superior to superphosphate; in the third season following the application of the phosphatic dressings the yield increases over the control (no phosphate) are, as could be expected, much smaller, but the heavier dressings still appear to have a definite residual effect. At Centre (3) the heavy slag dressing gives a yield increase of roughly 20% in the third season, but with this exception, the differences in residual values of basic slag and superphosphate are not very pronounced. The results generally show up the need for relatively heavy phosphatic dressings and support the view that, as a source of phosphate, there is little to choose between superphosphate and basic slag in which 80% or more of the phosphate is soluble in citric acid. Analyses of the produce and of soil samples from the experimental plots are being continued. Preliminary results indicate that an increase in the phosphate content of the produce follows the application of phosphatic dressings, and with

basic slag there is also a slight increase in the lime content of the crop.

Phosphate Fixation: The investigation on the colorimetric estimation of phosphate with the aid of a Hilger "Spekker" photoelectric absorptiometer, which was undertaken in connexion with studies on phosphate fixation, has been completed and a paper submitted for publication (10). The end concentration of reagents recommended by Truog and Meyer is employed, and a simple routine technique for developing and measuring a series of colours is described. Attention is also drawn to the need for strict control of acidity and other precautions to be observed. The phosphate present in dilute acetic acid extracts of various soils has been estimated by direct and indirect colorimetric methods and by a titrimetric method. Comparison of the results indicates that the direct colorimetric procedure, necessitating no pretreatment of the extracts, is suitable for most purposes. The method is also applicable to potassium hydrogen sulphate and calcium lactate extracts but, with the latter, it is necessary to prepare a calibration curve with standard phosphate solutions containing appropriate amounts of calcium lactate. The amount of phosphate taken for colorimetric estimation should be between 0.005 and 0.05 mg. P_2O_5, and the errors encountered are generally well within the range of ±5%.

During the year, work has been continued on phosphate fixation, i.e. the process resulting in the conversion in the soil of readily soluble or available phosphate into forms which are largely insoluble or unavailable to plants. Varying amounts of different phosphates with, in some cases, lime in addition have been intimately mixed with a phosphate deficient soil, and left exposed in the open in large earthenware pots sunk into the ground. Attention, so far, has been paid mainly to a study of the extent to which common methods of determining available phosphate account for the phosphate added and reflect the field response. Results have been obtained with the following extracting agents: dilute acetic acid, potassium bisulphate, calcium lactate, hydrochloric acid, ammonium acetate-acetic acid mixtures and magnesium bicarbonate. Representative samples of soil from the different treatments have also been used as sources of phosphate in a series of pot experiments. The results of these experiments have not yet been fully analyzed, but the indications are that ordinary methods of extraction do not reflect adequately the changes which are taking place. The investigation is being continued with a view to obtaining a clearer picture

of these changes, with particular reference to the general problem of efficient utilization of phosphatic fertilizers.

As indicated in last year's report, samples of soil were taken from a number of experimental plots at Craibstone in connexion with the above general investigation on phosphate fixation. Analytical work on these samples, however, has had to be postponed in favour of work on limestone analysis.

Time of Application of Superphosphate: It is essential under present conditions to avoid accumulation of stocks in vulnerable areas, and at the same time to make full use of the necessarily restricted transport and labour facilities available. Farmers, therefore, have been urged by the Government to take delivery of fertilizers whenever supplies are to be had. On many farms there is a shortage of storage accommodation and autumn application of fertilizers, where this can be undertaken, is one way of getting over storage difficulties. It is, of course, common practice to apply basic slag, mineral phosphate or bones during the autumn or winter. Except for autumn or winter sown crops and for grassland, superphosphate is, however, generally applied in spring. In the autumn of 1940 it was decided therefore to lay down a few experiments in order to find out whether superphosphate could be applied out of season without loss of efficiency. Experiments are being carried out on hay, oats and turnips; full results are not yet available but preliminary results indicate that in crop response there is little or no difference between autumn and spring application of superphosphate. In experiments with hay, autumn and spring applications both gave yield increases of some 8 cwt. hay per acre, when compared with control (no phosphate) plots. With oats at four centres, although the effect on the actual weight of the crop was small, the crops in both autumn and spring treated plots ripened about a week earlier and were superior in quality to the crops in the control areas. Results for turnip crops are not yet available but inspection shows no obvious difference between plots treated in autumn and spring, and in every case the crop in these plots is much superior to that in the control (no phosphate) treatment.

Conditioning of Fertilizers: A fertilizer mixture which would retain its physical properties and not set badly when stored for any length of time on the farm would be of great benefit to farmers taking delivery of manures out of season. In cooperation with a local firm of fertilizer

manufacturers a series of mixtures of sulphate of ammonia, superphosphate and potash salts was prepared with the addition of four different conditioning agents, viz: 1) peat litter, 2) ground dolomite, 3) sand, and 4) ground mineral phosphate. Each of the conditioners was present in the proportion of 10% by weight, and sacks of each mixture have been stored under conditions similar to those obtaining on the average farm. After 9 months storage the mixture with peat as a conditioning agent was much superior to the others in physical condition and showed little sign of setting in lumps. The possibility of using peat as a conditioning agent in fertilizer mixtures would appear, therefore, to be worthy of further investigation under present conditions. Field experiments with equal weights of the mixtures applied to various farm crops indicate that there is no difference in the fertilizing value of the different mixtures.

Crushed Biotite Schist as a Source of Potash: An investigation on the manurial value of crushed biotite schist was commenced in the beginning of 1940 and in last year's report it was shown that in the first season after the application of the experimental dressings to field plots the biotite schist had a certain manurial value, but in both unlimed and limed soil 100 lb. per acre K_2O from sulphate of potash was appreciably superior to 2½ times this amount of K_2O from the schist. The above field experiment has been continued, and the relative yield figures for grain + straw obtained with the oat crop in the second season following the application of the dressings may be summarized as follows:

Treatment	Relative yields	
	Unlimed soil pH 5.95	Limed soil pH 6.75
1 - Control, no potash	100	99
2 - 100 lb./ac. K_2O (from K_2SO_4)	110	107
3 - 50 " " (from biotite schist)	109	108
4 - 100 " " "	116	108
5 - 250 " " "	125	122

From the above figures it will be seen that the biotite schist has an appreciable residual manurial value and the residual effect of the heavy dressing is considerable in both the unlimed and the limed soil. With the oat crop, which is generally found to grow best in a

slightly acid soil, the lime dressing has had little effect on yield. It is proposed to continue the experiment in order to see the effects of the dressings on a hay crop - a crop which is likely to show greater response than oats to both potash and lime. During the year, a series of pot experiments was also carried out with soil from some of the experimental plots. The results of these experiments have not yet been analyzed, but from observation it appears that in these also the biotite schist has a greater residual effect than sulphate of potash.

Borax in Relation to Disease in Potatoes and Swedes: With a view to obtaining information on whether the occurrence of diseases in potatoes and swedes in the North of Scotland is to be associated with boron deficiency in the soil, a series of experiments with varying quantities of borax as a fertilizer was undertaken early in 1940 in collaboration with the North of Scotland College of Agriculture. At all the centres under experiment there was little or no disease in either potatoes or swedes and no evidence of boron deficiency has been found.

Cobalt Manuring and Pining in Stock: Experimental work on this problem which was discussed in last year's report has been continued in collaboration with the Animal Diseases Research Association. An account of preliminary results obtained in this joint work has been published (2), it being shown that pining in lambs due to cobalt deficiency can be cured and prevented by a cobalt-rich fertilizer at the rate of 2 lbs. cobalt chloride per acre. A larger scale confirmatory experiment has been carried out and the results obtained will be published shortly (11). Further experimental work on the relative uptake of cobalt by different pasture species and on the residual effects of the cobalt dressings is being continued and the examination of the cobalt contents of soil and pasture is being made the subject of special spectrographic study by R.L.Mitchell and R.O.Scott.

Soil Properties in Relation to the Occurrence of Grass Sickness in Horses: The paper on this subject referred to in last year's report has been published (3).

PEAT SOILS AND SOIL ORGANIC MATTER

Reclamation Work

In Lewis, a few experiments in progress before the war have been continued. No experimental work was undertaken at Carnwath, Lanarkshire during the year, but the reclaimed land is being farmed by the Department of Agriculture for Scotland.

Peat Survey

Under present conditions it was decided to reduce survey work on peat deposits to a minimum. Recent developments in the way of special enquiries indicate that this decision should be revised, and that survey work is necessary.

Peat and Compost Investigations

The water relationships of peat as a soil or as a constituent of soil: The tentative conclusion of last year has been confirmed, namely, that the effect on water-retention of peat additions to soil is somewhat different from the effect of additions to sand. In general terms it may be stated that, on a volume basis, the water-holding capacity of and the rate of evaporation from sand-peat mixtures is not much different from those obtained by calculation from the sand and peat used separately. On the other hand, small amounts of peat in soil decrease the water-holding capacity slightly and increase the rate of evaporation. This may be explained by the opener texture of the mixture as compared with either peat or soil alone. With large amounts of peat in soil (1:2) the mixture has the same properties as peat alone.

Routine growth tests on peat: These were not carried out this season because of --

(a) the small numbers of new peat samples obtained as a result of the limitation of survey work;
(b) the necessity of clearing up several points of technique such as:

    (1) The determination of whether there is an optimum peat-soil mixture, and whether this is sharply defined or varies much with different peats and crops.

(2) The establishment of a generally suitable test plant for our conditions and methods, or of suitable test plants for special investigations.

(3) The determination of the changes which occur in peat and in peat-soil-sand composts during the period of cropping, and whether those affect the growth of the crop.

The following experiments have been carried out with reference to these points:

(1) Cineraria, lettuce and tomato seeds were sown in seeding composts of peat with soil and sand. The proportion of peat to soil and sand varied from 0 to 1:1. It was found that lettuce and tomato seeds grew most strongly in the mixtures containing the larger proportions of peat, the reverse being true of cineraria seedlings, which germinated and developed more strongly in the soil-sand mixture without peat.

These seedlings were carried over as transplants into similar potting composts where it was found that with the cineraria seedlings the growth was reversed in relation to the peat-content of the compost. The best growth was obtained by using equal proportions of black peats and loam + sand, scirpus peat being better than cottongrass peat. With sphagnum peats the best growth was obtained with 1 part peat to 2 of loam + sand; but this was not quite so good as similar proportions of black peats and only slightly better than the 1 to 1 mixture of sphagnum peat. Soil and sand without peat was definitely poorest in rate of growth and in general appearance. The test was interfered with by individual idiosyncrasies of the plants and for that reason cineraria (at least of the particular type used) is not a good test plant, although very satisfactory in other respects.

It was found that the response of lettuce and tomato plants to different peat contents of the composts was masked by the previous history of the transplants, i.e. good transplants grew equally well in all the mixtures used and poor transplants were relatively poor in all. Experiments on these lines are being continued.

(2) A variety of seeds, chiefly of vegetables, have been tried out in order to ascertain their relative usefulness

as test plants. This section of the work was suspended because of the more immediate necessity of ascertaining the major changes taking place in peat and peat-containing composts during the period of cropping (section 3).

(3) As a result of the previous year's work it was found that during the cropping season in both seeding and potting materials very considerable alterations in the acidity and nutrient value of the materials might occur, chiefly because of the heavy leaching which results from the watering necessary under greenhouse conditions. For example, potting composts, to which the usual dressing of ¾ oz. calcium carbonate per bushel had been added, showed a fall in pH of from about 6 to about 4-4.5. In order to assess the cause of this change and of nutrient losses which appear to take place, a series of experiments is in progress, in the form of (a) practical scale leaching experiments in the laboratory and (b) growth experiments with controlled degrees of leaching.

(a) The general plan of these experiments is to prepare peats and composts containing peat with additions of lime and of nutrients, to water these with regulated volumes of water and to determine the lime and nutrient losses in the drainage water. An explanation of the results obtained will be sought for later in the ionic-exchange capacities of the peats and soils and in possible transformations of some of the substances of which peat is composed. So far it appears that the rate of leaching is governed by other factors besides the volume of water passing through the soil, e.g. intermittent drying or partial drying of the soil.

(b) The second group of experiments are growth tests of the normal type with, however, arrangements by which nutrient losses due to watering may be determined. From the experiments will be ascertained what proportion of the nutrients supplied to potting composts made up with different peats are:

(i) utilized by the crop
(ii) lost in the drainage
(iii) retained by the soil

as well as how far the losses which take place affect the growth of the crop. For example, a preliminary experiment indicates that growth reductions up to 20% may be incurred as a result of losses in ordinary watering.

Field Compost trials: The value of several of the composts hitherto made has been tested out in the field alongside dung and artificials, but the final assessment of the experiment has not yet been made.

Composting: Composting has been confined in the main to the use of fresh green materials such as lawn mowings and weeds. The chief aims of the work have been (a) to ascertain the losses of nutrients which may take place in the composting of such materials, and (b) to determine to what extent such losses can be prevented by admixture of peat, without detriment to the rate of composting and the quality of the compost produced.

It is found that very heavy losses of nitrogen and even more so of potash occur during the period of most active breakdown of green materials. Losses take place chiefly in the form of liquid which drains from the decomposing heap. The nitrogen losses are mainly but not wholly in the form of ammonia, which may nitrify as the liquid becomes fully exposed to the air. The potash content of drainage may be very high, amounting to 7% K_2O in the liquid lost; since in the compost heap the liquid may be more than 50% of the total weight the losses occurring in composting in the open may include, therefore, the greater proportion of the potash in the composting material. More exact data are being obtained.

In general it can be said that fresh, vigorously growing materials (like grass mowings) do not require nutrient additions to promote their decomposition. Additions of lime, nitrogen and phosphate have given no appreciable acceleration of composting. Lime is not necessary to maintain neutrality, since all the materials of this kind used (as well as straw with organic nitrogen added) maintain a high pH at least throughout the period of intense decay. This is mainly a result of ammonification, but the liberation of potash in the form of carbonate also takes place. It is obvious that a direct result of lime additions will be to increase ammonia and potash losses. These losses can be prevented by the use of soil or peat as an absorbent of the liquid formed during composting. (Soil is used in normal practice and, although other reasons are usually given, this may be its principal value.) By using peat a wholly organic compost can be obtained. It is found that a 1:4 (bulk) mixture of peat with grass mowings gave no loss by drainage, reduced volatilization of ammonia and gave a good compost. The method used was to inter-layer the grass and peat in depths of 1 in. peat

followed by 4 in. compact grass mowings. With softer weeds, e.g. comfrey, more peat is required; even with 1:1 mixtures some loss of drainage occurred. With 1:4 mixtures the losses were very high and the liquid contained as much potash per cent as if peat were not present, though the ammonia content was reduced somewhat; even under cover liquid losses have continued after six months of composting. Although sphagnum peat is more absorbent than black peat, the resultant compost is not considered to be so good as that from black peat (cottongrass and sphagnum).

Laboratory investigations: The changes taking place in grass composts and the effects of nutrient additions to these have been studied under laboratory conditions. The results are not completed but tend to confirm the conclusions arrived at from large scale work, viz: that additions of ordinary nutrients play a minor part in accelerating the decomposition of soft green materials.

Notes on methods: In connexion with these investigations the necessity for a method by which absolute changes (as distinct from relative changes) in composition of decomposing organic matter in bulk can be measured is very obvious. Theoretically the simplest method of achieving this end is by making use of any resistant immobile constituent of the materials, i.e. the "sand and insoluble silicate" fraction of the ash. Unfortunately, this is probably not wholly stable in fresh vegetable matter, and is usually so small that minor changes in it lead to major errors in calculation. To surmount this difficulty, reasonably large amounts of pure white sand have been introduced into materials to be composted as a stable, immobile constituent upon which such calculations might be based. This was done on both large- and small-scale experiments. The idea was found to be unworkable because of the difficulty of obtaining a homogeneous mixture of the sand and organic matter. The sampling error due to uneven mixing was much greater than was expected even where the organic matter was finely ground, so that duplicate determinations were not usually even moderately satisfactory. The method, therefore, had to be abandoned.

Petrol-alcohol mixtures as solvents for the extraction of the "fats, waxes and resins" fraction: Claims are made that greater quantities of "wax" are extracted from peat by petrol-alcohol mixtures than by the usual solvents. A series of experiments with organic solvents of the types suggested does not indicate any regular appreciable difference from the alcohol-benzene method at present in use.

Filtration of extracts: The filtration of extracts is one of the most time-consuming operations in the proximate analysis of organic matter. Various attempts have been made to surmount this difficulty.

(i) After hydrolysis the liquid to be filtered was shaken with neutral barium sulphate in order to improve mechanical separation and granulation of the sediment. Slight improvement was obtained, but not sufficient to warrant the adoption of this method.

(ii) The liquid was shaken with Kieselguhr and then filtered through a pad of Kieselguhr on the Buchner funnel with filter paper. Reasonably rapid filtration was obtained, but the filtrate became cloudy after a short time, and there was evidence that subsequent operations would be complicated by the possible introduction into the filtrate of very finely divided silica.

(iii) The supernatant liquid extract was removed as far as possible and centrifuged before filtration. In this way the time taken for filtration of extracts was reduced from eight days or even more to one day.

Methods of sub-fractionation of the water-soluble fraction of organic matter: Dr. Ashworth has carried out an intensive preliminary investigation of the possibilities of separating the water-soluble nitrogenous matter of soils and composts into fractions. This preliminary work was carried out on solutions of pure organic compounds and on water extracts of composts and of soils. Four schemes were extensively tested out:

(i) The destruction of primary amino-compounds with nitrous acid. This proved impracticable owing to the difficulty of removing excess of nitrite and nitrate, and to the uncertainty of the reactions of secondary amines and aromatic compounds.

(ii) The controlled distillation with alkali, in order to remove volatile amines and more readily hydrolysable amides.

(iii) The precipitation of alkaline or weakly acid water extracts with acid, with a view to separating off organic matter of low nitrogen content from the simpler nitrogen compounds.

(iv) The destruction of nitrogen compounds by means of regulated chlorination. It was found that the extent of

degradation is dependent on the type of nitrogen and the concentration of the chlorination solution; but non-nitrogenous groups interfere with the nitrogen breakdown. Further work is required to establish the usefulness or otherwise of the method.

The investigation so far has not led to any scheme of nitrogen fractionation, but has served to clear the way for further investigation.

SOIL SURVEY

The work on soil surveys has been continued in the areas in Aberdeenshire and Argyllshire described in last year's report. This year Dr. Hart has assisted with the work in Aberdeenshire. Assistance has again been given in connexion with the study of woodland areas where felling is in progress. Good progress has been made with the analyses of limestones in the Survey of Scottish Limestones. A small amount of laboratory work on the soils collected during 1940 has been carried out during the winter months. Soil sampling for advisory purposes has again been made a feature of the field work. An account of the survey made by Mr. Glentworth has been accepted by the University of Aberdeen as a thesis for the degree of Ph.D.

Argyllshire

A short visit to the Ardgartan Forest (Ann.Rep.1939-40, p.18) enabled further data on the relationship between the soils and vegetation to be obtained. The survey is complicated by the fact that the area was not enclosed all at once so that a great part of the vegetation is in a very unstable condition. Such changes as have occurred are not always readily seen without careful soil examination. A number of correlations between enclosed and unenclosed types have now been established.

A small number of chemical analyses on the soils was carried out. These analyses confirm the field identification of the soil types analyzed. Others have still to be examined. In general, the results of the analyses conform to those obtained for similar soils from other areas. Thus, in the creep brown earths, there is an increase in the sesquioxide content of the clay fraction with increasing depth, yet the oxalate-extract suggests that the soils are podzolized with a decided illuvial horizon (cf. Forestry, 1935, 9, 116). In the soils identified as podzolized the results of the clay analysis and the oxalate extracts show the same trend, both indicating the leaching and subsequent accumulation of sesquioxides. The gley types are all strongly leached and have high SiO_2/R_2O_3 ratios in their clays. As would be expected with soils derived from a siliceous parent rock, the content of exchangeable bases is generally low. The exchangeable K_2O in some of the bracken soils is, however, as high as in an average agricultural soil. One gley soil (from a ferruginous flush) showed a very high

base status, but the other gley types were low in bases.

A mineralogical examination of fine sand fractions from a few of the soils by Dr. Hart brought out some differences. On the whole the minerals in the sand have come from the mica schist, but in certain places proximity to the basic igneous rocks of the higher ground has resulted in certain ferromagnesian minerals being found in the drift of the lower slopes. These are not present in sufficient quantity, however, to have much influence on soil development.

Aberdeenshire

The 1941 survey is a continuation of that embarked upon in previous years and covering the area between Old Meldrum and Rhynie. The extension is on the northern side of that area and includes parts of the parishes of Tarves, Methlick, Fyvie, Meldrum, Rayne, Auchterless, Culsalmond and Forgue. It comprises an area of approximately 55 square miles.

During the survey, soil samples were collected for analysis and advice by the Advisory Department where required. The data will subsequently be correlated with soil type. Representative soil profiles of the various soil types established have been collected for analysis.

Topographical description of the area: The southern part of the area is bounded by a chain of hills with Tillymorgan on the west (1249 ft.) the highest point in the district, through Hill of Rothmaise (834 ft.) and Folla Hill (668 ft.) to Core Hill (804 ft.) on the east. To the north of this chain there is a tract of lower ground with a general elevation of 400 to 500 ft. but this is diversified by tracts of hilly ground sometimes rising to 649 ft. as at Drumsinnie and 582 ft. at Gordonston Hill. The ground in the areas of lower elevation is generally rolling with broad valley bottoms. The streams flow in an easterly to north-easterly direction joining the river Ythan. Near Fyvie the Ythan has had its channel overdeepened and the tributaries run in deep ravines forming the Mill of Crichie Den, Den of Crichie, Den of Tifty and Rothie Vale. North of Fyvie the Ythan runs in a fairly broad valley called the Howe of Haddo, but east of Fyvie it becomes a deep cleft with steep banks. The eastern side of the area, i.e. east of the Old Meldrum-Fyvie road, falls away in broad low undulations to altitudes averaging between 300 and 400 ft. On the western side of the area the land rises to 600 ft.

and reaches 1000 ft. immediately west of the mapped area.

Geology: The following rock groups occur in the area:

Highland Schists
- Old Meldrum Gneiss
- Fyvie Schists
- Macduff Schists
- Contact-altered Schists

Old Red Sandstone
? Pliocene Gravel.

The Old Meldrum gneiss is not extensively developed in this area. The rock of this group is a coarse gneiss, quartzose and sometimes micaceous. Eastwards from Rothienorman and south of Fyvie stretch the Fyvie schists, which in the eastern part consist mainly of argillaceous schists and grits. Knotted rocks also occur in this area and andalusite schists are to be found in the eastern part of the district. The Macduff group of schists is very extensively developed and consists of slates, argillaceous schists and grits. In the western part of the district from Tillymorgan northwards, slates are to be found and in the Rothienorman-Fyvie area argillaceous schists and grits occur. The contact-altered schists have been found at the junction of the Insch basic igneous mass and the Macduff schists. They are found from Kinbroom House, through the Hill of Rothmaise, to Culsalmond and consist of hornfelses.

The Old Red Sandstone occurs north of Fyvie in the Ythan valley and is made up of a coarse conglomerate and a dull red sandstone.

The Pliocene gravels were met with to the south of Windyhills near Fyvie. They consist of white gravels, formed of rounded pebbles of quartzite with layers of micaceous sand.

Few of the soils of the area, however, are developed on rock, most being formed on the superficial deposits. These are: peat, alluvium, glacial sands and gravels, and boulder clay. Peat is found in the Moss of Wartle, Moss of Redhall and Fisherford, but there is no very extensive development. Alluvial deposits are to be found along the banks of all the streams, the most extensive ones occurring along the Fordoun river and the Ythan. Glacial sands and gravels are not found extensively, the largest deposits occurring in the Howe of Haddo and around Fyvie. Boulder clay is the most extensive of the superficial deposits.

It is generally a grey brown stiff and compact stony drift. There is not usually much change in colour over the area apart from the Old Red Sandstone area, where it is dull red. The stone content varies with the underlying rock type.

Soils: The system of classification used was that outlined in the Annual Report 1939-40 (p.17). The main soil types covered are developed on drift derived from metamorphic rocks of a slaty texture and varying degree of metamorphism. In the west true slates are found and these gradually change through an argillaceous schist to an andalusite schist. They are banded by areas of grits which vary between fine-grained and pebbly texture, but which are commonly highly quartzose.

The common origin of the rock types, i.e. from metamorphosed sediments, results in certain common features of the soils developed on them. In texture the soils across the area are remarkably uniform, being of a heavy loam in the surface horizon and underlain by a very fine sandy to silt loam bright ochreous coloured B horizon which is developed on a creamy fine sandy drift. The latter is generally compact, the two upper horizons being mellow and friable.

The soils on the slates of the west have a shingly chip-like stone content, while the argillaceous and andalusite areas have a somewhat larger sized stone content of rectangular shape, averaging from 4 to 6 inches across. Stone dykes are characteristically absent.

Soil series established: Four new series of soils have been established. These have not yet been assigned to suites, further investigation being required.

(a) Rothie series on argillaceous schist.
(b) Tulloch " " grit, fine-grained and pebbly.
(c) Fyvie " " fluvioglacial gravel.
(d) Haddo " " Old Red Sandstone.

Soil series previously found to the south have also been found to occur in this area. These series are:

(e) Foudland series on slates.
(f) Foudland " " hornfels.
(g) Old Meldrum " " gneiss.

The Rothie series on argillaceous schist is podzolic

under virgin conditions but of course assumes a brown earth appearance where cultivated. In texture the surface soil is a heavy loam, friable, over a bright very fine sandy to silt loam B horizon which overlies a light khaki, slightly indurated, argillaceous schist drift. The soil has a moderate stone content of rectangular four to six inch stones, and there is a varied inclusion of fine-grained to pebbly grits of about the same size. The oromorphic associate is uncommon, but the three phytomorphic associates have been distinguished. The deep phytomorphic associate is more restricted than the corresponding deep phytomorphic associate of the Insch series, while the intermediate phytomorphic soil is most common. Within the area covered by this series the shallow soils are invariably found on the higher ground, and there is a preponderance of schistose grits among the stones found in these soils. Possibly the shallow associate may be linked with the Tulloch series on grit to be described later, but this awaits further investigation. The phytohydromorphic associate has a cloddy heavy loam to silt loam texture and a grey brown colour, while the gley horizon is a silty loam to fine sandy loam, grey in colour with some brown mottling.

The Foudland series resembles the Rothie series very closely in all respects except for its stone content. This consists of a fairly high proportion of small, one to two inch, chattery slates and results in a comparatively easily worked soil.

The Tulloch series, seen in the vicinity of Tulloch school between Old Meldrum and Fyvie, is of relatively small extent and contains, in so far as has yet been determined, only two associates - a hydrophytomorphic and a hydromorphic associate. The hydrophytomorphic is the more extensive, and consists of a grey brown heavy loam A horizon tending to a cloddy structure on a grey mottled to olive drab coarse sandy to sandy-clay, cloddy gley horizon, which is notably quartzose. The eastward distribution of this soil has still to be investigated.

The Fyvie series. In the Howe of Haddo, and extending southwards through Fyvie, pebbly gravels are found up to approximately the 250 ft. contour. The nature of the gravel is varied, but it contains a large proportion of Old Red Sandstone material. Oromorphic and phytomorphic associates occur, and their characteristic feature is the low moisture-retention capacity of the parent material. The soil types appear to resemble closely those of the Pitcaple series of the Insch suite, which are also developed

on fluvioglacial gravels.

The Haddo series on conglomerate and sandstone of the Old Red Sandstone formation. Northwards from Fyvie on the Turriff road there stretches a comparatively narrow band of Old Red Sandstone rocks, mainly coarse conglomerates; these are overlain by glacial drift, the texture of which is heavier than that of the drifts overlying the other rocks in the area. Two associates have so far been distinguished: one, a deep phytomorphic soil having a reddish brown silt loam surface horizon on a compact stony silty drift and an intermediate phase of a lighter texture, and two, a phytohydromorphic associate with a clay to clay loam A horizon over clay drift. This latter associate resembles very closely the Blairindinny phytohydromorphic associate found north of Rhynie.

In general the heavier textured subsoils met with in the Old Meldrum area are found to extend as far as Udny and possibly further to the east. These subsoils consist of a brown clay loam to sandy clay loam overlain by a lighter heavy loam which is frequently indurated. The surface soil is in general a fine loam in the well-drained positions and tends to be cloddy clay loam in lower ill-drained places.

Kincardineshire

The investigation of the composition of the parent materials of soils in Kincardineshire was continued to include the soils. This is an area of diverse rock types of widespread occurrences and has been subjected to three main glaciations, giving rise to glacial drifts from which the soils are developed. These drifts were studied in relation to the resulting soil profile development. Five main groups of parent materials were recognised based on origin, texture and mineralogical composition, and profiles of cultivated and uncultivated soils on these parent materials were collected and examined. Marked contrast is shown between the soils of the northern half of the area and the southern. In the north, where the soil parent material is drift derived from acid igneous rocks and schists, podzolization, pan development and gleying are marked features. Peat and peaty soils also occur extensively. The soils are very acid, have a low base status and the clay fraction ratios show a translocation of sesquioxides. In the south, where the drift is mainly derived from sedimentary and igneous rocks of Old Red Sandstone age, the soils show little sign of podzolization and

may be classed as Brown Earths; they are heavier and deeper. There is also a marked agricultural contrast, the soils of the southern area with their higher base status are intensively cultivated while much of the northern area consists of moorland and forest. The results of this investigation are in process of publication (14).

War Felling Research Project and Forestry Commission Sample Plots

Three parties were organized for the war felling scheme this year in Scotland and the members of the Soil Survey participated in their work. Woods in the Border Country, Central and West Scotland and in Aberdeenshire were visited and the soils examined and sampled.

The permanent sample plots at Benmore, Argyll, and Culloden, Inverness were visited and the soils described and sampled.

Some chemical analyses were carried out on the soils collected at Murthly and Grantown (mentioned in last year's report). The very slight podzolization noted in the field for the Murthly soils was confirmed by analyses of the clay fractions. There is a small though definite translocation of sesquioxides from the thin bleached layer and in one case from the mull horizon in spite of the presence of a moderate earthworm population. The soils may be termed slightly podzolized or "mull podzols". The base status of all the soils was low, the pH being about 4 under the larch and 4.5 under oak-birch.

Survey of Scottish Limestone Resources

This survey, carried out in conjunction with the Geological Survey, has made very good progress and three war-time pamphlets have now been issued (4,5,6). About 150 samples have been analyzed, of which about 100 required complete analyses and 50 partial analyses (CaO, MgO, CO_2 only). A pamphlet on an area including Fife and the Lothians is in course of preparation (15).

In connexion with the analyses of the limestones it has been found that the method for the determination of sulphur proposed by Hillebrand and Lundell (Applied Inorganic Analysis, p.841) is satisfactory for amounts of sulphide sulphur under 2% where the insoluble residue is low. When the insoluble residue is high the method appears to be somewhat less satisfactory. Further work on

this is in progress.

The analysis of a series of Cretaceous Greensands from Morvern and Mull, Argyll has been carried out on behalf of the Geological Survey. The majority of these proved to be very low in phosphate, but one bed at Loch Aline contained about 25% P_2O_5 and may prove a valuable source of raw phosphate for fertilizers.

SPECTROGRAPHIC INVESTIGATIONS

The two principal applications which are being made of spectrographic methods of analysis may be summarized as:

(a) Analyses of soil extracts for the alkalis and alkaline earths by the Lundegardh flame emission method - restricted at present chiefly to the determination of easily soluble or "available" potassium for advisory purposes.

(b) Determinations of the trace constituents of soils and pastures by more sensitive arc methods. These analyses often involve problems of chemical pretreatment and concentration, as many of the important trace constituents are present in the original materials in amounts below the lower limit of spectrographic detection, i.e. less than 1-100 p.p.m. depending on the element. Thus the investigation of any element raises two problems: the method of its determination and its significance in plant and animal nutrition.

For the spectrographic determination of easily soluble soil potassium by the Lundegardh method 20 g. soil are shaken with 800 ml. N/2 acetic acid, of which 650 ml. are concentrated to 50 ml. for analysis. The vast majority of the 3100 advisory samples examined by this method in the course of the year have shown contents of 4-15 mg. K_2O per 100 g. soil, with occasional values of up to 70 mg. for nursery or greenhouse soils. Even if actual values for other cations such as calcium, magnesium, strontium, manganese or sodium are not obtained, any abnormal content can be noted by visual inspection of the plates. Occasionally other cations such as lead, iron, nickel and copper are observed, and a small infertile area in East Aberdeenshire has been shown by the Lundegardh method to be associated with high nickel and copper contents - up to 10 mg. NiO and 4 mg. CuO per 100 g. soil being extracted by dilute acetic acid. The infertility can be ascribed apparently to the nickel content, but investigations are being continued.

A variable internal standard procedure for the cathode layer arc spectrographic method was described briefly in the preceding report. This method has been developed and extended, and a chemical concentration method suitable for the determination of several cations

simultaneously in plant ashes and soil extracts has been worked out. This chemical pretreatment is necessary for two reasons: (a) to obtain a determinable concentration of some important trace constituents (such as cobalt) in soil extracts or plant ashes and (b) to produce a material easy to manipulate, for filling into the carbon electrodes, and from which an accurate 5 to 10 mg. sample can be taken for determination of iron, the internal standard, by the salicylate colorimetric method (7).

A suitable precipitant has been found in 8-hydroxyquinoline, and conditions determined in which quantitative recovery of cobalt, nickel and molybdenum is obtained with quantities down to 0.001 mg., in the presence of iron and aluminium (3-30 mg.) as carriers. The precipitates so obtained are easily handled after ignition and very suitable for spectrographic treatment. This technique has been applied to the determination of these elements in plant ashes and soil extracts, contents equivalent to as low as 0.01 p.p.m. in the original material being determined. The problem of the availability of trace constituents in soils is being approached by the use of N/2 acetic acid extracts. This is being studied in conjunction with the amounts taken up by the plant. For practical considerations it is desirable to study these effects in hay and pasture, but this raises another problem, since the different constituents of the herbage have been found to have differing rates of uptake for different cations, and it is difficult to compare pastures from different soils as the botanical composition of the herbage varies. Other data suggest that the time of sampling and the amounts of the major plant foods present may affect the uptake of trace constituents.

This method has been used in the investigation of pastures and soils subjected to incremental dressings of cobalt, in connexion with studies on the relation of cobalt deficiency to the pining of stock and preliminary reports on part of this work have already been prepared (2,11,16). The inter-relation of the various trace constituents appears likely to provide interesting results.

Determinations have been continued of the trace element constituents of soils and pastures on which grass sickness in horses had occurred, with results which are so far inconclusive, as the variations in almost all the elements considered cover the range from high to low contents.

An extensive survey of the trace constituents in the

limestones of Scotland is being carried out by the semi-quantitative cathode layer method. This method, although not giving the precision of the method previously described, is rather more sensitive and is suitable for a rapid survey of most of the elements in a large number of samples. Apart from the usual constituents determined by chemical methods, varying contents of Co, Ni, Zr, V, Ga, Sr, Rb, B and others have been observed. The data so assembled should be of use in the selection of suitable liming materials for soils showing symptoms of deficiency diseases, as well as in determining the use of the limestone resources for other purposes. Determinations of the potassium and sodium contents have been made by the Lundegardh method, following a Lawrence Smith extraction, in the course of the chemical analyses of these limestones.

Some attention has been devoted to the colorimetric determination of copper in soils. The determination of copper appears to be very subject to errors due to contamination, as a result of the use of copper baths, etc. in the laboratory and, in the spectrographic method, the presence of variable traces of copper in the electrodes employed. A method for the determination of the total copper content of soils, involving sodium carbonate fusion and electrolyte separation of the copper, followed by colorimetric determination using sodium diethyl-dithiocarbamate, appears satisfactory. So far it has not been found possible to obtain at a reasonable cost electrodes sufficiently free from copper to enable determinations of low copper contents (below 100 p.p.m.) to be made accurately by a spectrographic method. A source of carbons suitable for most other elements has been found to take the place of electrodes previously purchased abroad.

The spectrograph can be applied quickly to the qualitative examination of many types of materials encountered in agricultural and soil investigations. Amongst materials tested during the year have been flue dusts (one of which was shown to contain a dangerously high content of manganese), sands for Mitscherlich pot tests, chemical precipitates (for purity or identification), minerals (one, of which less than 1 mg. was available, was shown to be a thorium silicate, the suspected presence of yttrium in addition not being substantiated) and a knife suspected of having been used to cut telephone wires.

A paper on the Ramage Flame Method for the analysis of solutions has been published (8).

SOIL MINERALOGY

The study of the mineralogical composition of the parent materials of the soils of Kincardineshire was completed and the results published (9). The parent materials are mainly glacial drifts and their distribution and the mineral composition of their fine sands are described. The drift in the northern part of the area was found to be derived mainly from acid igneous and schistose rocks and that in the southern part mainly from rocks of the Old Red Sandstone formation. Comparison is made with the composition of drifts similarly derived elsewhere in Scotland.

Investigations of the mineralogical composition of soils and their parent materials collected in the soil surveys being carried out in Aberdeenshire and Argyllshire were undertaken. These studies are made to assist in the classification of parent materials in the field studies of soils since most of the arable soils in Scotland are derived from drifts, both glacial and alluvial, and not directly from the solid rock. Typical samples from soil profiles on these drifts were selected and petrological examinations made of the fine sand fractions. Differences in composition were noted according to the underlying rock type but drifts formed from a variety of rock types were much in evidence. Several varieties of parent materials were distinguished by this means. The work is still in progress.

Soils derived from a group of basic igneous rocks in Aberdeenshire were investigated in detail. These soils exhibit unusual base exchange relationships. Layers from two soil profiles were examined and petrological studies of the sand fractions made, since this was apparently the seat of the exchange capacity. Separation of the individual minerals was carried out to obtain material for chemical analysis and the high base exchange capacity was found to be due to a mica. The optical characters of this mineral were determined. The investigation is still in progress.

STUDIES ON SOIL DRAINAGE WATER

The study of the drainage waters from the soil of the Craibstone lysimeters was continued during the year. The pasture remaining on the lysimeters was dug in during November 1940 and allowed to break down during the winter months.

At the end of April the soil was dug over again and 'Victory' oats sown at the rate of 5 bushels per acre, together with a manurial dressing of ¾ cwt. sulphate of ammonia, 2½ cwt. superphosphate and ½ cwt. muriate of potash per acre given to Nos. 2 and 3. No.1 received no manurial treatment. Owing to dry conditions during May the oats did not germinate and a further sowing was made at the end of the month. This also failed and, a third sowing at the end of June also proving unsatisfactory, rape was sown about the middle of July at the rate of 12 lbs. per acre. Germination was slow and, although growth on Nos.2 and 3 was quite satisfactory, that on No.1 was practically negligible. This crop of rape will not be taken off till towards the end of November.

Rainfall and Drainage: Rainfall during the winter months up to the end of February was very heavy, especially in November when practically 8 inches were recorded. Snowfall was abundant and snow lay to a considerable depth for long periods; on this melting, drainage came through freely, and from 64 to 92% of the precipitation appeared as drainage. Snow showers occurred during April and May, lying to about 3 inches for a day or two each month. In the summer months from 5 to 34% of the rainfall appeared as drainage, and rose to about 55% in the autumn. During the whole period from October to September 43.36 inches of rainfall, including snow, were recorded, of which from 61 to 68% appeared as drainage.

Colloidal Suspended Material: As before, this material appeared in the drainage waters irregularly and varied in amount from month to month. By far the greatest amount was removed during the winter months when abundant drainage flow followed upon comparatively little percolation. The rapid melting of the snow appeared to accelerate the liberation of this material. The greatest total amount was leached from No.1 and the least from No.3. By the end of May the drainage was free of colloidal material and nothing further appeared during the remainder of the year.

Soluble Constituents in the Drainage: Owing to an unexplained abnormal increase in the amount of total dissolved material in the drainage waters during the summer and autumn months, further analytical work is being carried out before final figures can be given.

TABLE IV

RAINFALL AND DRAINAGE
1st October 1940 to 30th September 1941.

	RAIN inches	DRAINAGE inches			DRAINAGE Per cent of rainfall		
		1	2	3	1	2	3
October	3.88	2.52	2.52	2.48	64.9	64.9	63.9
November	7.98	7.19	7.38	7.19	90.1	92.2	90.1
December	3.23	2.15	2.09	2.10	66.5	64.7	65.0
January	4.11	3.78	3.88	3.60	92.0	94.4	87.6
February	5.55	4.36	4.56	4.46	78.5	82.2	80.3
March	2.81	1.21	1.32	0.96	43.1	47.0	34.2
April	2.99	2.39	2.45	2.16	79.9	81.9	72.2
May	2.44	0.72	0.85	0.65	29.5	34.8	26.6
June	0.99	0.05	0.08	0.02	5.0	8.1	2.0
July	3.16	1.06	1.06	0.74	33.5	33.5	23.4
August	5.50	3.01	2.88	1.90	54.7	52.3	34.5
September	0.72	0.19	0.18	0.11	26.4	25.0	15.3
TOTAL	43.36	28.63	29.25	26.37	66.0	67.5	60.8

TABLE V

MATERIAL IN SUSPENSION IN THE DRAINAGE WATERS
Pounds per acre
1st October 1940 to 30th September 1941.

	Dried at 105°C			Loss on Ignition		
	1	2	3	1	2	3
October	49.84	13.49	14.04	5.16	1.45	1.19
November	90.84	41.62	31.21	9.74	4.52	3.74
December	22.16	11.24	13.93	2.49	1.28	1.61
January	22.45	11.44	14.81	3.41	1.67	2.11
February	5.71	6.30	5.97	0.97	0.92	1.01
March	1.67	1.80	1.39	0.35	0.35	0.33
April	1.41	1.78	1.85	0.22	0.22	0.24
May	0.68	0.66	1.14	0.15	0.15	0.20
TOTAL	194.76	88.33	84.34	22.49	10.56	10.43

PUBLICATIONS

Issued during the year:

1. "Liming and Manuring." By W.G.Ogg and A.B.Stewart. (Scot.J.Agric., 23, pp.145-156, 1941.)

2. "Pining in Sheep: its Control by Administration of Cobalt and Cobalt-rich Fertilizers." By J.Stewart (Animal Diseases Research Association), R.L.Mitchell and A.B.Stewart. (Emp.J.Expt.Agric., 9, 145-152, 1941.)

3. "Soil Properties in Relation to the Occurrence of Grass Sickness in Horses." By A.B.Stewart. (J. Agric.Sci., 31, 308-319, 1941.)

4. "Limestones of Scotland. Area IV. South-west Highlands and Islands." By J.G.C.Anderson (Geological Survey) and A.Muir. Geological Survey War-time Pamphlet No.13.

5. "Limestones of Scotland. Area V. Central Grampians." By J.G.C.Anderson (Geological Survey) and H.G.M. Hardie. Geological Survey War-time Pamphlet No.13.

6. "Limestones of Scotland. Area VI. Banffshire and North-east Grampians." By J.G.C.Anderson (Geological Survey) and A.Muir. Geological Survey War-time Pamphlet No.13.

7. "The Colorimetric Estimation of Iron with Sodium Salicylate." By R.O.Scott. (The Analyst, 66, 142-148, 1941.)

8. "The Spectrographic Analysis of Solutions by a Modified Ramage Flame Emission Method." By R.L. Mitchell. (J.Soc.Chem.Ind., 60, 95-98, 1941.)

9. "Soil Studies in Relation to Geology in an Area in N.E. Scotland. Part I. The Mineralogy of the Soil Parent Materials." By R.Hart. (J.Agric.Sci., 31, 438-447, 1941.)

In preparation:

10. "The Colorimetric Determination of Readily Soluble Phosphate in Soils." By E.G.Williams and A.B. Stewart. (To appear in J.Soc.Chem.Ind.)

11. "Pining in Sheep: II. Confirmatory Experiments in its Control by Cobalt-rich Fertilizers." By J.Stewart (Animal Diseases Research Association), R.L.Mitchell and A.B.Stewart. (To appear in Emp. J.Expt.Agric.)

12. "The Fractionation of the Organic Matter, including Nitrogen, of certain Soils and its Relation to their Quality." By M.R.F.Ashworth. (To appear in J.Agric.Sci.)

13. "Changes Occurring in the Organic Matter during the Decomposition of Compost Heaps." By M.R.F. Ashworth. (To appear in J.Agric.Sci.)

14. "Soil Studies in Relation to Geology in an Area in N.E. Scotland. Part II. The Soils and their Development." By R.Hart. (To appear in J.Agric. Sci.)

15. "Limestones of Scotland. Area III. East Central Scotland." By J.G.C.Anderson (Geological Survey) and H.G.M.Hardie. Geological Survey War-time Pamphlet No.13.

16. "Cobalt Manuring and Pining in Stock." By R.L. Mitchell, R.O.Scott, A.B.Stewart and J.Stewart (Animal Diseases Research Association). (To appear in "Nature".)