"SOIL STUDIES IN SOUTH AYRSHIRE"

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THESIS

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INTRODUCTION.

Man, being an omniverous creature, has always been dependent on the soil for the major portion of his diet. In consequence, a deep interest has been taken in the soil from the earliest days of civilization. This interest, until comparatively recently, has been taken wholly from the standpoint of practical agriculture. Descriptive terms such as Loamy, Marly, Chalky, Clayey, and Sandy have been applied to soils for many centuries and these were used in a number of the early surveys and attempts at soil classification. A survey on this basis was made in Ayrshire by Aiton (1) at the beginning of the nineteenth century. He prepared a soil map showing the division of the soils into clays, loams, sands and mosses as part of a report to the Board of Agriculture on the agriculture of Ayrshire.

The early surveys were mainly of a utilitarian character carried out in the simple hope and faith that the chemist would be able to classify the samples and from his laboratory investigations advise suitable manures, predict suitable crops and explain the best methods of cultivation.

The need for a suitable system of classification was obvious and attempts have been made to classify soils on the basis of geology, agriculture, natural vegetation, mineral composition, chemical composition, climate, colour, and texture. The geological classification is found to provide too broad a basis, and it has been shown by the Russian school, that, in a mature soil, parent material is of subordinate importance. The agricultural classification breaks down since the type of farming is not wholly determined by the soil, but largely by local economic conditions. Natural vegetation is determined very largely by climate and situation. Chemical composition as a basis is unsound since at present there are no satisfactory methods of analysis to enable us to correlate fertility with chemical composition. Any results of satisfactory analytical methods are only suitable for very local application. Climatic classification has proved suitable in Russia where it was developed, but in a country such as this, where the soils are still 'young' in a geological sense, the parent material still shows its influence. Although colour is an important property, it is not intimately connected with any important soil characteristic. The texture basis is the oldest and is still recognised to be of great value in a local survey, although it is a subordinate feature when soils are to be viewed in a broad way. Generally speaking, in South Ayrshire the system of farming and rotation depend on the texture of the soil. On the heavier land there may be ten years of grass in the rotation while on the lighter land there may be only two or three years of grass.

The fault with each of these systems is that a single criterion is used, whereas the complete soil is the product of a large number of factors. Shaw (7) expresses the evolution of the soil by means of the formula (which is not to be interpreted as an equation)

$$S = M\ (C+V)\ T+D$$

where S is the soil formed from the parent material M by climatic factors C and organic life V acting through a period of time T and modified by erosion or deposition D. Each of these is important in determining the character of the soil though under certain conditions any one might become dominant. All of these must be considered in the ideal classification. This classification must have a place for every soil encountered in the field. It must be capable of expansion to include every local variation and of contraction when it is desired to take a broad view of the soil for comparison with the soils of other parts of the world. A scheme to fulfil these conditions has been suggested by Marbut (2). We are indebted to the Russian school of soil scientists, notably Docuchaiev and Sibirtzev for emphasising that all the processes contributing to soil formation must be considered and to Glinka (3) for pointing out that these processes are expressed in the 'soil profile'. For the development of Glinka's theories, we owe much to Ramann (4) in Germany, to Hilgard (5) in U.S.A., and to Professor G. W. Robinson (6) in this country.

Glinka (3) defines the 'soil profile' as "the general appearance of the vertical section of a soil showing the morphologically different horizons. The profile of a soil represents an expression of those complex and refined chemical and biological processes through which soils are formed". The soil profile then, is the fundamental unit of study of the soil as it considers the soil as a whole.

Development of the Soil Profile.

Under cool, humid conditions, vegetation decomposes with the formation of organic acids which exert a solvent action on the mineral portion of the soil. Compounds of iron and aluminium are most readily attacked and may be removed as colloidal compounds in the sol condition. They may be carried down with the soil water to lower levels accompanied by colloidal humus and colloidal clay. For various reasons these colloidal solutions may be precipitated and the constituents deposited in more or less well defined layers thus bringing about changes in the colour and the texture of the profile. Loss of iron compounds causes a lightening of colour; accumulation of iron compounds gives rise to red or brown colours. For convenience, a system of nomenclature has been adopted in profile description. Briefly, it is this:- Layers of soil from which compounds have been leached are called "A" horizons or eluviated horizons. These are sub-divided into A_0 the surface horizon, consisting of litter, turf, or vegetation, followed in a downward direction by A_1, A_2 and as many as may be identified. Layers of soil at which compounds have been deposited are called "B" horizons or illuvial horizons. These are also sub-divided and are designated as B_1, B_2, etc. The unaltered parent material is referred to as "C". This may be rock as in the case of a sedentary soil, or alluvium or boulder clay as in the case of a transported soil. The depth at which this occurs depends on its nature and age. In Great Britain, the parent material generally occurs less than four feet from the surface (8). It is not necessarily unweathered since it may have been subject to a previous weathering. Soils may be derived from a non-uniform parent material. This may occur in the case or redeposited materials such as alluvium and boulder clay.

Studies of soil profiles have been made in this country by G. W. Robinson (9) in N. Wales, W. G. Ogg (38) in E. and N.E. Scotland, and by A. B. Stewart (10) in Aberdeenshire and W. Morley Davies (36) in W. Midlands, and all have furnished much analytical data of great value. L. L. Lee (11), S. G. Brade-Birks and B. S. Furneaux (12) have published work on profiles in Kent and the south eastern counties of England which is largely qualitative and descriptive and in consequence of little use for correlative purposes.

Laboratory investigations are made to determine the genetic relationships of soils. Since the weathering processes affect only a small portion of the soil, it is plain that if changes in composition are to be found by analysis, the data for the complete soil will signify but little, owing to the large bulk of silica and unweathered material. On the other hand, while the analysis of a strong hydrochloric acid extract of the soil gives an indication of the weathered and easily weatherable portion, the results so obtained are purely empirical. Robinson (9) reasons, that as weathering products are moved in the soil mainly in the colloidal form, and, as the colloidal complex is removed in mechanical analysis in the clay fraction, that analysis of this fraction is of the very highest value.

SOIL SURVEY IN SOUTH AYRSHIRE.

An opportunity to study the soils of S. Ayrshire was offered in the form of a soil survey. The object of the survey was to give an account of the soils and agriculture of the area for inclusion the Geological Survey Memoir, "The Geology of South Ayrshire". The survey was carried out under the direction of Professor D. N. McArthur of the West of Scotland Agricultural College where the laboratory investigations were made.

Previous work in the area.

A very rough texture survey was made by Aiton (1) and the results published in 1811. His remarks were not encouraging, for he says of the soils " - transitions from clay to loam, sand or moss are so frequent that it becomes extremely difficult to give, either in map or in writing, anything like a correct account of these diversities of soil".

The only other soil work undertaken was on isolated samples received in connection with the advisory scheme of the college.

Line of study.

It was decided to classify the soils on the basis of texture so that the survey would be of definite local importance, and to examine profiles so that these soils might be fitted into an appropriate place in a wide system of classification.

The value of quantitative rather than qualitative description was recognised, and samples for subsequent analysis were taken at frequent intervals. This resulted in great masses of data from field and laboratory which were compared to find in how far the qualitative and quantitative descriptions of the soils were in agreement.

The profiles have been thoroughly investigated in the laboratory in order to throw light on fundamental characters of these soils.

Conventional or empirical methods of analysis have been used as little as possible.

The following analyses were made by methods described under Laboratory Methods at a later stage.

1. Mechanical analysis.
2. Moisture.
3. Loss on ignition.
4. Loss on treatment with H_2O_2.
5. pH water.
6. pH $CaCl_2$.
7. "Lime requirement".
8. Colour - natural and mineral.

Two of the profiles have been further investigated in respect of exchangeable bases, saturation capacity, and composition of the clay fraction.

Field evidence was not such as to justify the determination of organic carbon and organic nitrogen. This was confirmed by the low figures for loss on ignition and loss on treatment with hydrogen peroxide in all but the top horizon of each profile, indicating moderate organic matter content at the surface and no accumulation below.

General description of the area.

The area chosen for special study is a strip approximately 5½ miles wide by 17 miles long, extending from Monkton and Ayr in the West to Sorn and Cumnock in the East. The area is devoted mainly to dairy farming. Sheep are reared on the high ground to the east, while a narrow belt near the coast is cropped. This belt of soil about 1½ miles wide runs from Auchincruive by Prestwick and Monkton to Shewalton Moss and ranks among the finest in Scotland. The names of towns and farms may be significant. The writer has noticed on many occasions that where names pertaining to the Church are in evidence, the soil in the vicinity is better than the average. There are many such names in this district:- Monkton, Prestwick, Kirkhill, St. Quivox. This may be due to discerning monks having settled and chosen the best or to the fact that they were good farmers, worked the land intelligently, resulting in a legacy of fertile soils.

The natural vegetation was probably deciduous forest which, according to Aiton (1), was cut by the

Romans, possibly as a precautionary measure. Later, he says, owing to tree stumps left, 'moss earth' overgrew the countryside. This was gradually reclaimed but tree remains are still to be found in the remaining mosses. The land, however, has been cultivated for many centuries and the trees now existing have probably been planted for shelter or for ornamental purposes.

Climate.

The climate is of the moist, humid type with the prevailing wind from the south west. The annual rainfall varies from 36" in the neighbourhood of Ayr to 45" to 50" on the high land in the vicinity of Catrine. Normally, this rainfall is spread over 217 days in the year. The nearest station publishing full details of the weather is situated at Kay Park, Kilmarnock, in the Irvine valley which is decidedly more humid than the area under investigation. Complete records have been kept at Auchincruive only since January, 1932. Previous to this date, only rainfall was recorded. The following figures are for the year 1932. The mean annual temperature was 47.6°F. which is almost identical with that of Rothamsted 47.8°F. The average humidity was 78.6%. An expression for humidity which may indicate the amount of leaching taking place is R. Meyer's N-S quotient (13). This is equal to R ÷ T x (100-H)/100 where

R - rainfall in mm.

T - tension of aqueous vapour at the mean temperature of the locality.

H - average humidity.

Although expressing all the climatic factors, the figure has no physical meaning and is high where temperature is low.

Substituting, we have the N-S quotient for Auchincruive represented by the figure 502, denoting a very humid climate. Comparison with other localities is shown by the following table:-

Rothamsted	Wye	Long Ashton Bristol
433	457	573
Aber Bangor	Kay Park Kilmarnock	Auchincruive
636	710	502

Lang (14) has classified climates according to "Rain

Factor" i.e. rainfall in mm. divided by mean annual temperature in °C giving for Kay Park 121, Auchincruive 104, Bangor 100. He gives the following limits for the principal soil groups:-

Peat soils	> 160
Black earths	160-100
Brown earths	100-60
Yellow earths, red earths, laterites	60-40
Saline soils	< 40

The winters are mild, the mean winter temperature being about 38°F. and prolonged spells of frost are rare. The lowest monthly average temperature of the soil at 1 ft. from the surface is 39.9°F. while at 4 ft. the lowest figure is 43°F. The soil, therefore, is never frozen and leaching can proceed throughout the year.

Under such conditions we should expect the soils to be free of the soluble products of weathering, i.e. to be of the podsolic type belonging to the pedalferic group in Marbut's classification.

Topography and Geology.

Most of the area under investigation lies less than 250 ft. above sea level. The surface is flat near the coast and rises gently to the east in a rolling, swelling fashion, typical of glaciated country.

Much of the area is covered by drift consisting in the main of boulder clay, sometimes to a very great thickness. The district has been subject to severe glaciation and there is evidence of this having taken place from the north west, the north north east and the south (15). The unaltered boulder clay is a very stiff, compact material, but does not show a high clay content on analysis.

There are raised beaches near the coast which give rise to soils of great agricultural importance. On the coast there are blown sands which make excellent golf courses.

There is much freshwater alluvium along the course of the River Ayr and on many farms inland the 'holms' are the only parts capable of being cropped successfully.

There are large areas of peat on the high ground to the east growing heather or rough grass. There are also isolated patches of peat, usually in small hollows.

The coal measures of the Ayrshire coalfield extend from Ayr to Monkton, Annbank, Auchincruive, Tarbolton and Stair. These are often associated with red sandstones. Red sandstones of Permian age occur in the Mauchline basin, and are quarried at Mauchline. There are numerous dolerite dykes and sills and the coal measures near Auchincruive are covered with dolerite. There are outcrops of volcanic rocks here and there, notably in the vicinity of Tarbolton.

FIELD METHODS.

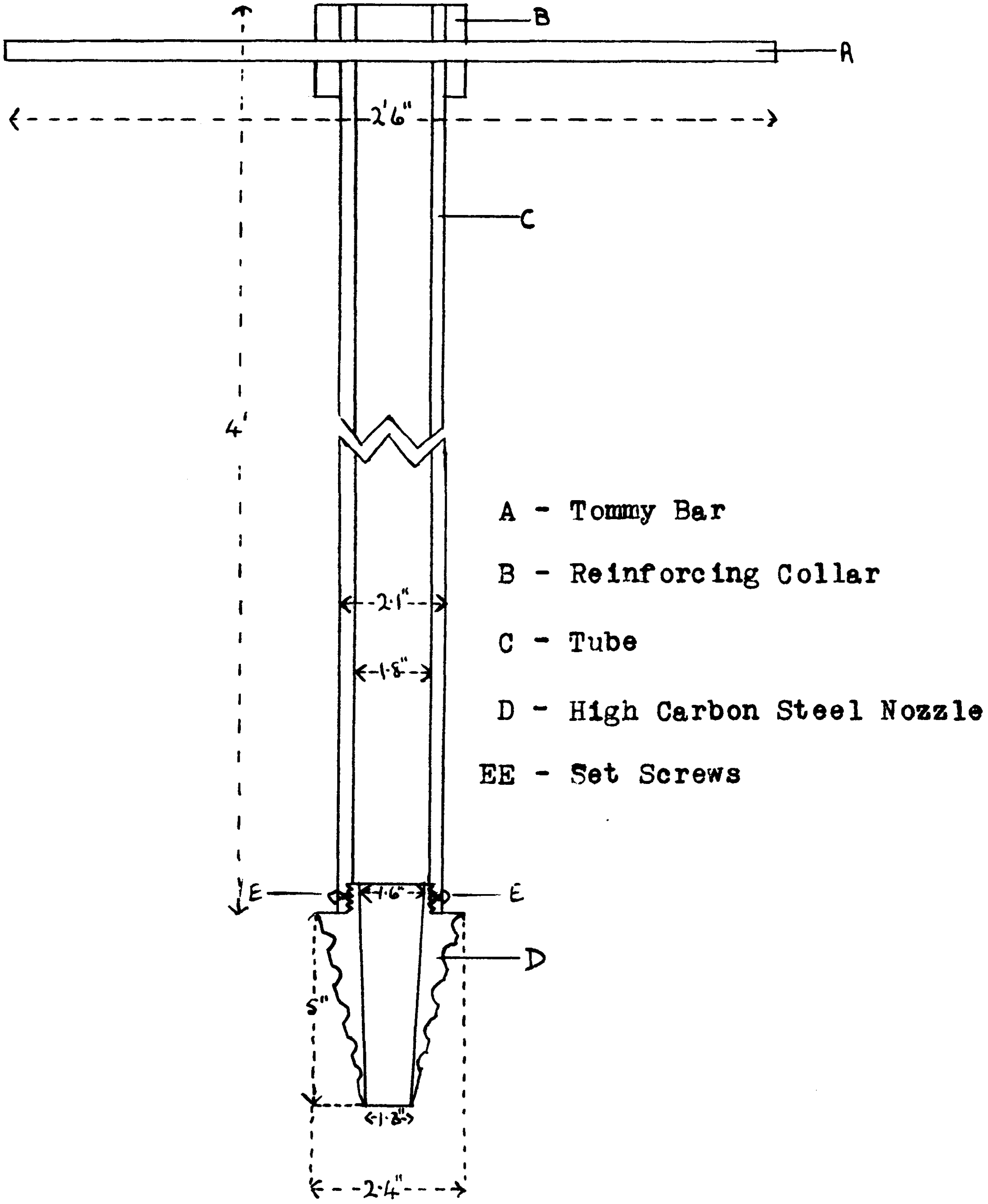
The procedure in the field was similar to that in the survey of Sheet 22 (15). Information was asked of the farmer on the following points:- acreage, rental, stock carried, drainage, use of lime and manures, crops, rotation and particulars of the soils on his farm. Six inch Ordnance Survey Maps were used and approximate soil boundaries were marked at the time of examination.

A 36" steel auger was used for the examination of the soil. This was used in preference to the split cylinder which is more difficult to manipulate. The latter instrument clogs up readily, the spit is difficult to remove, there is no 'downpull' as in the case of the auger and cannot be conveniently worked singlehanded.

The auger screw was 6" long and in practice the instrument was screwed down to this depth, withdrawn, and the trapped soil examined in the hand. This was repeated until the maximum depth of 36" was reached. Note was taken of colour, texture, mottling, 'stoneyness', moisture and reaction to B.D.H. soil indicator. Texture was examined by crumbling the soil in the hand and rubbing between the fingers, the degree of coherence or friability, determining the texture description. Changes in texture can be readily detected by this hand examination. The auger is readily stopped by stones so that examination to the full depth was not always possible. The soil texture, after being assessed by hand examination, was described on the map by an appropriate symbol and also by a serial number when a sample was taken. The symbol was entered with reference to the surface soil only. The other particulars, i.e. changes in texture and colour, depths at which such changes occurred, mottling, etc. were noted as a rough description of the soil profile, to be used later in the preparation of a preliminary profile map.

Frequent samples of soil and subsoil were taken in order to check the field observations. Where suitable exposures were found, e.g. in quarries, deep drains, cuttings, etc., profiles were examined and samples taken. No attempt was made to sample the

DIAGRAM 1. PROFILE SAMPLER IN CROSS SECTION.



A - Tommy Bar

B - Reinforcing Collar

C - Tube

D - High Carbon Steel Nozzle

EE - Set Screws

profile using the auger for the following reasons:- (a) that screwing distorts the column examined, (b) that it is impossible to eliminate mixing, (c) that thin or ill-defined horizons may be overlooked, (d) that the root system cannot be examined, (e) no true picture of the moisture conditions can be obtained.

The Profile Sampler.

Owing to a time limit being placed on the field work, it was out of the question to examine profiles by digging pits. There were but few suitable exposures in the area. An instrument was designed with a view to examining profiles rapidly, conveniently and accurately.

This consists of a 4' length of steam tubing (i.e. heavy gauge tubing) reinforced at one end by shrinking on a steel collar. The other end is screwed internally to take a high-carbon-steel nozzle as shown in diagram (1) opposite. The cutting edge of the nozzle is its narrowest part. Internally, it tapers out so that the core or monolith may pass easily up into the tube. Externally, it tapers out to a diameter somewhat greater than that of the tube. The outer surface is screwed deeply to give a 'downpull' effect similar to that of the auger. The larger hole made by the nozzle should minimise the friction of the soil on the outside of the tube. The instrument may be inserted in the soil by turning with a long tommy-bar, or by hammering.

In practice, the presence of pebbles was found to render the use of the instrument very difficult so that it is only of service where the soils are fairly free from stones. The core passes up the inside as the sampler is lowered and this can be tipped out into a split tube and the usual examination made. In its present state the instrument gives a core which is somewhat compacted but it is hoped that by experimenting with various designs of nozzle that this fault may be overcome.

LABORATORY METHODS.

Each soil sample was spread out, air dried, and pounded in a wooden mortar with a wooden pestle. This treatment breaks down lumps and there is but little grinding of the particles. The soil was next passed through the 2 mm. (round holes) sieve. This "air dry fine earth" was used for the mechanical analysis (16).

Abbreviated Mechanical Analysis.

This was carried out on all the routine samples, and the soils were classified on the basis of their mechanical analyses (17).

20 grams of soil were weighed out and thoroughly triturated with 1 per cent. ammonia using a rubber pestle. The mixture was poured through a 100 mesh sieve and washed clean with 1 per cent. ammonia. The 'coarse fraction' retained on the sieve was dried in the oven at 105°C. and weighed. The liquid passing the sieve was collected in a soil beaker and was made up to a mark at 10 cms. The contents were stirred and poured off after a

sedimentation period of 4 min. 48 sec. The residue in the beaker was triturated with 1 per cent. ammonia and made up to the 10 cm. mark. The operation was repeated until the supernatant liquid was clear at the end of the prescribed settling period. The residue in the beaker was dried at 105°C. and weighed as 'medium fraction'. The pourings, consisting of the fine particles in suspension, were collected, acidified with hydrochloric acid and allowed to stand overnight. This treatment flocculates the suspended material which was collected by syphoning off the supernatant liquid and filtering the sediment. This was dried at 105°C. and weighed as 'fine fraction'.

Moisture.

10 gms. of air dry soil were placed in the air oven at 105°C. for 24 hours and weighed. The loss in weight represents hygroscopic moisture.

Loss on Ignition.

The residue from the moisture determination was ignited in an electric muffle furnace and weighed.

The loss in weight represents organic matter and water of constitution.

Full Mechanical Analysis.

This was carried out on the samples from the profiles examined. The revised official method (16) was used with a modification of the pre-treatment of the sample. It was not deemed expedient to carry out the dispersion of the soil with hydrogen peroxide followed by N/5 hydrochloric acid as there is a considerable loss by solution, and it was desired to preserve the clay fraction for full analysis. A 20 gm. sample was triturated and washed through the 70 mesh sieve (.2 mm.) with 1 per cent. ammonia into a 1,000 cc. shaking bottle. This was shaken in an end-over-end shaker for 48 hours at 40 revolutions per minute. The 'coarse sand' remaining on the sieve was dried at 105°C. and weighed, then ignited and weighed. The 'fine sand', 'silt', and 'clay' were separated by sedimentation. The contents of the shaking bottle were transferred to a soil beaker, made up to the 10 cm. mark with 1 per cent.

ammonia, and poured off at intervals of 8 hours until clear after standing for this period. The clay was removed in this way and the combined pourings were evaporated in order to prevent any change in composition. The silt and fine sand remaining in the beaker were separated by making up to the 10 cm. mark with water and allowing a settling period of 4 min. 48 sec. All fractions were weighed, dried at 105°C., and ignited. Sixty-six samples were analysed by this method. Several were repeated with the official pre-treatment and pipette methods of sampling in order to compare results. It was not anticipated that there would be any serious divergence between the two sets of results since the soils are carbonate free and organic matter is low. There was very good agreement in the coarse and fine sand fractions by both methods. As was anticipated, the replacement of the revised official pre-treatment caused a slight drop in the clay figures with a corresponding increase in the silt figures. These differences usually amounted to 2 - 3 per cent. of the total soil. This difference indicates that the soil aggregates have been incompletely dispersed by the method of pre-treatment used here.

Other workers on the composition of clay have used slightly different fractions:- Hendrick and Ogg (35) used the clay obtained by the "1906 method". W. O. Robinson and Holmes analysed the "colloidal" clay, while G. W. Robinson uses clay obtained by allowing a settling period of 24 hours after dispersion with sodium hydroxide.

Soil Reaction. pH (Water).

As field tests using the B. D. H. soil indicator had shown that all the soils encountered in the area were acid, and as manganese is absent, it was convenient to determine the pH of the soil using the quinhydrone electrode (18). The soil water ratio used was 1 : 5 as recommended by Crowther (19). Air dry samples were used so as to secure comparable conditions throughout. This was done since the pH value of the soil is somewhat reduced by air drying and it was not convenient to determine pH values immediately after sampling.

Determination of 'Lime Requirement'.

'Lime Requirement' was determined by the electrometric method of Hardy and Lewis (20). 10 gms. of soil are shaken with 40 ccs. of neutral .2 molar calcium chloride solution and the pH determined using the quinhydrone electrode. .03N. lime water is added in 5 cc. quantities and the pH determined again. This operation is repeated until the pH value reaches 7 or over. A titration curve is drawn and interpolated at pH 7. The 'Lime Requirement' is calculated from this figure.

The exchangeable hydrogen in the soil complex is displaced by the large excess of calcium ions added and presumably forms free hydrochloric acid which is titrated with the standard lime water.

The method is rapid and convenient and while the results are valuable for comparative purposes, they are empirical and should be interpreted in the light of field experiments. Crowther (19) has shown, and it has been confirmed in this area (42), that lime added in accordance with this 'requirement' does not raise the pH of the soil to 7. pH 7 is, however, only the theoretical point where there is no longer an acid reaction. The soil shows no sudden change in properties when this condition is produced.

Many of the most fertile soils in this area are acid, with pH values ranging from 5.0 to 6.0. It is doubtful whether in south Ayrshire, the return for applying lime to give pH7 would be commensurate with the outlay. Indeed, there is some evidence that the disease Grey Leaf Spot in oats may be caused by an excess of lime interfering with the uptake of manganese by the plant. This question is being investigated at present in a series of pot experiments. Where drainage is not a limiting factor, lime applied at the rate of this 'requirement' should be sufficient to counteract 'sourness', provide sufficient calcium to supply the needs of the plant and to keep the soil in a satisfactory physical condition by the flocculating of the clay.

The method gives a figure which may be taken to represent the 'saturation deficit' of the soil, and has been used as such to show the percentage saturation of the horizons in profiles 6 and 10.

Soils with over 10% loss on ignition, i.e. indicating a high organic matter content, were found to be very highly buffered, resulting in very high figures for 'lime requirement'.

Loss by Treatment with Hydrogen Peroxide.

20 gms. of soil were treated with 60 ccs. of 6% (20 vol.) hydrogen peroxide and warmed on the water bath. When frothing had ceased, more peroxide was added until there was no further action. The residue was filtered, washed, dried at 105°C. and weighed. The loss in weight was corrected for hygroscopic moisture. Part of the organic matter of the soil is oxidised by the peroxide and is removed as carbon dioxide and as soluble organic compounds. According to Robinson and Jones (21), this loss should give an index of the humified organic matter, although the

suggestion is severely criticised by McLean (22). A small amount of the mineral matter, principally sesquioxides, is also dissolved out.

THE DETERMINATION OF EXCHANGEABLE BASES.

The acetic acid extraction method of Rice Williams (23 and 24) was used to determine total bases, calcium and magnesium, in the horizons of profiles 6 and 10, all being carbonate free.

Total Bases.

25 gms. of soil passing the 1 mm. sieve were placed in a beaker with 200 ccs. of .5N acetic acid, stirred several times and allowed to stand at least two hours. The supernatant liquid was poured on a filter and collected in a 1,000 cc. graduated flask. The soil was then washed on to the filter with .5N acetic acid and leached using approximately 7 ccs. at a time, till 1,000 ccs. of filtrate were collected. This was evaporated to dryness in a large porcelain basin during the first stages, and transferred later

to a 9 cm. basin. When the evaporation was completed, the basin was placed in the steam oven for a short time and ignited at dull red heat in the electric muffle for five minutes. On cooling, 20 ccs. of .2N hydrochloric acid were added, rubbed well with a 'policeman', covered with a clock glass and allowed to stand overnight. The contents were filtered and washed well with boiled distilled water. The excess acid was determined by back titration with carbonate free .2N caustic soda using phenolphthalein as indicator, the titration being carried till the pink colour persisted for ten seconds.

Leaching with acetic acid presumably brings into solution all the exchangeable bases as acetates, and by ignition oxides and carbonates of the alkaline earths and alkalies are formed which should be quantitatively soluble in hydrochloric acid. Sesquioxides are also dissolved. They are not rendered completely insoluble by the ignition and some acid is used in dissolving them. Owing to the hydrolysis of iron and aluminium chlorides, this acid can be titrated when phenolphthalein is used as indicator.

Exchangeable Calcium.

25 gms. of soil were treated as for total bases, and 1,000 ccs. of leachate collected. 500 ccs. were taken and the calcium precipitated as the oxalate, by adding 5 ccs. .88 ammonia, 10 gms. ammonium chloride and excess saturated ammonium oxalate solution. This was boiled and allowed to stand overnight. The precipitate was filtered, washed with water and the calcium determined by dissolving in dilute sulphuric acid and titrating with decinormal potassium permanganate solution.

Exchangeable Magnesium.

The filtrate from the above was made alkaline with ammonia, and sesquioxides precipitated and removed. The magnesium was precipitated with sodium phosphate, allowed to stand 24 hours, filtered, washed and dissolved in dilute nitric acid. It was then reprecipitated with sodium phosphate. The precipitates from all the horizons were too small to be weighed with any degree of accuracy, weighing as they did, in the neighbourhood of .015 gm.

It is intended to investigate the possibility of estimating the magnesium by estimating the phosphate in the magnesium ammonium phosphate precipitate. Phosphate can be estimated colorimetrically in minute quantities, (25) by the blue colour produced on reduction of an acid phospho-molybdate solution.

FUSION ANALYSIS.

Fusion analyses were made on the clay fractions in each horizon of profiles 6 and 10. The methods of Hillebrand (26) and Clowes and Coleman (27) were adopted.

The clay in each case was ignited and ground to pass the 100 mesh sieve. 1 gm. was fused with 5 gms. fusion mixture (50% A.R. Sodium carbonate + 50% A.R. potassium carbonate). The melt was dissolved up in hydrochloric acid, taken to dryness on the water bath, and baked at 120°C. in the air oven for two hours. This operation was repeated in order to render the silica completely insoluble. The mass was extracted with concentrated hydrochloric acid and then with boiling water. The silica was filtered off, dried and ignited. The filtrate was collected in a litre flask and made up to the mark and the other constituents estimated in suitable aliquots.

Determination of Iron.

100 ccs. were made alkaline with ammonia. The precipitate was filtered, washed and dissolved in dilute sulphuric acid. The solution was passed through the Jones' reductor and titrated with decinormal potassium permanganate solution. No correction was made for titanium as qualitative examination proved that it was present in extremely small quantity.

Determination of Sesquioxides.

Sesquioxides were precipitated from a 250 cc. aliquot by ammonia. The precipitates were ignited at dull red heat and were corrected for phosphate.

Determination of Phosphorus.

Phosphorus was precipitated in a 100 cc. aliquot as ammonium phosphomolybdate. The precipitate was dissolved in excess carbonate free caustic soda solution and back titrated with standard hydrochloric acid using phenolphthalein as indicator.

Determination of calcium.

The filtrate from the sesquioxide determination was used and calcium was precipitated as the oxalate. The precipitate was allowed to stand overnight, filtered, taken up in dilute sulphuric acid and the calcium determined by titration with decinormal potassium permanganate solution.

Determination of Magnesium.

Magnesium was precipitated in the filtrate from the calcium estimation by sodium phosphate and ignited and weighed as $Mg_2P_2O_7$.

Determination of Aluminium.

Aluminium was determined by difference.

SOIL COLOUR ANALYSIS.

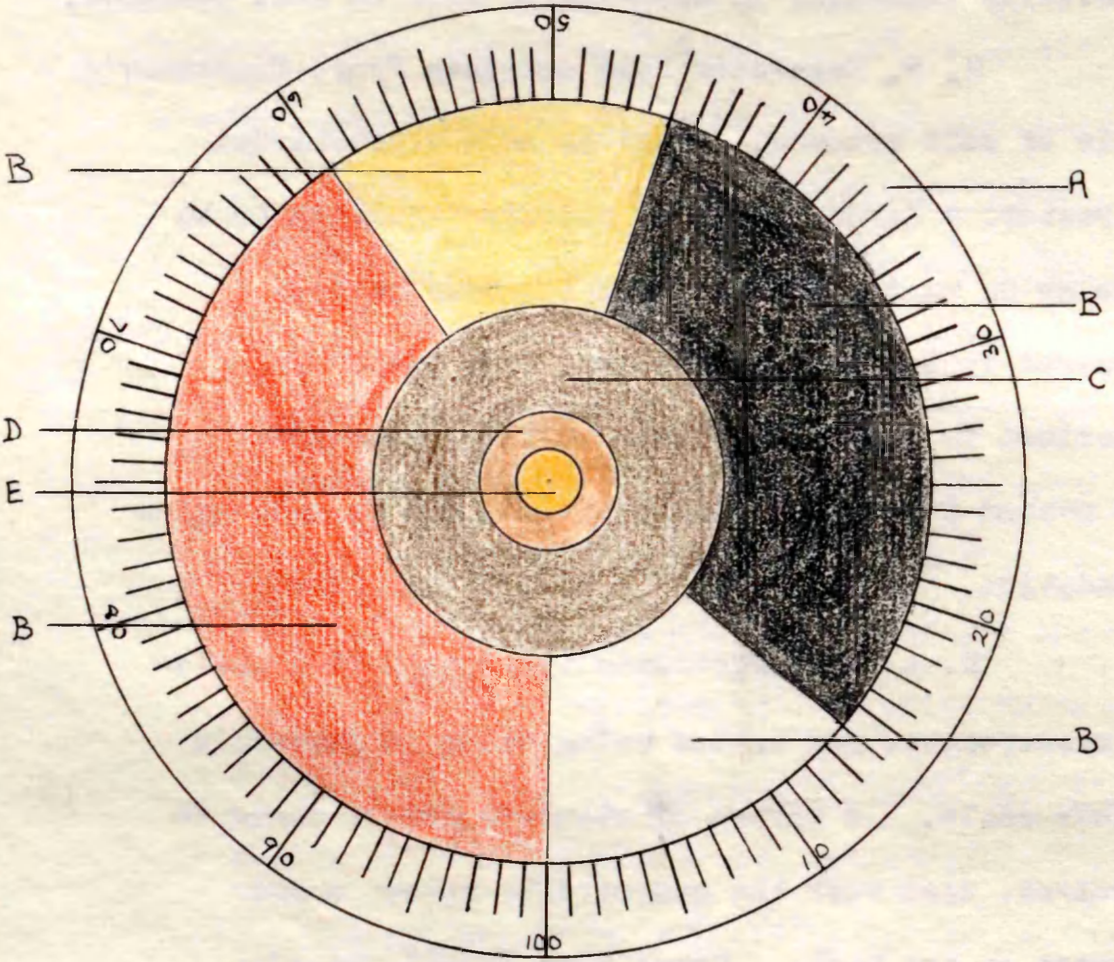
Hutton (28) and other workers (29, 30, 31) have stressed the importance of the accurate expression of soil colour. Some system of colour measurement is especially important in descriptive work on soil profiles.

S. F. Negovelov (30) outlines Prof. Tiuremnov's scale of soil colours. This is of a conventional character, a large number of colours requiring to be made up by mixing barium chromate, iron oxides, powdered chalk, and lamp black. The colour is described in milliequivalents of these compounds. The method is a very lengthy one and has no scientific foundation.

N. A. Archangelskaia (32) suggests a system of measurement, her method being based on Ostwald's colour scale. A series of standard colour cards is required, each with the appropriate colour number stamped on the back. These give "tone", leaving black and white to be "judged". The method appeared to be somewhat tedious and costly, so an apparatus was devised as suggested by Hutton (28) with the improvement suggested by Shaw (33).

DIAGRAM 2

PLAN OF COLOUR MEASURING APPARATUS(not to scale).



A- Scale (graduated to read % colour)

B- Colour Discs.

C- Soil Colour Disc.

D- Fibre Washer for clamping Discs.

E- Knurled Screw for tightening Clamp.

This consists of four discs (12.5 cm. in diameter) black, white, yellow, and red, which are slit along a radius, and mounted concentrically, on the shaft of an electric motor. The discs can be adjusted to give segments of varying proportions of each of the four colours as shown in the diagram opposite. When the motor is speeded up to 1,500 - 2,000 r.p.m. the blending of optical sensations gives the impression of a single colour. Practically all soil colours may be reproduced by varying the segments. It is not possible to obtain the same colour by more than one setting of the discs. A scale is attached, and the percentage of each colour may be read off direct. At the time this work was carried out it was not possible to obtain a set of discs similar to Hutton's, although these are now available from "Universal Color Standards", Baltimore, U.S.A. British Colour Printers' standard inks were kindly supplied by Messrs. Mander Brothers of Wolverhampton for the preparation of the red and yellow discs. These colours are of definite wave length and are reproducible.

It was desirable to prepare records of the colour of each sample, in its natural state and also after treatment with hydrogen peroxide. Whittles (34) suggests a method, but this entails treatment with celluloid varnish which was found to darken the colour of the soil to approximately that of the moist sample. This gives a permanent record. It was desirable also to measure the colour of each sample before and after the treatment with hydrogen peroxide.

The soil colour disc was made up on Whatman's No. 5 filter paper 5.5 cm. in diameter. The filter paper, with the soil sample number stamped on the underside, was placed in a Buchner funnel. A small quantity of a water suspension of the soil was poured on, and sucked dry. A very thin even covering was essential, a thick layer giving trouble through curling and cracking on drying. When quite dry, the disc was pressed flat between layers of blotting paper. This gives the air dry soil colour and eliminates the effect of moisture on the soil colour. Thin glue and celluloid cement were tried in turn to act as adhesives, but were found to darken the disk considerably. It was then observed that unless fractions 3 and 4 were very low, the disc, even without adhesive, could stand a fair amount of handling, and could be used as a permanent colour record if carefully stored. A hole was punched and the disc mounted above the standard discs as shown in the diagram. When the motor is speeded up, two coloured rings are produced. The segments are set to produce a colour identical with that of the soil disc, i.e. the inner ring. This is done by trial and error.

Colour discs were prepared of the 66 samples of the 10 profiles examined. Natural and mineral colours were analysed and the results are presented in tables.

The apparatus is cheap to prepare, rapid and sensitive in use, and the results are reproducible in any part of the world by any worker using similar standard discs.

A true expression of the colour is not obtained where mottling or staining occurs in the natural soil. Mottling is caused when drainage conditions are restricted or impeded due to impervious layers or to the existence of a high water table. When a mottled horizon is sampled, the soil is thoroughly mixed in its preparation for analysis and the results for colour are at this stage of doubtful value for diagnosis. In a case such as this the qualitative expression must be used. Mottling occurred in some of the profiles examined but it was slight and the samples were treated as the others.

CORRELATION OF TEXTURE CLASSIFICATION BY HAND EXAMINATION AND MECHANICAL ANALYSIS.

It was noticed that the texture assigned to a soil in the field at the time of sampling did not always agree with that assigned from its mechanical analysis. Discrepancies occurred too frequently to be accounted for by accident or by error of judgement and it was decided to make investigation. The divergence was most noticeable where soil and subsoil were sampled. In nearly every case the subsoil was described as belonging to a heavier class than the soil yet the analyses showed but little difference.

693 soils were sampled and described in the field in a long series. Later, these were classified from the field notes. The texture was also determined by an abbreviated mechanical analysis of each sample. The results are presented in table (1) which is condensed in table (2).

409 soils were sampled and classified direct

in the field. Texture was determined by abbreviated mechanical analysis and the amount of correlation is shown in table (3).

Texture from analytical data is arranged horizontally and from field observations, vertically. e.g. Table 2 - Of 28 soils described as Sb, mechanical analysis showed 1 to be an Sa, 16 to be Sb, 10 to be La and 1 to be Peat.

TABLE 1.

Texture classification Field V. Laboratory.

		Sa	Sb	La	Lm	Lb	C	Peat
Sa	lS							
Sb	hS		1					
	lL		2					
	l-mL		1					1
	l-mL	1	12	10				
La	mL	1	20	42	3			1
	m-hL	1	18	93	20			
	m-hL		2	93	42			
Lm	hL		1	47	58	2		
	h-cL			21	27	3		
	h-cL			8	29	7	1	
Lb	cL			2	21	14		
	cL-C				1		1	
C	cL-C						3	
	C						3	
Pt	PtyL							15
	Peat							26

TABLE 2.

Texture classification Field V. Laboratory.

	Sa	Sb	La	Lm	Lb	C	Peat
Sa							
Sb	1	16	10				1
La	2	40	228	65			1
Lm			76	114	12	1	
Lb			2	22	14	1	
C						6	
Peat							41

	% Lighter	% in agreement	% Heavier
Sa			
Sb	3.4	57.2	38.4
La	12.6	67.8	19.6
Lm	37.4	56.2	6.4
Lb	61.5	35.9	2.6
C		100	
Peat		100	
Total	21.9	64.2	13.9

TABLE 3.

Texture classification Field V. Laboratory.

	Sa	Sb	La	Lm	Lb	C	Peat
Sa							
Sb							
La		4	11	1			
Lm		6	39	49	20	6	58
Lb			4	18	13	7	9
C							
Peat							176

	% Lighter	% in agreement	% Heavier
Sa			
Sb			
La	25.0	68.7	6.3
Lm	37.5	40.8	21.7
Lb	52.4	31.0	16.6
C			
Peat		100	
Total (excl.Pt.)	38.8	42.1	19.1

It may be well to discuss the mechanical composition of the soil at this stage. Physically, soil is a heterogenous mass of mineral particles with a certain amount of organic matter, moisture, and air. The soil, after preparation for mechanical analysis, has been passed through the 2 mm. sieve. This "Air dry fine earth" consists of particles ranging from 2 mm. in diameter down to the very finest of colloidal clay. The particles are graded, according to their effective diameters, into four fractions, in the revised official method for mechanical analysis (16). These are:-

(1)	Coarse sand	2 mm. - .2 mm.
(2)	Fine sand	.2 mm. - .02 mm.
(3)	Silt	.02 mm. - .002 mm.
(4)	Clay	below .002 mm.

The varying proportions of these fractions determine the texture of the soil, i.e. a soil with a large proportion of silt and clay will be 'heavy' while one with much coarse and fine sand will be 'light'.

In the laboratory the fractions are estimated as ultimate particles. Under field conditions, i.e. in the natural state, the particles are bunched together to form aggregates which are effective as larger particles. They may be held together by the humus which is destroyed by the pre-treatment with hydrogen peroxide, or cemented by calcium or other compounds which are dissolved out by the hydrochloric acid. The clay may be kept in the flocculated condition by the action of lime or other compounds, a condition which is reversed on shaking with ammonia. As a result, the natural soil possesses 'structure' which is distinct from 'texture' assessed by mechanical analysis. The term 'structure' is used here in the simple sense (43), meaning a condition where the individual particles exist in aggregates and is not to be confused with its use in the compound sense, i.e. in describing special forms such as granular, crumby, columnar, etc. The hand examination of soil in the field then, is an examination of structure which is not a fundamental property but is capable of alteration to some extent. Structure is closely associated with 'tilth', and therefore agrees well with the farmer's opinion of his soil. Moisture conditions are apt to influence the 'feel' of the soil, a wet soil tending to give a suggestion of heaviness, and a dry soil of lightness. Then again the soil, if under grass for a number of years, would become somewhat compacted while if recently ploughed up would definitely seem lighter. The presence of organic matter may tend to give 'body' to a light soil and to give 'lightening' to a heavy one.

Discussion of results.

Table 2 shows results from the first season in the field, using a long series in describing the soils. The figures show a tendency for the light soils to be classed on the heavy side. It is only in rare cases, however, that the texture assessed by both methods differs by more than one class. The Sb and La soils out of agreement possibly have had a certain plasticity and coherence due to organic matter and moisture conditions, while the Lm and Lb soils may have been altered by liming and cultivation so as to appear fairly friable or 'chaunery'.

Table 3 is compiled from the results of the second season in the field. Agreement here is not so good unless in the La class. There is a pronounced tendency to class on the light side. A short series was used during this season and the standard of comparison may unconsciously have been somewhat altered. The samples were taken chiefly in a grazing country and the mat of roots has given an effect of 'lightness'. Many of the discrepancies will be due to border line cases while the method of classification cannot be considered perfect since no account is taken of the organic matter, classification being made on a mineral basis. The effect of organic matter on the heavier types of soil is doubtless an important one.

Conclusions.

The results in Table 2 showing over 64 per cent. agreement may be considered reasonable when all factors are considered.

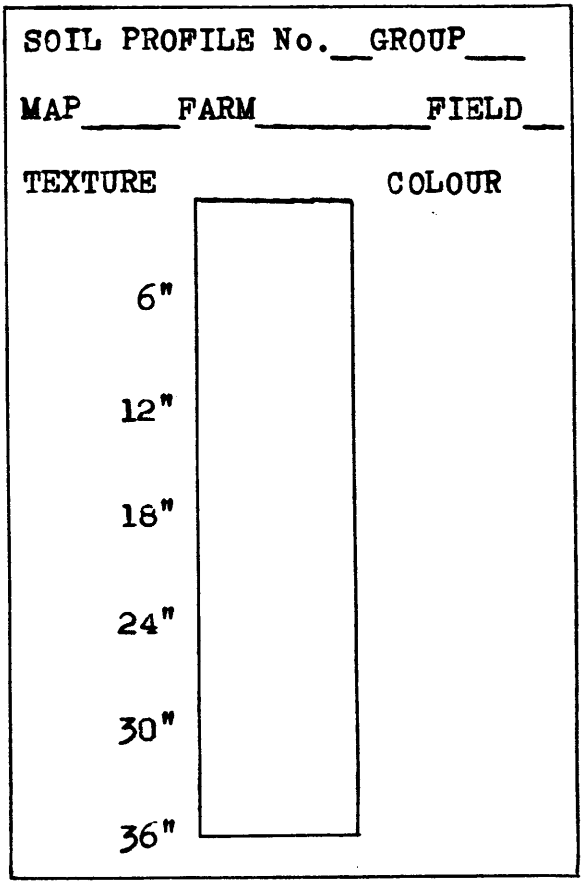
The use of a long series in the field is important. This may be shortened so as to reduce the number of classes if the soils are to be mapped.

The figures show that, in this area, the frequency of sampling and the mapping of the soils from analytical data have been fully justified.

Peat and peaty soils have been excluded from this discussion since they are classified as such on the basis of loss on ignition only.

PRELIMINARY PROFILE SURVEY.

A fair idea of the soil profile to a depth of 36" was obtained using the auger as described under "Field Methods". About six hundred profiles were examined in this way. A diagram of each was made on a card, thus:-



SOIL PROFILE No.__ GROUP___

MAP_____ FARM_________ FIELD__

TEXTURE COLOUR

These were sorted out into groups with a view to preparing a preliminary profile map which should be of great assistance when the area is to be surveyed on the basis of the soil profile.

According to W. G. Ogg (37), a change in the soil profile may be expected where there is a change in colour or texture of the surface soil. Therefore an attempt was made to sort the card profiles into groups according to the colour and texture of the uppermost layer. On this basis the number of different groups was much too large to be conveniently dealt with on the map. It was found in the preparation of the other maps (Soil Texture, pH, Lime Requirement) of the area, that the maximum number of different classes should not exceed eight. If the card profiles were grouped according to the general colour similarity, the number of classes could be limited to eight.

Groups in first sorting -

(1) No colour change to the depth examined.
(2) Underlying soil lighter in colour than surface soil.
(3) Grey or greyish layer in profile or grey soil.

(4) Underlying soil red or with reddish tinge.

(5) Passing into purple brown.

It was found necessary to subdivide (1), (2) and (3) so that the classes adopted for mapping are now

(1) No colour change to depth examined.

(1a) As (1), but soil is red in colour.

(2) Underlying soil lighter in colour than surface soil.

(2a) As (2), but lighter layer is yellow or with yellow tinge.

(3) Grey or greyish layer in profile or grey soil.

(3a) As (3), but with evidence of accumulation at a lower level.

(4) Underlying soil red or with reddish tinge.

(5) Passing into purple brown.

Owing to the number of types in groups 3 and 3a, distinction had to be made. G following the group number signifies that the grey layer is on the surface, while P following indicates that the profile is developed under peat.

There is, as yet, no data available regarding these profiles and they have been grouped on the basis of colour similarity only. It may reasonably be anticipated that when sampling is done and analyses are made, that the number of classes will be considerably reduced. It seems advisable, however, to err on the safe side by using rather a large number of classes in the preliminary map.

In order to permit of presenting a fair amount of detail and to permit of its being submitted herewith, the map was prepared on the scale of 2" to the mile and is submitted in folder at back. A typical profile for each group is shown in colour. It is suggested that this map be used in conjunction with the Soil Texture Map when it is desired to select the sites of the pits in the detail profile survey. Changes in the parent material may be obtained from the geological maps. Topography may be judged from the contours given on the texture map leaving only such factors as vegetation, drainage and moisture conditions to be considered in the field. The time and labour saved by using this map will be realised, when it is considered, that two workers in an area such as this, where there are few exposures, can only open and examine at the most four pits per day.

1

Brown
without
change

1A

Red-brown
without change

2

Brown
passing to lighter brown

2A

Brown
with yellow brown horizon

3

Brown soil
with greyish horizon

3G

Greyish soil
passing into brown

3P

Peaty soil or
peat with bleached layer
over brown soil

3A G

Greyish soil
passing into reddish brown.

3A

Dark brown soil
with greyish brown horizon
passing into reddish brown

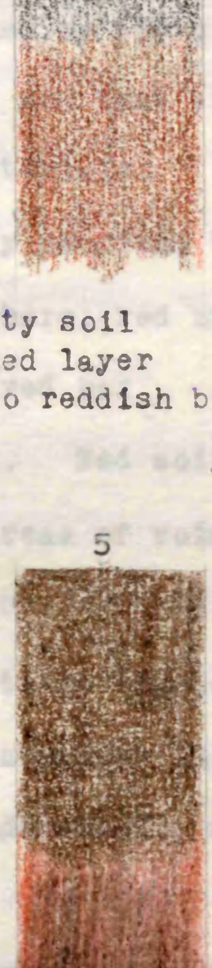
3A P

Peat or peaty soil
with bleached layer
passing into reddish brown

4

Brown soil
passing into reddish brown

5



Brown soil
passing into purple brown

Preliminary Profile Map - Discussion.

A large proportion of the map is represented by groups 4 and 5, i.e. brown soils passing into red or purple with depth. This may be explained by the great extent of the red sandstones in the area and that these red or purple horizons are the parent materials.

Profiles of group 1 are chiefly confined to the soils on the raised beaches. Elsewhere, red or purple horizons might have been encountered had examination been made to a greater depth. Red soils in group 1A are few and are found near areas of volcanic rocks.

Soils in group 2 probably owe their lightening of colour to a smaller content of organic matter in the underlying layers and may not differ fundamentally from groups 1, 4 and 5.

Profiles such as 2A are only found to occur in very occasional isolated patches. The yellow horizons are usually clay with considerable mottling and the colour developed may be due to the drainage conditions.

Groups 3 and 3A are those which have grey or greyish layers somewhere in the profile. It appears that in many cases the names of the farms with such soils are highly significant. The areas concerned, apart from the peat districts, are not extensive and there may only be a small part of the farm in one of these groups. Such names as Moss, Muir, and Wood figure prominently, e.g. Mosshead, Mossgeil, Mossblown, Mosside, Barmuir, Barmuirhill, Woodhill, Woodside, Shawwood. Others with some significance are Blackdyke, Blackside, Bogend, Brackenhill, Newlands. In most cases, there is no longer any sign of moss, of muir, or of wood. The grey layers, however, are indications that the soil has been reclaimed from such an original state. Decided grey layers were only found under a cover of peat or forest litter, never under grass or in cultivated soils. There is now little moss except on the high land and in occasional waterlogged hollows. Many of the profiles in group 3 have the greyish layer at 0 - 9", and often the grey amounts only to a tinge. it may be reasonably supposed that at one time the grey colour was predominant due to excessive leaching but that tillage operations and change of vegetation have brought about a redistribution of the sesquioxides.

In group 3A the evidence of accumulation was the occurrence of a reddish horizon under the grey. There is the possibility that this may be the parent material and the grey may be caused by impeded or restricted drainage which only detailed study in the field and laboratory can prove.

A number of profiles have been inspected in well grown woods without having been described in particular or having been sampled. Generally, under the trees where there is a good accumulation of litter, a bleached layer was found and a horizon showing accumulation at a greater depth, i.e. a typical podsol. However, where treeswere thin and grass was able to grow, no signs of leaching were found. Such differences in profile were sometimes observed only a few yards apart. This would suggest that the surface layer plays a very large part in the development of the profile.

Ten profiles have been examined in the field and investigated in the laboratory and the results are now submitted. Each is discussed after the results of analysis and all are discussed in general at a later stage.

PROFILE NO. 1

Location - Exposure near Westtown Bridge 5 miles east of Mauchline.

Elevation - 650 feet.

Topography - Sloping hillside.

Vegetation - Pasture.

Drainage - Free.

Parent Material - Boulder clay on cementstone group, Calciferous Sandstone Series.

Horizon	Depth (Inches)	
1	0 - 7	Very dark brown La.
2	7 - 15	Reddish brown Sb.
3	15 - 30	Faint purple brown La.
4	30 - 42	Faint purple brown Sb. slightly indurated.
5	42 - 50	Yellow brown Sb.
6	50 - 53	Rock blue grey with white mottling. Crumbles in hand.
7	53 - 70	Yellow brown Sb.

TABLE 4.

Profile No. 1. Mechanical analysis.

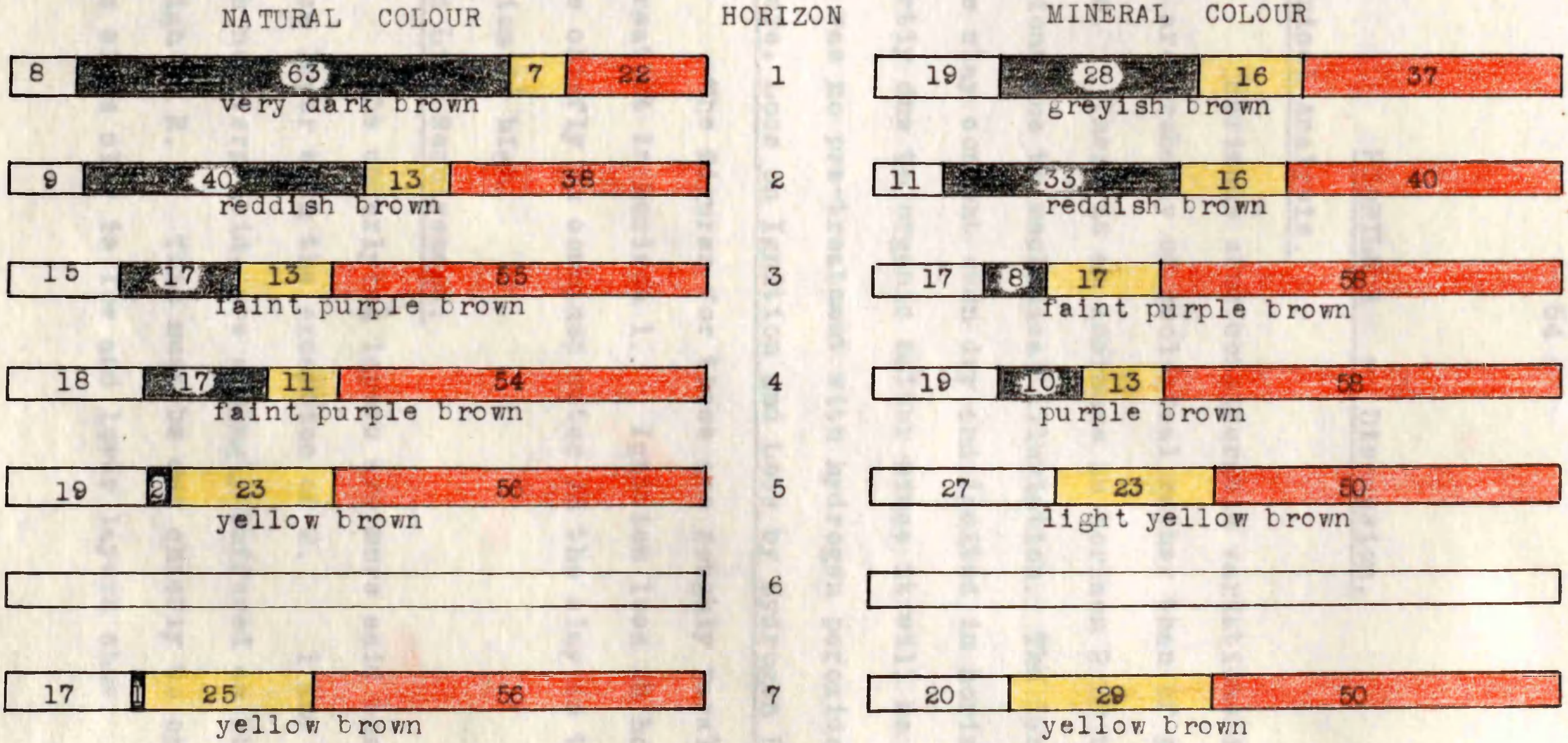
Fractions expressed as percentages 'Air dry fine earth' (<2 mm.)

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at 105°C					
1	50.91	34.45	5.62	7.48	4.1	14.9	10.4
2	40.76	39.95	6.48	8.31	3.0	7.0	1.5
3	26.65	38.60	14.18	18.50	1.6	3.9	0.9
4	28.66	48.17	6.79	14.20	1.0	1.6	0.8
5	30.64	48.98	8.53	10.30	0.7	1.7	0.4
6		Rock					
7	44.34	38.33	7.22	9.53	0.7	2.2	1.4

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions ignited					
1	59.82	33.21	4.41	3.26	6.12	4.56	.288
2	39.78	37.96	5.62	6.08	6.40	4.88	.245
3	26.10	37.90	13.31	16.56	5.76	4.66	.165
4	28.56	47.66	6.42	13.40	5.81	4.91	.071
5	30.54	48.42	8.05	9.49	5.77	4.70	.066
6							
7	43.90	37.57	6.75	8.57	5.81	4.88	.072

TABLE 5

PROFILE NO. 1. Colour analysis.



PROFILE 1 - Discussion.

Mechanical Analysis.

Horizons show considerable variations in texture which are probably of geological rather than of pedological origin. There is an increase in horizon 2 of the finer fractions due to mechanical illuviation. The large drop in the clay content oven dry and ignited in horizon 1 is partly due to organic matter since it will be remembered there was no pre-treatment with hydrogen peroxide.

Moisture, Loss on Ignition and Loss by Hydrogen Peroxide.

The figures for these are roughly parallel and are greatest in horizon 1. Ignition loss in horizon 3 is due chiefly to combined water in the clay as this fraction is high.

pH and Lime Requirement.

The underlying layers are more acid than the surface layer with the exception of 2. 1 and 2, though not very acid, are strongly buffered as shown by the high L. R. This must be due chiefly to organic matter since clay is low and lower layers show practically no buffering.

Colour.

There is a large amount of black in horizons 1 and 2. This is accounted for by the organic matter since it is cut down considerably by the peroxide treatment. There is slight evidence of bleaching in the mineral colour of 1 and enrichment in 2 of sesquioxides may be responsible for the reddish tinge. It is not possible to decide where the true parent material occurs.

PROFILE No. 2

Location - Exposure on bank of River Coyle at Auld Byres.

Elevation - 300 feet.

Topography - Very gently sloping.

Vegetation - Pasture

Drainage - Free

Parent Material - Freshwater Alluvium - Second Terrace.

Horizon	Depth (Inches)	
1	0 - 9	Darkish brown La.
2	9 - 18	Brown La.
3	18 - 27	Brown La.
4	27 - 31	Darkish brown Sb.
5	31 - 33	Brown La.
6	33 - 38	Darkish brown Sb.
7	38 - 40	Faint grey brown Lm.
8	40 - 42	Darkish brown La.
9	42 - 44	Dark brown Sa. with black shale and gravel.
10	44 - 48	Dark brown Sa. with brown gravel.

TABLE 6

Profile No. 2. Mechanical analysis.

Fractions expressed as percentages 'Air dry fine earth' (<2 mm.)

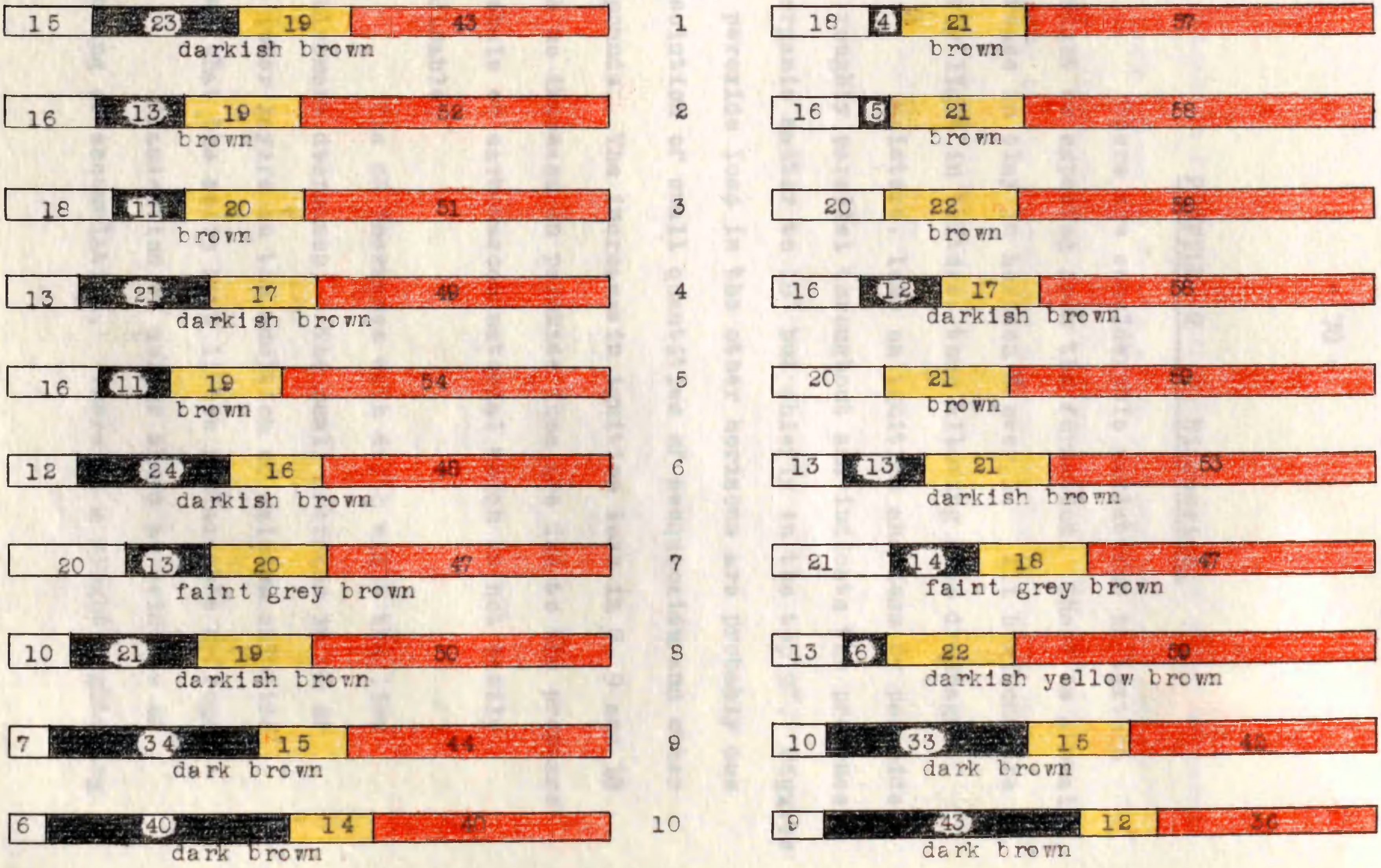
Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at	105°C				
1	19.71	46.18	19.12	11.99	2.5	7.1	5.7
2	22.43	42.34	16.97	15.06	2.7	5.6	1.5
3	19.65	50.12	12.60	15.47	1.9	3.8	1.8
4	24.12	60.67	5.57	6.93	1.7	3.0	1.3
5	27.03	50.88	9.33	10.12	1.5	2.9	1.0
6	21.15	67.99	4.68	4.61	1.4	2.3	0.4
7	5.56	60.25	19.61	12.60	1.5	3.0	1.3
8	11.01	60.78	13.19	13.40	2.0	3.8	0.3
9	78.83	14.44	3.16	2.68	1.8	3.5	1.1
10	79.74	13.82	2.59	2.60	2.0	3.5	1.2

TABLE 6 (Contd.)

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
	Fractions ignited.						
1	18.61	44.96	17.12	8.98	5.67	4.39	.227
2	21.30	41.55	15.62	12.99	5.86	4.76	.165
3	19.22	49.39	11.73	13.49	5.95	4.97	.128
4	23.49	59.65	5.06	5.83	6.28	5.61	.084
5	26.53	50.07	8.65	8.75	6.19	5.35	.084
6	20.71	66.78	4.20	3.72	6.26	5.56	.068
7	5.46	59.35	18.78	11.12	6.26	5.31	.068
8	10.66	59.69	12.35	11.73	6.28	5.40	.090
9	76.24	13.85	2.82	2.19	6.32	6.14	.048
10	77.12	13.18	2.28	2.18	6.32	6.21	.060

T A B L E 7

PROFILE No. 2. Colour Analysis



NATURAL COLOUR					HORIZON	MINERAL COLOUR				
15	23	19	43	darkish brown	1	18	4	21	57	brown
16	13	19	52	brown	2	16	5	21	58	brown
18	11	20	51	brown	3	20		22	58	brown
13	21	17	49	darkish brown	4	16	12	17	55	darkish brown
16	11	19	54	brown	5	20		21	59	brown
12	24	16	48	darkish brown	6	13	13	21	53	darkish brown
20	13	20	47	faint grey brown	7	21	14	18	47	faint grey brown
10	21	19	50	darkish brown	8	13	6	22	59	darkish yellow brown
7	34	15	44	dark brown	9	10	33	15	42	dark brown
6	40	14	40	dark brown	10	9	43	12	36	dark brown

PROFILE 2 - Discussion.

There are considerable variations in texture as might be expected from the formation. There is a small increase in clay in horizon 2 over 1. All horizons are fairly light in texture, thus allowing free drainage.

Moisture, loss on ignition and loss by peroxide are roughly parallel throughout and indicate the presence of organic matter to 18" but chiefly in the top 9". Figures for peroxide loss in the other horizons are probably due to solution of small quantities of sesquioxides and other compounds. The increases in ignition loss in 8, 9 and 10 with no increase in peroxide loss are due to the presence of shale or carbonacous material which is not easily oxidisable.

The pH increases with depth while the lime requirement decreases. The small decrease in pH of the lower layers on the addition of calcium chloride shows that the soils have little replaceable hydrogen.

Examination of colour shows no evidence of leaching or accumulation. There is a slight lightening of colour in 1 - 6 with peroxide. In the other horizons the dark colour is due to shale and the mineral colour shows little change. The colour variations are due chiefly to the periodical change in the minerals laid down by the stream.

PROFILE No. 3

Location - Exposure on bank of River Coyle on Carbieston Mains.

Elevation - 250 feet.

Topography - Very gently sloping.

Vegetation - Pasture.

Drainage - Free.

Parent Material - Freshwater Alluvium - present terrace.

Horizon	Depth (Inches)	
1	0 - 12	Dark brown La.
2	12 - 28	Dark brown La.
3	28 - 42	Dark brown Sb.
4	42 - 48	Dark brown Sa.
5	48 - 54	Dark brown La. with bleached sand grains.
6	54	Dark purple brown mudstone with rounded pebbles and striated flat stones.

TABLE 8.

Profile No. 3 Mechanical analysis.

Fractions expressed as percentages 'Air dry fine earth' (<2 mm

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at 105°C.					
1	14.13	47.46	17.37	17.28	2.8	6.6	3.1
2	12.49	48.40	17.08	19.14	2.9	6.3	1.5
3	11.57	57.87	13.11	13.37	2.7	5.1	1.2
4	39.64	49.64	5.09	3.98	1.6	2.9	0.7
5	10.36	66.26	10.54	8.83	2.4	4.3	1.6
6	16.95	40.71	19.68	20.83	1.3	4.0	1.6

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions ignited					
1	13.39	46.59	15.77	14.29	5.98	4.87	.167
2	11.99	47.50	15.58	15.21	6.16	4.79	.185
3	11.04	56.65	11.83	11.16	6.17	5.13	.134
4	38.84	48.62	4.57	3.33	6.40	5.47	.063
5	9.69	66.26	9.50	7.55	6.32	5.38	.085
6	16.49	40.07	18.50	18.66	8.17	7.88	

TABLE 9

PROFILE NO. 3. Colour analysis.

NATURAL COLOUR					HORIZON	MINERAL COLOUR				
13	40	14	33	dark brown	1	15	34	16	35	cold brown
12	36	17	35	dark brown	2	17	28	18	37	brown
10	40	14	36	dark brown	3	16	28	17	38	brown
14	35	16	35	dark brown	4	18	25	18	39	brown
14	32	18	36	dark brown	5	19	24	19	38	brown
17	30	10	43	dark purple brown	6	21	23	11	45	purple brown

PROFILE 3 - Discussion.

The variations in texture are typical of river alluvium with seasonal deposition. Horizon 2 shows a small increase in clay content.

Organic matter in moderate amount is confined to the top layer. Loss on ignition figures in 2 and 3 are due to combined water in the silt and clay fractions.

Acidity decreases with depth with a sudden rise at 6. Figures must be used with caution since the quinhydrone electrode may only be used to pH 7.5. The pH in $CaCl_2$ in horizon 6 shows that the soil is not base saturated although possessing an alkaline reaction. Horizon 2, though less acid than 1, has more replaceable hydrogen and is more strongly buffered.

Colour shows little change with depth or on treatment with H_2O_2. Carbonaceous material accounts for the darkish tinge which is not affected by peroxide.

PROFILE No. 4

Location - Exposure at Byres Bridge on Ayr-Cumnock Road.

Elevation - 173 feet.

Topography - Gently sloping.

Vegetation - Pasture.

Drainage - Impeded.

Parent Material - Freshwater Alluvium.

Horizon	Depth (Inches)	
1	0 - 9	Dark brown Sb.
2	9 - 20	Brown La.
3	20 - 26	Brown Lb. with red and yellow mottling.
4	26 - 28	Grey brown Lm. with yellow and grey mottling.
5	28 - 30	Greyish brown La.
6	30 - 36	Warm brown Sb. with red mottling.
7	36	Warm brown Sb.

TABLE 10.

Profile No. 4 Mechanical analysis.

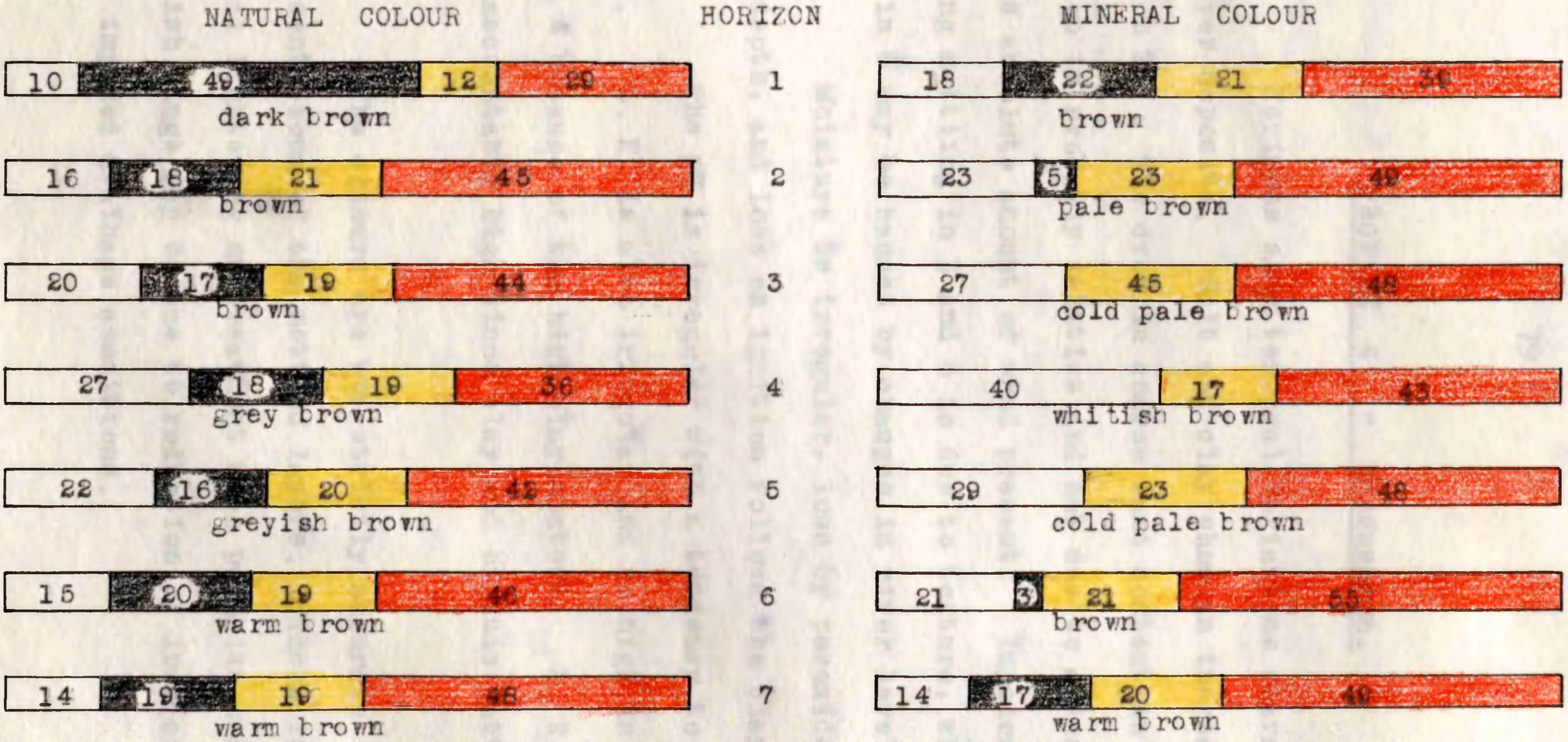
Fractions expressed as percentages 'Air dry fine earth' (<2 mm.)

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at 105°C.					
1	19.28	48.22	15.77	13.19	2.9	8.1	5.5
2	12.97	47.26	17.26	18.48	3.1	6.4	3.2
3	6.13	34.29	23.19	32.47	3.4	7.7	3.7
4	2.70	49.47	17.92	27.07	2.6	6.0	2.7
5	5.47	66.70	10.86	14.73	1.8	4.2	2.2
6	21.58	58.51	7.83	9.62	1.9	3.7	1.4
7	47.28	33.36	9.39	7.50	3.2	5.0	1.6

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions ignited					
1	18.16	46.78	14.69	10.40	5.98	4.60	.167
2	12.25	46.28	15.70	15.93	6.14	5.49	.107
3	5.70	33.67	21.36	27.85	6.07	4.86	.152
4	2.61	48.82	16.55	23.43	5.90	4.83	.144
5	5.25	65.87	9.88	12.79	5.95	5.05	.099
6	20.92	57.65	7.09	8.38	6.16	5.13	.149
7	45.52	31.89	8.37	6.33	6.57	6.20	.053

T A B L E 11

PROFILE No. 4. Colour Analysis.



NATURAL COLOUR					HORIZON	MINERAL COLOUR				
10	49	12	29	dark brown	1	18	22	21	39	brown
16	18	21	45	brown	2	23	5	23	49	pale brown
20	17	19	44	brown	3	27		45	48	cold pale brown
27	18	19	36	grey brown	4	40		17	43	whitish brown
22	16	20	42	greyish brown	5	29		23	48	cold pale brown
15	20	19	46	warm brown	6	21	3	21	55	brown
14	19	19	48	warm brown	7	14	17	20	49	warm brown

PROFILE 4 - Discussion.

Horizons show textural variations characteristic of river deposits. Silt and clay show an increase in horizon 2. The drop in coarse sand content in this horizon is probably relative and not due to a decrease in the absolute amount of sand present. Impedence causing mottling in 3 and 4 is due to texture, while that in 6 may be caused by changes in river level.

Moisture is irregular, loss by peroxide falls with depth, and loss on ignition follows the clay content.

The pH is irregular with a tendency to rise with depth. L. R. is also irregular and is high in horizons 3 and 4 because of the high clay content. L. R. of 6 is unaccountably high since clay and organic matter are low.

The colours are not strictly accurate representations of the mottled layers. There is a general lightening on treatment with peroxide and the lightish tinge may be due to reduction of iron compounds under impeded drainage conditions.

PROFILE No. 5

Location - High Park - Exposure on edge of stream.

Elevation - 250 feet.

Topography - Steep slope.

Vegetation - Pasture.

Drainage - Slightly impeded.

Parent Material - Freshwater Alluvium - present terrace.

Horizon	Depth (Inches)	
1	0 - 9	Cold brown Lb.
2	9 - 15	Brown Lb. with sandstone pebbles.
3	15 - 18	Greyish brown clay with much shale.
4	18 - 24	Greyish brown clay with shale, slight iron pan.
5	24	Rotten rock.

TABLE 12.

Profile No. 5 Mechanical analysis.

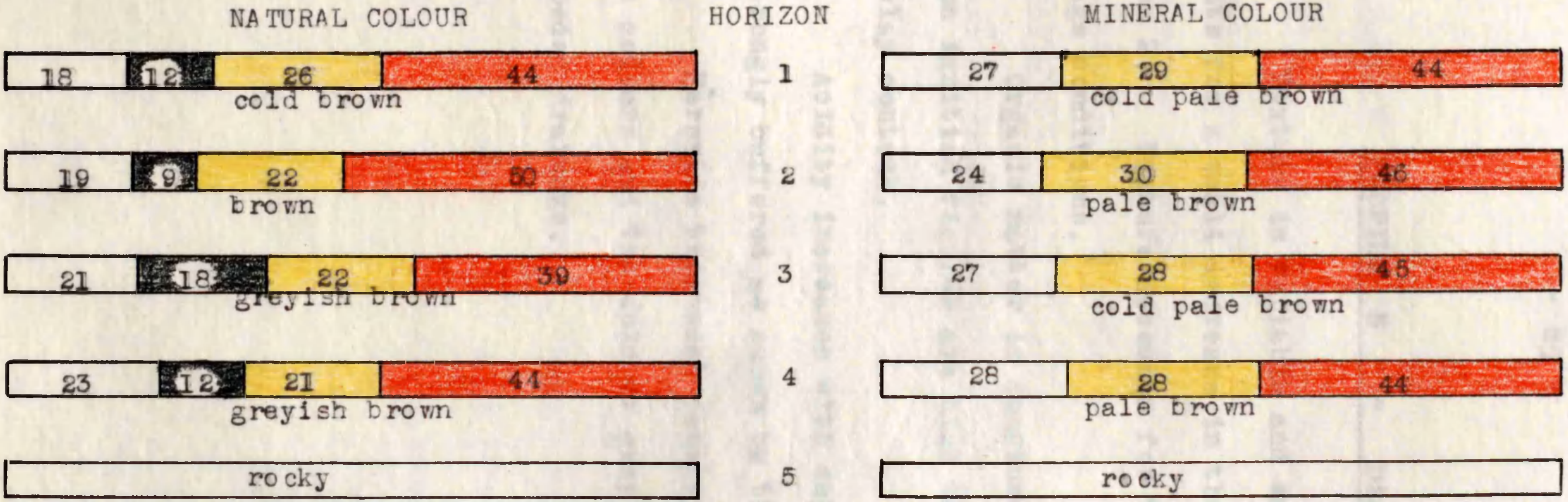
Fractions expressed as percentages 'Air dry fine earth' (<2 mm.)

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at 105°C.					
1	9.27	34.11	20.73	33.02	3.4	10.3	5.8
2	8.63	33.70	20.15	33.27	3.2	8.1	2.0
3	8.41	15.82	26.87	38.48	4.3	11.2	3.1
4	9.61	21.38	24.47	40.42	4.2	11.2	3.3
5	9.18	12.39	26.08	47.84	4.3	11.0	2.6

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions ignited.					
1	8.56	31.41	18.76	27.67	5.70	4.41	.281
2	7.89	33.01	18.64	28.74	5.29	4.34	.309
3	7.43	14.70	24.20	37.57	4.96	4.03	.372
4	8.42	20.00	21.99	34.23	4.90	4.21	.396
5	7.99	11.69	23.57	41.30	4.72	4.17	.600

T A B L E 13

PROFILE NO. 5. Colour analysis.



NATURAL COLOUR					HORIZON	MINERAL COLOUR			
18	12	26	44	cold brown	1	27	29	44	cold pale brown
19	9	22	50	brown	2	24	30	46	pale brown
21	18	22	39	greyish brown	3	27	28	45	cold pale brown
23	12	21	44	greyish brown	4	28	28	44	pale brown
rocky					5	rocky			

PROFILE 5 - Discussion.

Texture is variable and mechanical illuviation accounts for a small increase in the clay content of horizon 2. Texture accounts for the slightly impeded drainage conditions.

Organic matter is confined chiefly to horizon 1. Loss on ignition figures are high throughout due to the high clay content.

Acidity increases with depth and all horizons are strongly buffered as shown by the high L. R. figures.

Peroxide treatment causes a decided lightening of the colours and the cold or grey tints may be caused by impeded drainage.

PROFILE No. 6

Location - Auchincruive - Dairy School Foundations.

Elevation - 130 feet.

Topography - Gentle slope.

Vegatation - Wooded pasture.

Drainage - Free.

Parent Material - Boulder clay on Productive Coal Measures.

Horizon	Depth (Inches)	
1	0 - 12	Warm dark brown Sb.
2	12 - 24	Warm brown Sa.
3	24 - 36	Rust brown Sa.
4	36 - 38	Yellow brown.
5	38 - 44	Yellow brown Sa.
6	44 - 48	Cold brown Sa.
7	48	Cold brown clay.

Diagram 3.   Profile 6 Summation Curves.

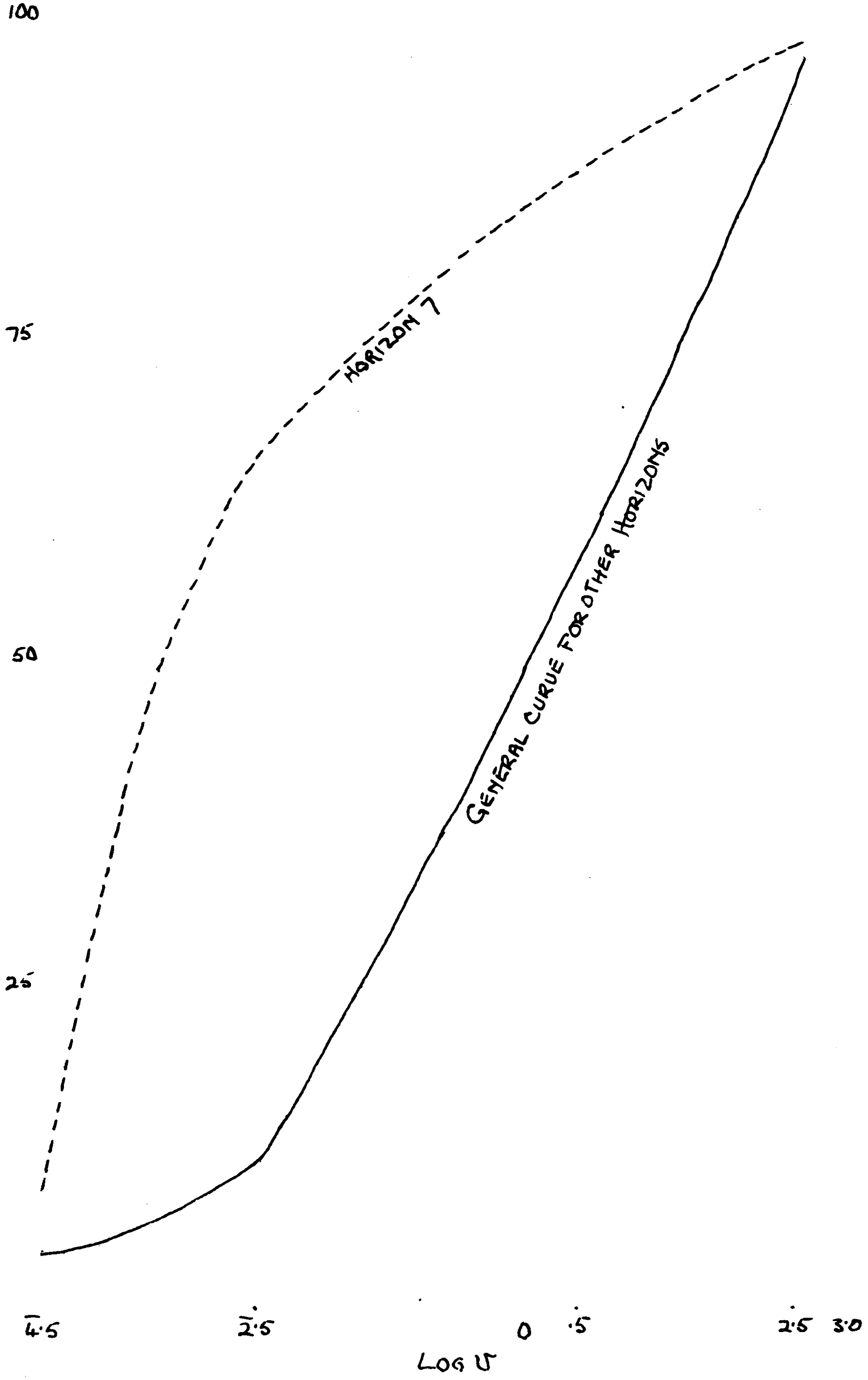


TABLE 14.

Profile No. 6 Mechanical analysis.

Fractions expressed as percentages 'Air dry fine earth' (<2 mm.)

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at	105°C.				
1	33.51	41.48	10.37	10.57	3.2	7.3	5.5
2	34.48	48.58	7.79	7.07	2.6	4.3	1.9
3	39.82	46.80	6.53	4.76	2.5	3.6	2.9
4	34.75	45.61	9.91	7.51	2.5	4.0	2.9
5	25.44	59.97	7.00	6.18	1.9	3.2	2.9
6	29.13	54.68	9.39	5.40	1.5	2.8	1.8
7	9.26	21.78	45.44	20.39	2.7	4.8	1.6

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions	ignited.				
1	32.81	39.90	8.98	6.84	5.17	4.45	.252
2	33.66	47.60	6.99	4.94	5.72	5.09	.195
3	39.48	45.73	5.68	3.24	5.95	5.35	.167
4	34.29	44.59	8.77	5.57	6.14	5.33	.173
5	25.15	58.97	6.30	4.64	6.14	5.42	.140
6	28.71	53.75	8.74	4.48	6.26	5.76	.110
7	9.14	21.43	43.01	18.72	6.48	5.56	.068

TABLE 15

PROFILE No. 6. Colour Analysis

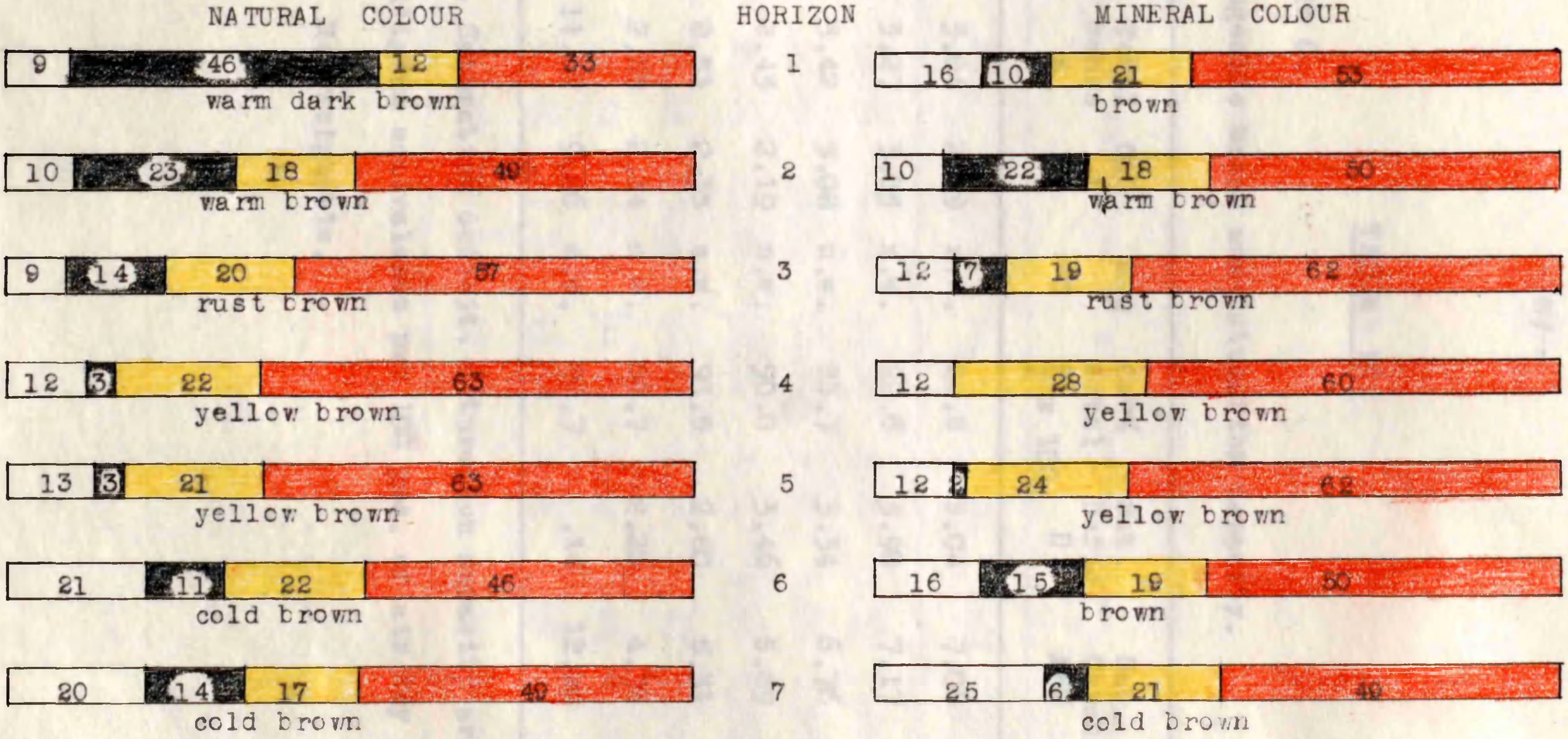


TABLE 16.

Profile 6.

Exchangeable bases and saturation capacity.

Hor.	Total bases A	CaO B	MgO C	CaO% total $\frac{B}{A}$ x 100	Sat. Defic. D	Sat. Capacity A+D	% Sat. $\frac{Ax100}{A+D}$
1	3.04	2.69	n.w.	88.5	5.04	7.08	42.8
2	3.27	3.03	n.w.	92.6	3.90	7.17	45.6
3	3.42	3.08	n.w.	85.7	3.34	6.76	50.6
4	2.43	2.19	n.w.	90.0	3.46	5.89	32.8
5	2.51	2.35	n.w.	91.5	2.80	5.31	47.3
6	2.58	2.24	n.w.	86.7	2.20	4.78	54.0
7	11.12	9.86	n.w.	88.7	.14	12.26	90.6

Bases, Saturation deficit, Saturation capacity are expressed as milligram equivalents per 100 gms. of air dry soil.

n.w. Not weighable.

TABLE 17.

Profile 6.

Fusion analysis of clay fractions.

Results expressed as percentages of ignited clay fraction($<$.002mm

SiO_2/R_2O_3 expressed as a molecular ratio.

Hor.	SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	CaO	MgO	SiO_2/R_2O_3
1	38.90	29.24	17.06	2.90	3.30	.99	1.64
2	36.02	33.53	21.12	3.20	1.05	1.082	1.30
3	29.93	29.86	24.70	4.51	3.66	1.05	1.11
4	29.28	27.09	34.95	2.72	.47	1.09	1.00
5	32.34	26.33	31.70	3.29	.44	1.21	1.17
6	43.06	30.15	15.38	2.10	.54	1.41	1.83
7	49.93	26.54	14.54	.67	.70	1.15	2.36

PROFILE 6 - Discussion.

Texture is somewhat variable and there is a sudden change at horizon 7. The fine fractions in horizon 1 have perhaps been increased by surface erosion from the upper slopes of the hill. Texture is light, permitting free drainage.

Organic matter is moderate and is confined chiefly to horizon 1.

Acidity decreases with depth. Lime requirement decreases with depth also but all horizons appear to be strongly buffered for the L. R. figures are high.

Colour shows evidence of slight accumulation in horizon 3 and this is confirmed by the silica/sesquioxide ratio of the clay fraction.

Exchangeable bases.

Calcium is the dominant exchangeable base and the results for its percentage of the total bases are in keeping with those of Hendrick and Newlands (39), Smith (40), and Stewart (10) of other Scottish soils. Magnesium was not estimable by gravimetric methods. Total bases are low in this profile in horizons 1 - 6 where the clay content is small. There is a sudden increase with amount of clay in horizon 7.

Saturation capacities, as might be anticipated, are approximately parallel to the clay and organic matter contents, since soils owe their properties of base exchange to the colloidal complex, i.e. the clay and organic matter. The amount of saturation increases with depth typical of soils of the podsolic group.

Composition of the clay fraction.

The horizons are all decidedly sesquioxidic in character with the exception of No. 7. Magnesium is fairly constant but calcium shows decided variations. Phosphorus is remarkably high in all horizons except 7. The composition of the clay in 7 is very similar to that of horizon 5 in Profile 10. The mechanical analysis figures indicate a certain amount of water working so that the clays in each horizon may not be genetically related. Iron shows an increase to horizon 4 chiefly at the expense of silica. The silica sesquioxide ratio shows an increase in the proportions of sesquioxides to horizon 5 where there is a very sudden change. It is not possible to attribute the large change in character of the clay to pedogenic processes and it is possible that horizons 6 and 7 may be underlying geological material. There is evidence of podsolisation in this profile due to the fairly acid surface layer and to the vegetative covering of grass and trees.

PROFILE No. 7

Location - Whitehill - Exposure in old Marl Pit - five miles from Ayr on Dalmellington Road.

Elevation - 300 feet.

Topography - Gentle slope.

Vegetation - Pasture.

Drainage - Impeded.

Parent Material - Boulder clay.

Horizon	Depth (Inches)	
1	0 - 11	Darkish brown Lb.
2	At 11	Grey brown Lm.
3	11 - 42	Darkish grey brown clay with grey mottling.
4	42 - 108	Brown Lm. with grey mottling.
5	108	Dark grey brown clay.

TABLE 18.

Profile No. 7 Mechanical analysis.

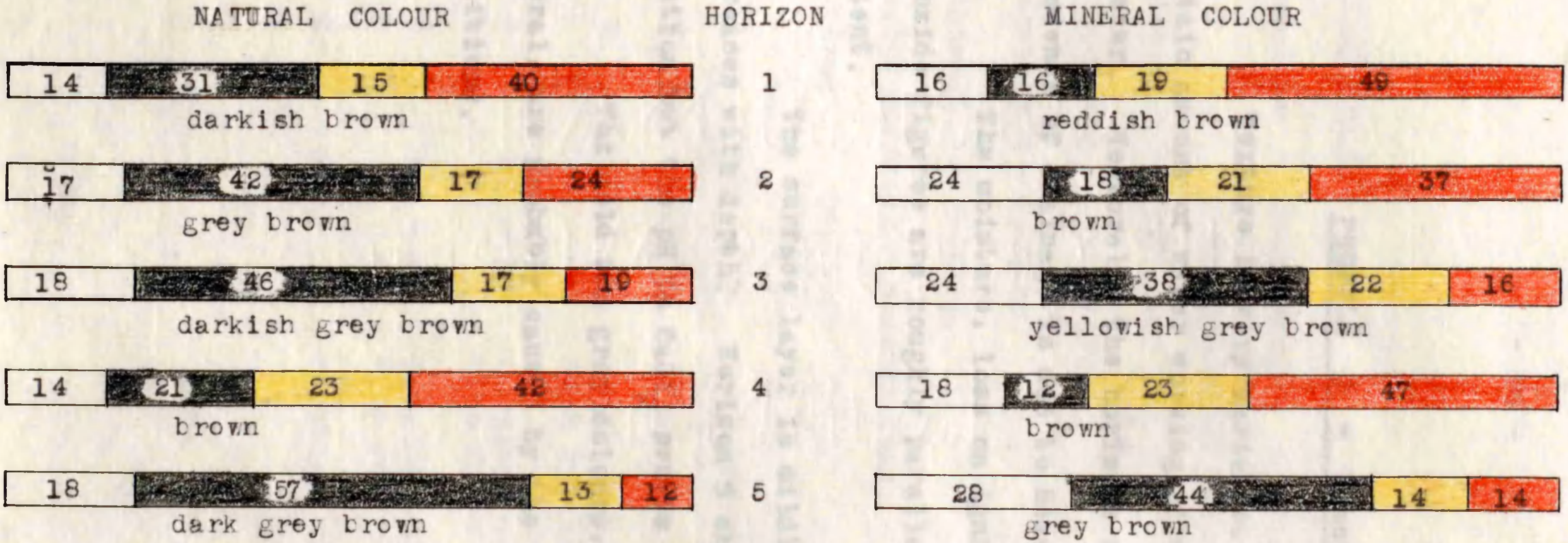
Fractions expressed as percentages 'Air dry fine earth' (<2 mm.

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at 105°C					
1	10.88	36.73	22.45	25.54	3.6	7.5	4.0
2	3.68	66.41	15.41	11.67	3.0	4.6	3.5
3	1.14	26.15	26.79	39.95	6.6	6.3	3.8
4	16.59	41.35	19.01	19.78	2.6	5.5	2.6
5	1.58	33.39	27.36	31.95	6.1	6.0	1.5

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions ignited					
1	10.22	35.48	20.40	22.34	5.96	5.02	.167
2	3.54	64.49	14.20	10.16	6.22	5.94	.060
3	1.08	25.00	24.81	36.50	6.24	5.11	.182
4	16.15	40.66	17.64	17.34	6.87	6.16	.083
5	1.50	31.76	25.43	29.20	7.35	6.80	.023

T A B L E 19

PROFILE No. 7. Colour Analysis.



PROFILE 7 - Discussion.

Texture is very variable, possibly due to a certain amount of water working of the surface of the glacier. Texturally the horizons seem to be unrelated. Impedence of drainage is due to heavy texture.

The moisture, loss on ignition and loss by peroxide figures are roughly parallel to the clay content.

The surface layer is mildly acid and acidity decreases with depth. Horizon 5 shows an alkaline reaction but the pH in $CaCl_2$ proves it to be unsaturated.

The cold and grey colours, both natural and mineral, are probably caused by the impeded drainage conditions.

PROFILE No. 8

Location - Sessionfield - Exposure in Marl Pit - five-and-a-half miles from Ayr on Dalmellington Road.

Elevation - 300 feet.

Topography - Gentle slope.

Vegetation - Pasture.

Drainage - Impeded.

Parent Material - Boulder clay.

Horizon	Depth (Inches)	
1	0 - 6	Dark brown Lm.
2	6 - 14	Brown Lm.
3	14 - 21	Light brown Lm. with yellow brown and grey mottling.
4	21 - 30	Darkish purple brown Lb. with sandstone.
5	30 - 45	Darkish brown Lm. with yellow mottling.
6	45	Darkish brown Lm.

TABLE 20.

Profile No. 8 Mechanical analysis.

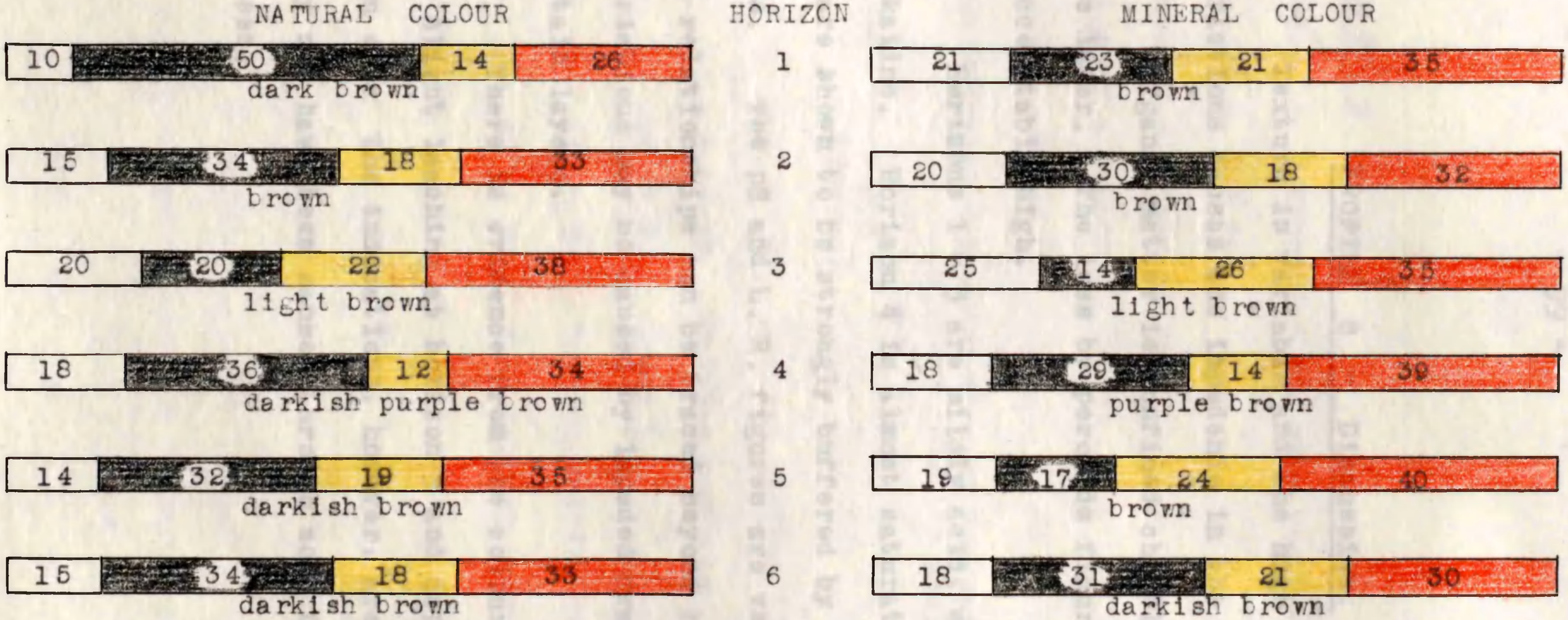
Fractions expressed as percentages 'Air dry fine earth' (<2 mm.)

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at 105°C.					
1	13.32	37.78	24.47	19.07	5.36	9.85	6.7
2	8.49	44.79	26.17	17.12	3.4	6.1	2.5
3	6.94	43.19	24.94	22.56	3.6	6.3	5.5
4	12.20	31.90	23.00	29.52	3.6	6.9	1.2
5	15.56	45.32	23.02	12.22	3.5	6.3	1.8
6	10.56	43.87	26.55	15.16	4.1	6.0	1.1

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions ignited					
1	12.20	35.76	21.18	15.65	6.41	5.36	.204
2	8.18	43.18	23.87	14.97	6.71	5.88	.068
3	6.65	42.21	22.79	18.19	6.29	5.33	.143
4	11.35	30.40	20.69	26.70	7.84	7.30	Nil
5	14.84	43.61	20.69	10.51	7.26	6.25	.051
6	10.06	42.02	24.14	13.34	7.26	6.54	.033

T A B L E 21

PROFILE No. 8. Colour Analysis



NATURAL COLOUR					HORIZON	MINERAL COLOUR				
10	50	14	26	dark brown	1	21	23	21	35	brown
15	34	18	33	brown	2	20	30	18	32	brown
20	20	22	38	light brown	3	25	14	26	35	light brown
18	36	12	34	darkish purple brown	4	18	29	14	39	purple brown
14	32	19	35	darkish brown	5	19	17	24	40	brown
15	34	18	33	darkish brown	6	18	31	21	30	darkish brown

PROFILE 8 - Discussion.

Texture is variable and the high content of fine fractions causes the impedence in the drainage.

Organic matter is confined chiefly to the surface layer. The loss by peroxide figure in horizon 3 is unaccountably high.

Horizons 1 - 3 are mildly acid, while 4 - 6 are alkaline. Horizon 4 is almost saturated. Horizons 1 and 3 are shown to be strongly buffered by their high L. R. figures. The pH and L. R. figures are very variable and no relationships can be traced beyond horizon 2. The variations may be caused by impeded drainage conditions in certain layers.

There is evidence from the colours that there may be slight leaching at horizon 3 and deposition at horizon 4. The indications, however, are very slight and may not have been caused through soil forming processes.

PROFILE No. 9

Location - Raithhill - One mile south west of Coylton.

Elevation - 320 feet.

Topography - Gently sloping.

Vegetation - Pasture.

Drainage - Free.

Parent Material - Boulder clay on Teschenitic and Olivine-dolerite sills.

Horizon	Depth (Inches)	
1	0 - 9	Darkish reddish brown Lm.
2	9 - 18	Darkish brown Lm.
3	18 - 24	Brown La.
4	24 - 30	Darkish reddish brown La.
5	30 - 36	Cold darkish brown La.

TABLE 22.

Profile No. 9 Mechanical analysis.

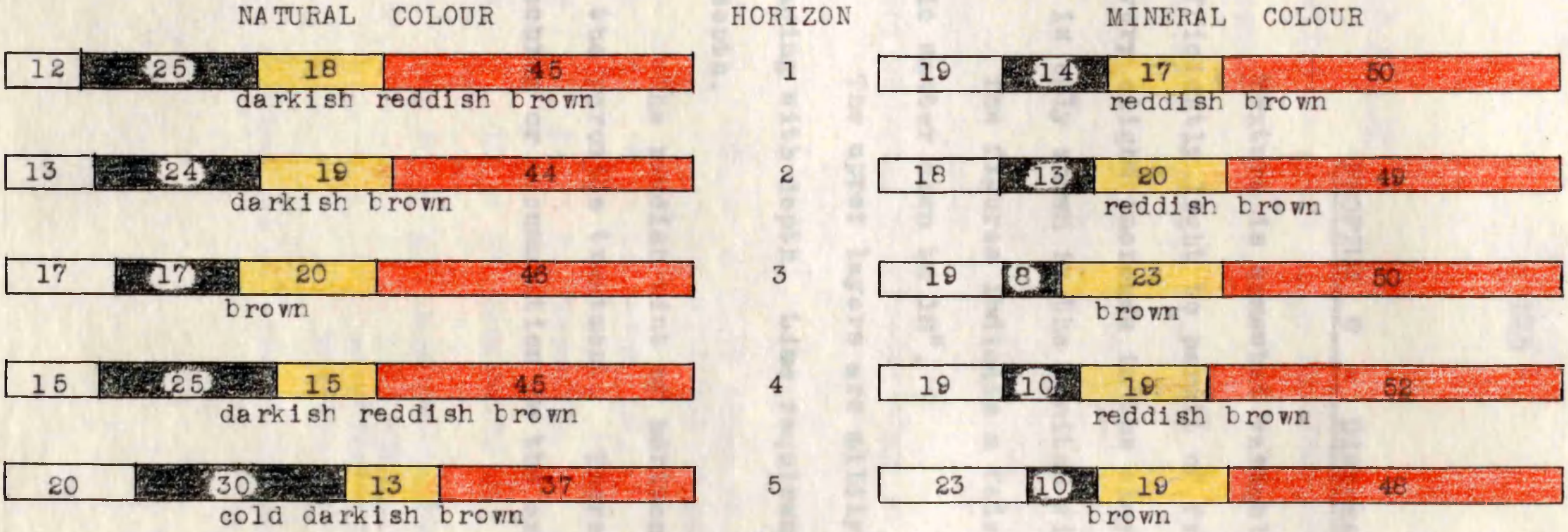
Fractions expressed as percentages 'Air dry fine earth' (<2 mm.)

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at 105°C.					
1	16.48	37.28	23.02	17.80	5.42	7.78	3.9
2	18.60	38.56	20.69	17.43	4.72	8.38	3.7
3	23.53	41.37	19.76	10.85	4.49	6.63	1.6
4	26.17	40.78	18.79	9.95	4.31	6.64	1.2
5	20.94	41.55	20.31	14.06	3.14	6.65	1.3

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions ignited					
1	14.95	36.03	20.26	13.56	5.89	4.84	.204
2	17.32	37.37	18.47	13.72	5.94	4.99	.173
3	22.29	39.61	17.71	9.27	6.33	5.66	.081
4	24.65	38.95	16.93	8.52	6.33	5.70	.060
5	19.76	39.56	18.54	12.35	6.70	6.35	.042

TABLE 23

PROFILE No. 9. Colour Analysis.



PROFILE 9 - Discussion.

Texture is somewhat variable and in all horizons is sufficiently light to permit of free drainage. There is a very slight increase in the clay content in horizon 2 which is only shown in the ignited figure.

The figures indicate a fair proportion of organic matter down to 18".

The upper layers are mildly acid, the acidity decreasing with depth. Lime requirement also decreases with depth.

The reddish tint of horizons 1 and 2 is brought up by the peroxide treatment. There is no evidence, however, of leaching or accumulation in the examination of the colour.

PROFILE No. 10

Location - Peel Hill, Auchincruive - Exposure in gully.

Elevation - 100 feet.

Topography - Gentle slope.

Vegetation - Bent. Wood Rush. Bird's foot trefoil. Yarrow. Sweet Vernel. Moss. Wild White Clover. Cultivated at one time but now used only for grazing.

Drainage - Free.

Parent Material - Boulder clay on Teschenitic Dolerite Sills

Horizon	Depth (Inches)	
1	0 - 4	Dark brown La. with mat of grass and roots.
2	4 - 11	Brown La.
3	11 - 14	Brown La.
4	14 - 16	Compacted Sb. light brown.
5	16 - 33	Dark purple brown compacted boulder clay with considerable shale or carbonaceous material. Small pebbles and stones up to 3".

Roots observed to 21" chiefly stopping at 11½".

Diagram 4. Profile IC Summation Curves.

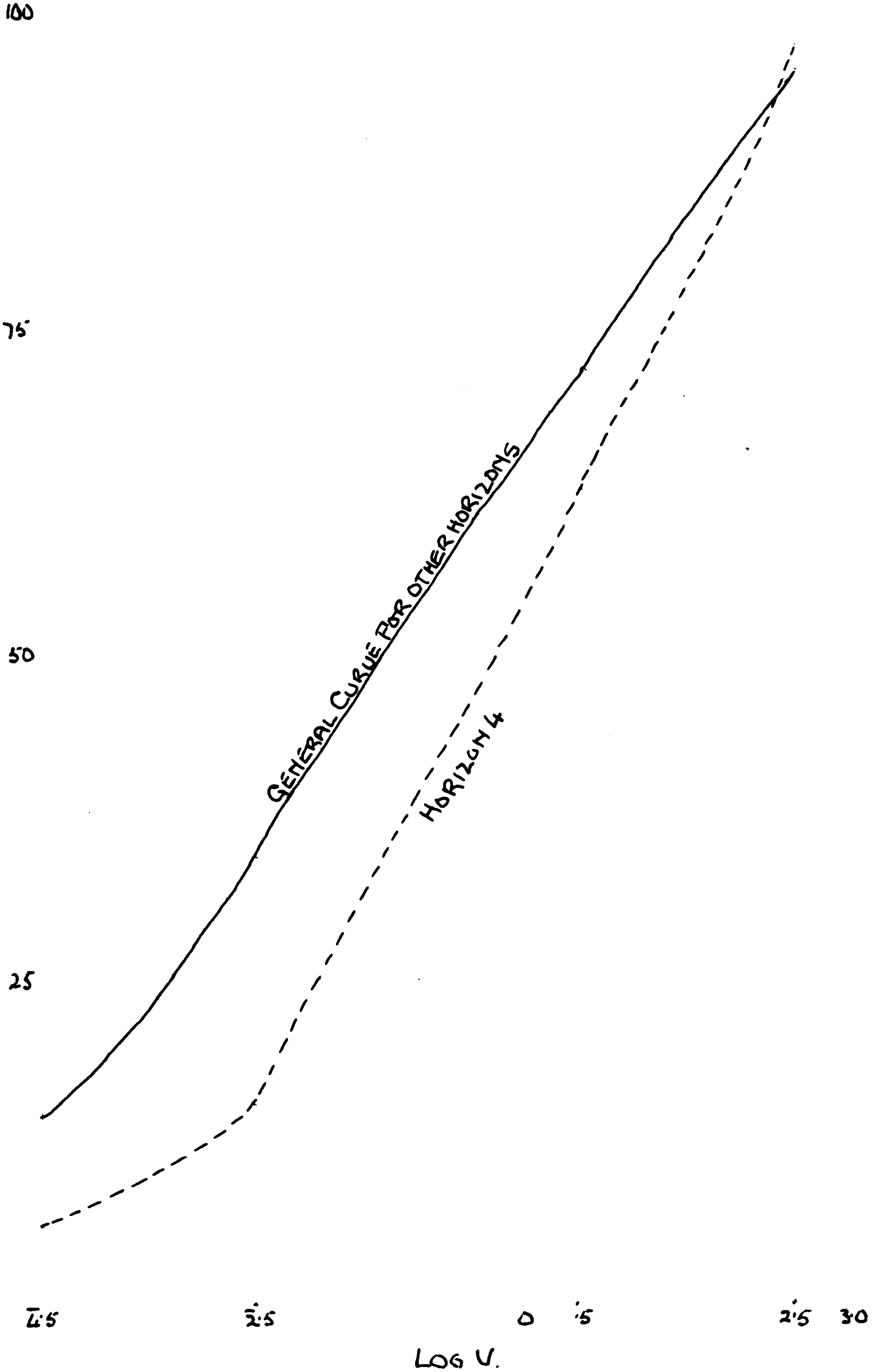


TABLE 24

Profile No. 10 Mechanical analysis.

Fractions expressed as percentages 'Air dry fine earth' (<2 mm.)

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	Moist.	Loss on Ign.	Loss by H_2O_2
		Dried at 105°C.					
1	26.99	36.84	16.26	12.58	7.33	10.53	6.8
2	25.86	41.21	17.73	12.14	3.05	6.59	3.8
3	23.70	38.34	19.77	14.70	3.49	3.87	1.5
4	35.30	48.34	9.31	6.02	1.03	2.99	.6
5	24.80	45.05	17.91	11.01	1.23	4.00	1.3

Hor.	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH Water	pH $CaCl_2$	Lime req.% $CaCO_3$
		Fractions ignited					
1	24.69	35.01	13.59	8.85	5.63	4.98	.289
2	25.12	40.05	15.68	9.52	5.74	4.88	.210
3	23.48	37.75	18.39	13.02	6.61	6.40	.053
4	34.69	47.74	8.50	5.05	6.56	6.33	.045
5	24.39	44.24	16.67	9.55	7.44	7.20	Nil

T A B L E 25

PROFILE No. 10. Colour Analysis.

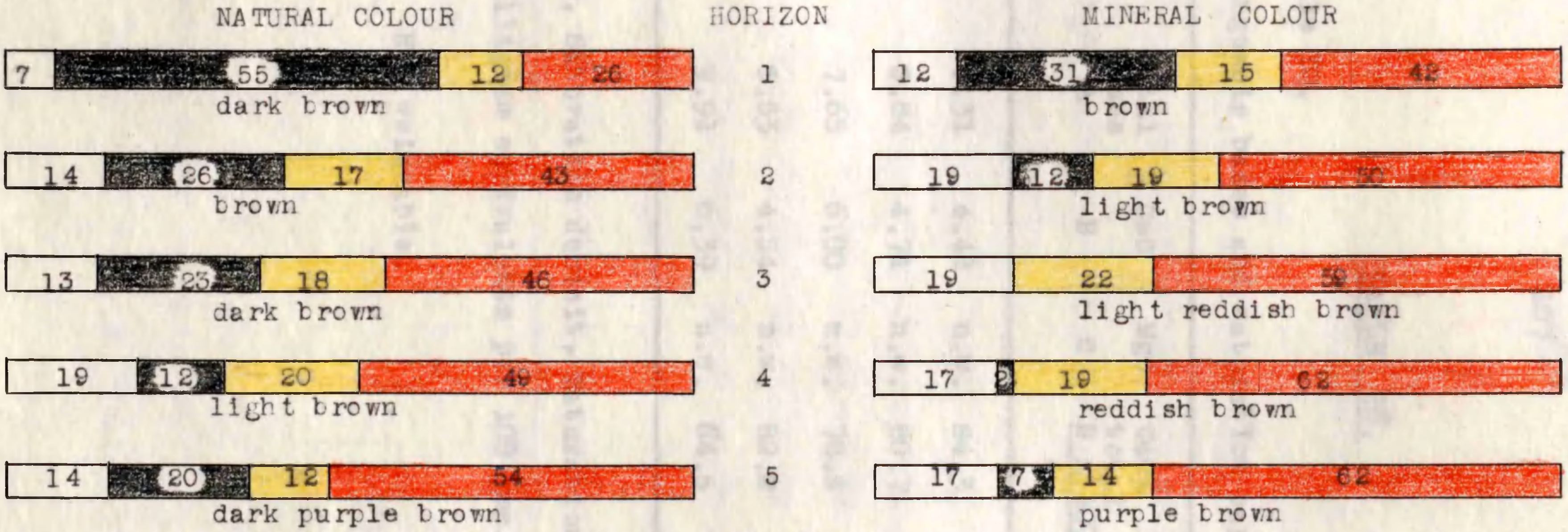


TABLE 26.

Profile 10.

Exchangeable bases and saturation capacity.

Hor.	Total bases A	CaO B	MgO C	CaO% total $\frac{B \times 100}{A}$	Sat. Defic. D	Sat. Capacity A+D	% Sat. $\frac{A \times 100}{A+D}$
1	5.31	4.48	n.w.	84.3	5.79	11.10	47.8
2	5.84	4.71	n.w.	80.7	4.20	10.04	58.2
3	7.65	6.00	n.w.	78.5	1.05	8.70	87.9
4	5.53	4.54	n.w.	82.2	.90	6.43	86.0
5	9.91	6.39	n.w.	64.5	.00	9.91	100

Bases, Saturation deficit, Saturation capacity are expressed as milligram equivalents per 100 gms. of air dry soil.

n.w. Not weighable.

TABLE 27.

Profile 10.

Fusion analysis of clay fractions.

Results expressed as percentages of ignited clay fraction

SiO_2/R_2O_3 expressed as molecular ratios.

Hor.	SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	CaO	MgO	SiO_2/R_2O_3
1	45.28	27.68	17.90	1.29	.86	1.07	1.96
2	45.70	28.82	16.78	.83	.63	1.11	2.00
3	47.81	27.94	16.78	.76	.47	.73	2.10
4	46.81	29.46	14.26	.58	.51	.61	2.01
5	48.56	26.54	14.54	.61	.63	.62	2.30

PROFILE 10 - Discussion.

Horizons are fairly uniform in texture with the exception of a thin horizon of heavy sand at No. 4. There is a slight increase in silt and clay contents of horizon 2 due to mechanical illuviation. Texture is light throughout and drainage is free.

Organic matter is chiefly in horizon 1 and in smaller quantity in horizon 2.

pH and Lime Requirement decrease with depth and horizon 5 has an alkaline reaction. Horizons 1 and 2 show fairly high lime requirement due to buffering action of the organic matter.

The mineral colour gives slight evidence of accumulation in horizons 3 and 4 but this is not confirmed by the silica/sesquioxide ratio of the clay fraction. However, the base saturation in these horizons is high.

Exchangeable bases.

As in profile 6, calcium constitutes the major proportion of the exchangeable bases throughout the profile, which again is in keeping with the results for acid soils in general. Total bases are somewhat higher in this profile owing to the higher clay content.

Saturation capacities follow the clay and organic matter figures again and the sandy horizon 4 has the lowest exchange capacity of all. The percentage saturation shows the usual increase with depth.

<u>Composition of the clay fraction.</u>

There is little change in composition in the profile until horizon 5 which is definitely more siliceous. There is a slight tendency for the silica to increase with depth. Aluminium is fairly constant but there is a definite falling off in the iron content in a downward direction. Phosphorous is highest in horizon 1, probably as a result of treatment of the grass with mineral phosphate or other phosphatic fertiliser. Calcium and magnesium are highest in horizons 1 and 2. The molecular silica sesquioxide ratio is fairly constant but shows a sudden small increase at horizon 5. This is presumably the parent material but texture shows evidence of water working. There is a possibility that this profile is truncated, a podsol profile developed under heath or moss and the A layers removed by erosion and the soil now formed on the sesquioxide enriched B horizon. There is also the effect of ploughing to be considered. Any accumulations at plough depth would be turned up and the new surface would be richer in sesquioxide. This seems the more probable explanation. The distribution of the sesquioxides and the silica sesquioxide ratios are very similar to those of certain cultivated soils in North Wales described by Robinson (9).

GENERAL DISCUSSION.

Mechanical Analysis.

Ten profiles have been described. These were examined in boulder clay deposits and river alluvium which cover most of the country. There is much variation in texture in the horizons of each profile, a point which might be expected from the conditions of formation. There is a general increase in the content of clay in horizon 2 over horizon 1. This is shown up better in the figures for ignited fractions. This increase has doubtless been caused by mechanical eluviation from horizon 1. The drop in coarse fraction content in horizon 2 compared with horizon 1 is probably relative and not absolute. The coarse sand and fine sand fractions are considerably reduced by ignition, due in many cases to shaley material and roots, etc.

Where drainage is impeded, the reason can be traced to heavy texture rather than to a high water table.

The differences in texture between the horizons of the profile are often too great to be attributed to pedogenic processes. These are more likely to be the result of water working on the surface of the glacier and to water sorting in the case of river deposits.

Moisture, loss on ignition and loss by hydrogen peroxide.

Results of these determinations indicate that the organic matter is confined to horizon 1 with no accumulation at lower levels. Loss on ignition figures, with the exception of those for horizon 1, are roughly proportional to the clay content. The treatment with hydrogen peroxide probably dissolves out 1 - 2 % of mineral matter.

pH.

All the soils are lacking in calcium carbonate and the surface layers are mildly acid. There is a general rise in pH with depth except where drainage is impeded. The pH, as was anticipated, was decreased considerably by the addition of neutral $CaCl_2$ due to the displacement of the hydrogen ions by the calcium. In several cases the soil has an alkaline reaction in water while the pH is still reduced by the $CaCl_2$. This points to the soil being unsaturated although there is sufficient base present in the complex to give an alkaline system.

Lime requirement.

There is a general decrease with depth showing an increase in the base status. Horizon 1 has usually the greatest lime requirement due to the strong buffering action of the organic matter. This figure is usually high where the clay content is large, this constituent having a large base exchange capacity. The lower horizons, where the texture is light, are shown to be approaching saturation and are practically unbuffered.

Colour.

The need for the replacement of verbal colour description by quantitative data has been recognised. The colours are described quantitatively, but, as there is no ready means of interpreting the figures at present, the qualitative descriptions are given also. There is little evidence from the colour which would enable differentiation to be made into A, B, and C. horizons.

As the soil colour is influenced largely by organic matter, this has been destroyed with hydrogen peroxide in an attempt to show the unobscured mineral colour which is a fundamental property of the soil. The percentage of black generally decreases with depth and on treatment with hydrogen peroxide unless where carbonaceous material is present which is not destroyed by the peroxide.

Exchangeable bases.

Calcium is the base occurring in largest proportion in all horizons of the profiles examined, a result which agrees well with data for other acid soils furnished by Hendrick and Newlands, Smith, Robinson, Hissink and others.

Total bases in both profiles are determined mainly by the amounts of clay and organic matter. Profile 10 has the higher base status, its higher clay content conferring superior retentive powers, while additions have doubtless been made when the soil was cultivated.

Saturation capacities are approximately parallel to the clay and organic matter contents. The increase in the amount of saturation with depth is a strong indication that these soils belong to the podsolic group.

According to Mattson (42), highly sesquioxidic clays have the lowest base exchange capacities while highly siliceous clays have the highest. There is a distinct difference between the characters of the clay in the two profiles, but, as the absolute quantities of clay and organic matter were not determined, Mattson's suggestion could not be tried out.

Composition of clay fraction.

Analysis of the clay fractions of profiles 6 and 10 shows no similarity between them except in the lowest horizon of each. In profile 6 the silica/sesquioxide ratios show evidence of podsolisation although this has not proceeded far enough to be apparent in the field. The upper layer is fairly acid and the soil has possibly been undisturbed for seventy years, since this profile is located in the wooded pasture overlooked by the Auchincruive mansion house. Previous to this, the field was probably under cultivation.

Profile 10 is typical of a large area of farming land in the district. The field where the observations were made was cropped at one time but has been used for grazing for an unknown number of years. There is no evidence of transportation of the sesquioxides and their even distribution throughout the profile points to a soil similar to Ramann's (4) Braunerde (brown earths). This is likely to be a result of cultivation, as the character of the clay fraction as evidenced by the silica/sesquioxide ratios, has very strong affinities with some cultivated soils of North Wales described by Robinson (9).

SUMMARY.

Special work in connection with a Soil Survey in South Ayrshire has been described. Climate, topography, geology, and farming have been dealt with.

Field and laboratory methods have been detailed and a new instrument for rapid profile examination is suggested. A method for the measurement of soil colour has been dealt with in full.

A comparison has been made between texture from hand examination and mechanical analysis of a large number of samples.

Part of the area has been profile surveyed and a preliminary profile map is submitted. Ten profiles were examined and have been fully investigated in the laboratory and the soils have been placed in a wide scheme of classification.

The value of analytical data for correlative purposes has been recognised and qualitative descriptions and empirical methods of analysis have been used as little as possible.

CONCLUSIONS.

The study of soils in this area is complicated by the predominance of drift, chiefly boulder clay, which gives rise to non uniform parent materials. The climate is such as to give soils of the podsolic group. The results show the following general similarities:- (1) The soils are mildly acid, (2) There is mechanical eluviation of the fine fractions from the upper layers, and illuviation at a lower level. This is slight, and is not sufficient to alter the texture. (3) There is a decrease in acidity with depth. (4) There is an increase, with depth, in the amount of base saturation. Base exchange capacity is not high as the soils examined are light textured and low in clay content. It is probable that the base reserves of these soils are not high, since they are derived from sedimentary rocks which have undergone previous weathering. There are no well marked colour changes under a cover of grass by which horizons can be identified as A, B, and C. The analysis of the clay fractions of a soil profile once cultivated shows an even distribution of sesquioxides throughout, evidenced by the molecular silica/sesquioxide ratios.

It would appear then that these soils examined belong to the group designated by Ramann (4) Braunerde (brown earths). These brown earths have affinities with the podsols in that they are free of calcium carbonate, and soluble products of weathering, but leaching is not severe under a mildly acid humus and there is comparatively little transportation or eluviation of the weathered complex. Profile 10, typical of a large area of cultivated soils, has strong affinities with the cultivated soils of North Wales, described by Robinson (9), showing silica/sesquioxide ratios of approximately 2 throughout the profile. Stewart (10) shows the regradation of a podsol under cultivation to a type closely resembling a brown earth.

As the original vegetation was probably deciduous forest with ground vegetation, the natural profile would be of the brown earth type. On the removal of the forest there was deterioration to moss or heath, with the consequent development of podsol profiles, the bleached layers of which are causing the grey colours of some of the soils encountered. Reclamation from heath and moss by cultivation has brought about a redistribution of the sesquioxides, causing regradation of the podsol profile to the original brown earth type. Where moss or peat has not been reclaimed the profile is still of the podsol type.

<ins>NOTE</ins>:- The Soils Correlation Committee working under the auspices of the Ministry of Agriculture visited this area in the summer of 1932 and the members have recognised the soils as belonging to the series "Drifts of varied composition" (44).

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Firth of Clyde
Prestwick
Monkton
Ayr
Whitletts
Auchincruive
Annbank Sta.
Tarbolton
Failford
Mauchline
Catrine
Sorn
Auchinleck
Scale 2" to 1 mile
Roads
River Ayr
Probable boundaries