"A REVIEW OF THE METHODS AND THEORY OF SOIL SURVEY;
AND A SOIL AND LAND UTILISATION SURVEY OF A SAMPLE
STRIP ADJOINING EDINBURGH FIELD."

by

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The work described in the Reports by E.K. Clark, G.M. Dickin, N. Orr, P.W. Schedler, T.J. W. Sinethurst, and P.R. Weare forms part of a project of the Soil Science and Chemistry Department which started in 1956 and in which successive postgraduate students will probably take part for some years. This project is intended to serve three purposes:

(a) to contribute to the solution of problems of land-use policy in Trinidad;

(b) to give some information on general problems of maintaining or increasing fertility, especially in the most widespread class of soils of the humid tropics - the strongly leached Latosols;

(c) to provide training in soil and agricultural surveys and the appraisal of soils.

(a) The work relates to the land-allocation policy put forward in 1942-1944 by the Lands Advisory Committee, on the basis of a provisional soil map and other data. This proposed the acquisition of nearly 90,000 acres of land considered to be required for water-supply purposes or, on account of topography or soil or both of these, unsuitable for agriculture. These areas are shown on the map opposite, which also shows the existing Forest Reserves and other areas of Crown Forest (from the Administrative Report of the Forest Department for 1955), and the areas of Crown Land which the Lands Advisory Committee considered probably suitable for allocation to agriculture - 20,000 acres in the Nariva Swamp and a total of 15,000 acres of other land.

The choice of the neighbourhood of Freeport and Edinburgh Field for this work was influenced by comments of Dr. Greene on his visit to Trinidad early in 1956. Dr. Greene was impressed by the extent of unproductive and semi-derelict land, with a considerable range of upland soil types, in Central Trinidad, and suggested that it might possibly be better at this stage to spend money on fertilizers to make some of these areas productive than to proceed with a very costly scheme of reclamation of the Nariva Swamp.

The neighbourhood chosen included much unproductive land, whilst the scattered cultivated areas showed generally rather poor growth of crops; a block of 4,500 acres had been suggested (with its boundaries subject to revision on the completion of further survey) as unsuitable for agriculture, in the Land Allocation Policy, and both land in this block and that adjoining it appeared to merit close investigation.

(b) The published soil map of 1952 shows a considerable extent of the Las Lunas Series in this locality, and this - probably being classifiable as a sandy Latosol - seems to be one of the most suitable soils of Trinidad to study in relation to general problems of fertility (as do also the Phoenix Series, found in two of the sample strips studied in the 1956-1957 Session, and the Moruga Series, occurring about 4 miles further south). Types of general problems which it is hoped to investigate on this soil include those of fixation of atmospheric nitrogen, the accumulation of organic matter and its transformations, and the effects of lime.

This soil differs markedly in its physical properties from those which are of chief importance in regard to agricultural development in Central Trinidad - the heavy clays of Talparo, Ecclesville, Cunupia, and Brasso Series.
It is proposed to regard the soil-survey part of these investigations as part of a general study of the natural region formed by the drainage basin of the Caparo River. C.F. Charter introduced the procedure of dividing territory into drainage basins, in comprehensive soil surveys in Ghana, and it is instructive to follow this (where communications make it convenient), because it brings out most clearly the relationships of soils to landscape.

E.K. Clark and R. Orr's sample strips were only on the edge of the Caparo Basin, and reached (and in one case crossed) the Couva River - which forms the adjoining drainage basin, to the South. They were sited in parts of the San Francisco Land Settlement, which it was of special interest to a study, but they give information on the soil types of the Couva-Caparo divide, and this forms a contribution to the study of the Caparo Basin.
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This thesis is in two parts.

PART I comprises a review of the methods and the theory of soil survey.

PART II is the report of the survey of a sample strip in the EDINBURGH (CARLSEN) FIELD area in Central Trinidad, on an area previously mapped by Chenery (1952) as McBean sands to loams, but which this investigation showed to be of a more silty nature, and more compatible with the description of Chenery's Freeport Loams.
PART I.

INTRODUCTION.

Wherever man exists, a form of land use is practised. The forms vary in intensity, but where conditions have remained fairly static or changed but slowly, the the pattern is usually finely adjusted to the conditions. In New Guinea for example, a tribe was discovered practising a system of bush fallow with success, for being unaffected by civilisation, both they and their agriculture were well attuned to the environment, (Graham 1944). In older European countries, though ways have changed, nevertheless the system of farming has become adjusted to the conditions as they changed, and are in fairly good balance. It is where a comparatively undeveloped country has made suddenly great advances that the system of agriculture is totally unsuited to the conditions now prevailing. For example, in East Africa today, the better areas are overcrowded, due to the increase in population in the last fifty years; the old system of bush fallow is no longer suitable, and the soil fertility is no longer being maintained. Even in the less populated regions, increase in the cattle populations is having a disastrous effect upon the soil (East Africa Royal Commission : Report 1955).

In all countries land is ultimately limited, and in some it is already becoming scarce. In a planned economy, it is essential to know the quality and extent of all resources. Thus a survey of the land or soil, and assessment of its value should be a part of the program of any country. Because of its scarcity, use of the land should be planned, taking into consideration the period under which use it is intended to place the land, and the ease with which it may be converted to another use. Thus where permanent building is envisaged, some consider that the planners should not look less than 300 years ahead. These then are the more general reasons for and aims of soil survey.

The more directly agricultural aims of soil survey are indicated by Kellogg (1949) and Stephens (1953)* as being to define areas of reasonable uniformity, such that the experience of the past,
and the lessons of experiment may be applied with reasonable certainty to the land. This emphasises the importance of additional work without which the value of a soil survey is severely limited, for as Riechen and Smith (1949) say, the value of a soil survey is often restricted by the amount of technical knowledge available, and the survey increases in value as time passes and more information becomes available. Graham (1944) emphasises this indirectly when dealing with land use, for he sees that ideally every farmer or land manager should possess a knowledge of ecological principles, and a particular knowledge of his area.

Thus a report must be produced with the map of the area, and a means must be provided by which the users of the land can get information about new ideas and methods.

THE PROCESS.

The process of survey concerns the delineation of areas in which the soil is reasonably uniform. This involves the examination of soils in the field, the assessment of the characteristics that are considered important, and then grouping of these soils according to similarity or difference (Cline 1949), (Crowther 1953).

The Field Procedure - There are several stages to a survey, but these are not necessarily distinct in time. Initially the area to be surveyed must be chosen, and it must be decided with what accuracy each part shall be surveyed. This might seem obvious, but it is mentioned because in some countries the productivity of the land is limited not by soil conditions but by the lack of rainfall. In East Africa, areas likely to be valuable for crop production are defined in terms of the quantity, distribution, and reliability of rainfall (East Africa Royal Commission : Report 1955). It is to these areas that attention will first be given. Also it is in such areas that greater attention will be given to details in soil differences.

If a topographical survey has been carried out in the area concerned, then these maps will be used for the groundwork and the final mapping. If these are not available, then maps may be made from aerial photographs...
photographs. Whatever maps are used, aerial photographs may be of great value in selecting the routes by which the ground is covered, and for the interpolation of soil boundaries.

Next the ground is traversed, auger borings are made, road cuttings examined, and an approximate estimate is made of the variability of the soils in the area, and their distribution.

The soil profile* is the accepted unit of investigation, and emphasis is placed upon characteristics that are readily recognised and estimated by the trained man in the field. These include colour, number and depth of horizons, distribution of organic matter and roots, texture, structure, kinds of soil animals, and rapid approximate estimation of pH, calcium carbonate, etc. Additional and more precise chemical and physical analyses may be carried out on a limited number of profile samples, the amount carried out usually depends upon the laboratory facilities and labour available.

Classification - It is at this stage that the arguments and major problems arise. The practical surveyor has now to group the profiles into the unit of classification known as the Series. Robinson (1949) describes the soil series as a group of soils having similar profile characteristics, and formed from similar parent materials under similar conditions. The important word is "similar", for this definition amounts to saying that there is no rigid definition of a soil series. In fact the essential characteristic of a soil series is that it is a range of soils. One of the inherent problems of soil classification is that a soil series under one set of conditions may include a greater range of soil variation than it does under a different set of conditions.

There are some who hold the view that soil survey theory completely disregards observation. These base their criticisms upon the belief that there is no such thing as an individual soil. Jenny (1946) regards the soil profile as being a point of intersection in a

* The soil surveyor attempts to divide his area into units of landscape, but the ultimate mapping and classification of soils depends upon the profile characteristics observed.
number of curves, and the soil as a continuous variable. Kellogg (1949) simply accepts the idea of soils both as individuals and possessing three dimensional status. Robinson (1950) argues that if this were not so, the field man would not be tempted to map them as individuals. The difference between the two views is clearly one of degree. Take for example a large land mass like the U.S.A. or Asia. From the sea the climate becomes progressively drier until it becomes so dry that desert prevails. Climate taken over the whole area changes gradually, and nowhere can a sudden discontinuity of change be recognised in the overall pattern. It does in fact change imperceptibly until it is plainly apparent that new conditions prevail. This manifests itself in vegetation differences, e.g., in a change from forest to grassland, and it also shows itself in soil differences. Thus certain broad zones and model sets of conditions are recognised, and yet one merges into another. The subtle changes may be accomplished in a shorter or a greater distance depending upon the incidence of other factors, e.g. topography. This gradation is rather similar to the ecotone of the ecologist. Here then one has the two outlooks, the recognition of zones (practical), together with the idea that they form just a part of a continuous variate (theoretical). Thus the difference is one of degree, depending upon the extent to which one divides up the continuous variate. If one recognises broad differences only, then one may regard the soil as an individual - whereas if one takes the division to its conclusion then one must recognise an infinite number of classes. There is also the very practical consideration that there is neither the technical means, nor the labour to carry out the detailed work needed to accomplish the theoretical approach. From the point of view of obtaining information of practical value, it is the broad differences that are important, i.e. the ones which the surveyor can recognise in the field, and so present methods are of value. Yet even so, the theoretical approach has something of value to contribute, and should not be ignored. Research from ends should be carried out.
The soil series is a unit with dual characteristics, for it is both a practical unit recognisable in the field, and a unit which bears some relationship to the genesis of the soil. This genetic aspect of the soil series is of great value to the soil surveyor, for in grouping the soils he endeavours to work out the history of the area. In this part of the work, GEOLOGY can be of great value. This approach is logical, for if the soils were formed under the same conditions they must have come from deposits laid down at the same time. The concept of the series shows some deference to the views of those who regard the soil as being a continuous variable, for it always includes a number of types and phases, and in other respects is a very fluid or plastic concept.

Having grouped the soils into suitable series, there are two approaches to the subsequent grouping of these, which is shown diagramatically below:

- Profiles (points in a continuous variable)
- Series (types and phases)

Cartographical grouping

Categorical grouping

Nygard and Hole (1949) draw the distinction between CATEGORICAL UNITS, e.g., the soil family, zonal groups, etc., and the CARTOGRAPHICAL UNITS, e.g., the soil association, soil complex of the U.S.A., catena, and land system of Australia. The latter were evolved either to suit special conditions, or for the purpose of small scale mapping, or both. The concept of the Soil Catena evolved by Milne in Tanganyika is an excellent example of a unit serving both purposes. In that country, large areas of the land surface were found to vary regularly in topography, and soil changes varied in like manner. It was clearly a waste of time to map the actual soil boundaries accurately as they occurred, and so the whole area was mapped as a catena. The individual soils constituting the catena were described, as were the places in which they were found. Christian et al. (1953) make it clear that the concept has found use in Australian work as the Land System. In Canada a similar kind...
kind of concept, the soil association has found application. This differs from the catena in being less a geographical concept and more a genetic grouping of soils. Moss (1954) indicates that in Canada the parent material and the physiographic units are the important factors determining the inclusion of soils in any soil association, whilst in the U.S.A. the concept has a more general meaning, the soils being grouped using any factors that seem convenient for the purpose. Apart from their value in small scale mapping, these CARTOGRAPHICAL UNITS provide an excellent method of recognizing the continuous variability present within soils, without destroying the dictum that a soil is an individual. Indeed Jenny (1946) points out that his system of sequences derived by deduction from mathematical formulae, have many things in common with catenae described by field men, and defined by them from field experience. Dickson and Crocker (1953a, 1953b, 1954) have been working on the lines suggested by Jenny, and although it yields little of practical importance agriculturally, yet it is a line of investigation not to be neglected.

The second method of grouping soils into CATEGORICAL UNITS is perhaps less successful. At any rate much controversy is involved, probably due in large measure to a lack of knowledge of genetic processes in different soils. The process involves the grouping into soil families and zonal groups. Another reason for its lack of complete success is that it seeks to imitate the type of classification employed for plants and animals. This approach is unsuited, for with organisms one is classifying a genotype that is inherited independently of the environment, i.e., there is a definite discontinuity of variation present that is attributable to the presence or absence of certain particles, whereas with soils one is classifying something which is entirely the product of the environment. The only thing that a soil may be said to inherit is its mineral skeleton, yet in genetic treatments of soils the over-riding importance of the climate is emphasised, while the other genetic factors of the environment, namely organic activity, topography, parent material, and time being considered, but given second place. The
importance of climate has been realised from field experience over large continental areas, and is probably the correct emphasis to adopt. This then imitates the ecological approach to plants. From this point of view, one could regard the process as the invasion of a mineral skeleton by organisms, which evolve a series of communities, the succession being finally limited by the action of some limiting factor of the environment, for example, climate. One could then adopt a classification of climaxes of various sorts. But then one would be left with the very obvious problem of relating such a classification to soil fertility. The fact of the matter is that soils are considerably different from plants, and a classification will have to be evolved for them, not borrowed wholly from a classification used for other populations that have inherently different properties. In this connection the work of Dickson and Crocker mentioned above, is interesting. They investigated a series of mud flows of different age, and attempted to trace the changes, both biological and physico-chemical that had taken place, i.e., an ecological investigation not confined to the vegetation. Such an approach regards the soil as a dynamic system, and not as a static thing that having been formed, no longer changes, which is rather the emphasis that soil survey methods tend to place. Both are value, and should not be neglected, and neither should be regarded as yielding up the complete story.

SUBSEQUENT EVENTS.

As has been indicated, the map is of little value if nothing further is done. It is clear that with the aid of soil maps, experimental stations can be correctly sited for dealing with the problems of one particular soil. A means must be provided by which information gained can be disseminated amongst those that use the land.

In the U.S.A. great care is taken to pass on information and to advise individual farmers. This is done in two ways - through the survey report itself, and by the planning of soil conservation practices for each individual farm.

The Survey Report is couched in terms that farmers can understand.
understand, and scientific terms are introduced with care. In the more recent reports a glossary of terms is included. The report commences with instructions for its use, and the reasons for producing it are given. Other useful information is included, concerning transport, markets, schools and other facilities, intended for those newly come to the area, or hoping to farm there. Soil series and types are described individually. Soils are grouped into Use Suitability Groups, and land into Capability Classes. Management is described, and criticism is made where it is considered appropriate. The use of lime, fertilisers, rotations, drainage improvements are discussed. Then follows a general treatment of soil genesis and a brief description and classification of the soils of the area into higher classification categories. Finally a sheet summarising in table form all the chief characteristics of the soil series described is produced, either bound into the report or included loose, for use with the map. In addition, there is a table of yields to be expected of the various crops on the various soil types, under conditions of good and moderate management.

The second approach to the problem involves the detailed planning of the best methods to use on the land. To this end, Land is classified. Graham (1944) expresses the American aim by saying that "Land Use Classification should relate to the physical capacity of the land, to produce given crops for an indefinite period without exhaustion of the land, or waste of land resource", i.e., to produce the maximum compatible with the need to maintain soil fertility. The first part of the process requires the allocation of the land of the area into appropriate Land Use Capability Classes. There are eight Land Use Capability classes recognised by American Survey. Classes I, II, III, are those on which permanent cropping of some sort is considered possible, with the application of certain practices. Class IV land is considered unsuitable for continuous or permanent cultivation, and may be cultivated intermittently, but must not be put down to crops requiring inter-row cultivation. Classes V, VI, and VII are suited to grazing with varying degrees of restriction, while Class VIII is of no productive value, and
is for wild life, etc., and includes waterlogged land, such as marshes and ponds. The main consideration determining the value of the land is the slope, being one of the most important factors contributing to erosion.

Thereafter each area is considered in turn, and, taking into account the Land Use Capabilities already assessed, and also the experience of soil surveyors, and of farmers who use the land, recommendations for land use are drawn up, and maps produced. Each farmer receives a map of his farm, together with recommended uses to which each parcel of land that he possesses should be put. The reasons for the recommendations are given. It is important to realise that in this process of giving advice no recommendation is ever considered final, and that the maps and recommendations are kept under constant revision, and are amended as the occasion demands, or when new facts, methods etc., are discovered. The process is mainly one of intelligent guesswork, for although attempts have been made to calculate an index on a quantitative basis, none have proved as successful or as versatile as the system at present employed. Graham (1944) gives an example of this process with accompanying sketch maps on pp. 120-1. This gives some idea of what is done subsequent to the survey in a country whose investigations of the soil have been and are continuing to be very thorough.

**CONCLUSIONS.**

In this examination of the process and problems of soil survey, its concepts, aims, and subsequent uses, it must be concluded that soil survey should precede any form of land planning or land utilisation. It is never an end in itself, but is part of a sequence of events in an integrated study of the soil and soil/plant relationships. Any such complete sequence may be visualised as having a number of stages, for example - (1) Survey, the chief aim of which is to define areas or limits between the soils that are reasonably uniform. (2) Intensive scientific investigation, which attempts to sort out the properties of the soils defined, both...
physical, chemical, and their relationships to yield.

(3) Elucidation of special problems, these always appear as soon as the conditions change, and will require investigations on a field scale, as well as a more fundamental level, e.g., physiological investigations.

Thus such an investigation will never be complete, and the soil map will as time progresses become more useful, even though its form may change somewhat as a result of further study.

THE SPECIAL CASE OF TRINIDAD.

Trinidad is in the position of having a soil map and report for its central region which includes much of the agriculturally useful area. More of this region is being reclaimed to west and east from swamp. While the rest of Trinidad should be surveyed, it is clearly over much of the first stage outlined above.

The users of the land may be divided into two main groups, the Estate Owners - by which is meant those who farm the land on a large scale; and the peasant users. From the point of view of the development of agricultural practice outlined above, this is an important distinction, for the estates possess adequate numbers of trained personnel who know how to get the recent information, and who in fact, carry out some investigations of their own. The Peasant Agriculturist, on the other hand, shows generally a low standard of husbandry and agriculture. The problem in this case is not so much one of not having the technical information, or of being unable to pass it on, for there are now not a few experimental stations and substations scattered about the island. It is much more an economic problem. Jolly (1956), lists poor quality land, underemployment of labour due to seasonality of production, poor system of land tenure, fragmentation of holdings, poor marketing systems for local products, and lack of capital as contributing factors to this problem. Of these, capital is the most pressing need. Undoubtedly the problem of the seasonality of production could be overcome were the capital available to make it less necessary to have a quick cash turnover.  

/ Thus ...
Thus a balanced system of farming could be adopted that could give employment throughout the year to those that worked on the land. This in turn would mean that becoming full time and not part time farmers, the occupiers would achieve greater understanding of the intricacies of the farming system adopted. The provision of capital would also prevent the fragmentation process, which prevents the use of pen manure on much of the land, due to transport costs, and makes it impossible to grow some crops on some of the outlying land for fear of larceny.

But though capital is the major need, it is a problem in which care must be taken to remedy, due to the tendency of many peasants to see only the short term advantages. In other words care must be taken to see that the capital is in fact used for the purposes for which it was intended.

Thus the main problem is an economic one, but tied up with this is undoubtedly the problem of finding new and more suitable systems of farming. Here the work of Jolly (1956), provides a means of solving this problem.
PART II: THE FIELD SURVEY.

INTRODUCTION.

The investigations were prompted by the growing need for land in Trinidad, and the consequent need to estimate the value of the poorer lands that are at present little used.

The area taken was one of poor soils to which little attention has been given in the past. It is a peasant area. Three small sample strips were selected for detailed survey, the relationships of these with one another is shown in Map (1). The report of sample strip No. 1 appears below. At the same time other similar investigations were being carried out in an area devoted to a land settlement scheme.

The Aims of the Survey - The aims of the whole survey were to examine in detail a cross section of the soil types present, and to establish representative types for a reconnaissance survey in the future.

The Sample Strip - The sample strip with which this report deals, is situated about 1½ miles from Longdenville, on a piece of land between the Caparo Valley road and the road running down the side of Carlsen (or Edinburgh) Field. The strip is situated upon an area designated by Chenery as McBean Series. The relationship of the strip to the series described by Chenery is shown on Map (1).

The Geology of the Area - According to the geological map that Suter (1954) presents at the end of his report on the Geology of Trinidad, the area is situated on the Pleistocene Gravel Terrace. Though much of the whole survey area is on this type of terrace, nevertheless sample strip No. 1 is on an adjoining alluvial terrace.

METHODS.

The Siting of the Strips - This created some difficulty, as the exact location of the roads of the area was uncertain, and it was considered expedient to site the strips as close to the roads as possible to facilitate access. Also, to ease travelling problems, it was thought desirable to site the strips in groups. The final choice is shown on
The Size of the Strips - It was decided that the area would be spanned by three traverses, each about 880 yards long, and each 176 yards from its neighbour. The traverses were taken as far as the Caparo Valley Road, and there terminated as on the opposite side the land was under sugar cane, and obviously disturbed. Thus time permitted a fourth traverse (traverse D) to be put through. As a result, two of the traverses were about 800 yards long, one was about 400 yards long, and one of intermediate length. Each is 176 yards from its neighbours, at the base line, and they run approximately at right angles to the road or base line.

The Traverse - As the road along the edge of Carlsen Field is straight, it was decided to use it as a base line, and to run the traverses to the east of this, as Estate cane was planted on the other side of it. The road runs approximately north and south, the actual bearing taken by army prismatic compass being 13°. In order to have some fixed point of reference, the start of traverse A was sited at a white concrete post situated at the road side, and standing beside the concrete cover to a part of the water supply system of the area. The concrete post had upon it the following:

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HX
11
401
8
Ft.
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This point was 512 yards from the junction with the Caparo Valley Road. The base points of all the other traverses were chained off from this point, using a 100 ft. Engineer's Chain.

The traverse lines were kept reasonably straight by the use of the prismatic compass, and of Ranging Rods, where the vegetation permitted their use. Save in conditions of open savannah, a straight line had to be cut under supervision.
The only measure of distance used on the traverses was that of pacing. The paces were then checked along the standard length of the base line, and were found to be approximately a yard in length. As each line was traversed, the auger borings, topography and vegetation were surveyed in along the traverse line, using the Double Line Booking method. Any detail lying off the traverse lines was either sketched in where it could be seen, or was mapped in later by interpolation, and after exploration. Thus a composite topographical-vegetation map of the area was made as the survey progressed, the larger maps at the back (Maps (2) and (4)) are direct tracings of this.

The Vegetation - For the sake of uniformity, it was decided to use the following classification for the vegetation on all the strips.

1. High Forest - forest growth over 50 ft. high (none in the area).
2. Secondary Forest - forest regrowth 20 - 50 ft. high, regardless of age.
3. Thicket - forest regrowth 4 - 20 ft. high, with a predominance of upright stems.
4. Tangle - forest regrowth under 20 ft. high, with a predominance of scrambling climbers.
5. Bush Regrowth - first stage of regrowth to thicket or secondary forest, on ground left fallow up to 2 years.
6. Cultivated land - details of the crops grown being given.
7. Broken Forest - tall trees left from earlier cycle, with thicket, tangle, or secondary forest.
8. Savannah - vegetation with predominance of grasses; comprising in this case mainly derived savannah, induced by fire.

The Soils - It was decided at the commencement of the survey that sampling should be done at points along the traverses which seemed most suitable to the surveyor. Subsequently the area proved so uniform that except where the topography changed appreciably, the samples were taken every 60 - 100 yards. At these points, a small hole about 18" deep was dug with a spade. Samples were taken of appropriate levels, as indicated...
indicated by changes in colour. Again at most of the auger points, the profile characteristics as determined by the eye were so similar that it became practice to sample at the following depths: 0-2", 2-4", 4-8", 8-18", and below 18". The samples below 18" were taken by auger boring at the bottom of the hole. The auger used was the standard 1" diameter auger. While in the field, the soil characteristics were described on a standard sheet. The samples were then taken to the laboratory and laid out in bamboo strips, the layers appearing in the sequence in which they had occurred in the profile. These were then grouped by similarity in the laboratory, but the final grouping was also dependent upon the impressions gained in the field.

This is a method evolved by Charter in the Gold Coast, and taken up by Vine et al. (1954) in Nigerian survey. It was evolved for conditions where large numbers of junior assistants were available but comparatively few trained staff. The junior assistants would go out into the field and collect samples at regular intervals, and would bring these back to the laboratory. Here they would be laid out in bamboo strips, and grouped by the more qualified staff. It is a method designed to speed up the work of survey, by enabling the few highly trained staff to devote their attentions to the job requiring the highest degree of training. But it depends upon the presence of large numbers of junior staff. Also, a large number of samples must come in each day, for else one cannot group them when fresh. As a method, it has possibilities for training personnel, for these can try investigations on their own, and can have their conclusions checked by an experienced man when they get back. But a method for experienced surveyors, it takes up more time than is merited by it as a method of checking field conclusions. An experienced surveyor can usually make up his mind in the field. If it is used by a man of experience then it would be wise to limit the number of samples brought in. It may on the other hand, be valuable in correlating the work of several surveyors working as a team in different parts...
Cross-sectional representation of the levels along the Carlsen (Edinburgh) Field Road.

(For Reduced Levels and Distances involved, see the Appendix.)
Having grouped the auger samples, profile pits were sited accordingly, but not necessarily upon the traverse lines. These were sunk to a depth of six feet. These were described in the field, and sampled. The samples were laid out in boxes, arranged on a sliding scale, so that considerable depths could be included, and yet all the profiles would be comparable. Samples from each layer were taken for pH analysis, and mechanical analyses were carried out on some of the samples. The colour was described using the Munsell Soil Colour Charts. Textural estimates were made by hand, using standards for comparison, on those samples that did not go for mechanical analysis.

R E S U L T S.

THE GEOLOGY AND PARENT MATERIAL.

The soil parent material is alluvium. The profile pits show no signs of bedding or of stratification, while in the profile pit that resembles Chenery's SEVILLA CLAY SERIES, there is evidence of sedimentation in still water.

The general geology of the area becomes clearer as one passes along the Carlsen Field Road. From the junction with the Caparo Valley Road, the ground rises from the lower terrace, which is the present flood plain of the river, up to the level on which the survey strip is sited. This, as already stated, is also alluvial, but is of older origin. At about 260 yards from the southernmost traverse, the land after dipping, rises again to the same level, but the area has a different origin. Here, the exposed surfaces at the side of the road show contacts between sedimentary geological beds, sloping downwards at an angle of about $25^\circ$ to the north. The sedimentary beds consist of a coarse sandstone, overlaid by a light grey clay stratum, which in turn is overlaid at the foot of the slope by a bed of quartz pebbles, which forms a spring line. A shallow well is situated at the side of the road at this point.

Most of the sample strip is situated on the level terrace, but
here and there depressions are present which are the extension of the erosion surface as marked by the lower terrace. These are shown on Map (4). The relationships of the terraces to the sample strip are shown in the cross-sectional diagram opposite page 16.

THE VEGETATION.

The distribution of the vegetation types found in the area are shown in Map (2). The main types present are –

- Fire savannah
- Tangle
- Secondary Forest Regrowth.

The Savannah - The main grass present is *Imperata brasilienis*. At the commencement of the dry season, the grass is burned to provide fresh leaves for the few cattle that are grazed upon the area. The burning is undoubtedly responsible for maintaining the area under grass.

Beard (1946) described a vegetation type which he called "Fire Savannah". This savannah vegetation fits that description.

Tangle - This type covers considerable parts of the area. Some of it is burned with the grass, but the rest escapes. Little use is made of it.

This is a transitory vegetation type, and is probably included in Beard's Fire Savannah mentioned above.

LAND USE.

CROPS.

The crops grown include sugar cane, rice, maize, bananas, root crops of various sorts, citrus, and a few coconuts.

Rice - This crop is grown in the depressions during the wet season.

The savannah land, and in some cases the other land is covered by a network of ditches. These ditches form a system to collect the run off water into the depressions where the rice is grown. This run off from the higher ground is the sole source of water for the rice in the area. After the rice is harvested in December or January, the stock are permitted.
permitted to graze the paddies.

The standard of rice cultivation is not high. In some parts where there was clearly insufficient run off to provide the water needed for a whole season, the paddy was choked with weeds, and very little rice was to be seen.

Also, as the success or failure of the crop depends upon the rains, the yields are inclined to be erratic. In this particular season the rains came rather later than usual, so that insufficient water was available in the early stages for growth, and too much was present at harvest. Thus the crop was virtually a complete failure. These conditions are quite contrary to those found in good rice cultivations, where the first essential realised is the full control of the water.

Sugar Cane - Like the rice, the peasant cane was not in a particularly good condition. It was of the thin type, tall, and planted at a high density.

Citrus - The two orchards present were not well managed. The one near the Caparo Valley Road was in a better condition, the weeds being slashed in places, presumably because of its accessibility, while the one on traverse D, was overgrown in all places, and it was a considerable problem to cut one's way through it.

Coconuts - Few coconuts were actually growing on the area, and were only found on the Freeport series near the Carlsen Field Road. In this soil there were many dead coconut roots present indicating that palms may have been grown at some earlier date. On the other side of the Caparo Valley Road was a small grove of coconut palms. These did not appear to be in very good condition. Very few nuts were present, and those that were present were borne singly. Most of the plants seemed to be dying.

Mixed Crops - These comprised bananas, roots (Colocasia antiquorum), maize, pigeon peas and sweet potatoes.

The management of these seemed better than the management of...
the other crops mentioned; the bananas, maize, and root crops on
traverse C looked particularly promising. But despite this improve-
ment the management was not remarkably good. The land upon which these
were growing had clearly just been reclaimed from secondary forest. The
sweet potatoes were grown in the rice paddies during the dry season.
The crop seemed to be reasonable, which might be related to the higher
water table.

LIVESTOCK.

A few cattle and water buffalo are grazed upon the savannah
and parts of the tangle. The burning of the grass is clearly associated
with this utilisation of the savannah, the aim being to provide fresh
green material for grazing. After the rice has been harvested the live-
stock are permitted to graze the stubble. In some instances the live-
stock can be a nuisance, for unless carefully watched they may wander on
to an unharvested patch of rice, and completely destroy that crop.
This may result from intentional loose tying of the animals, or it may
be just thoughtlessness on the part of the owner of the animals, who
may have harvested his own adjacent rice plot, and have forgotten that
his neighbour had not yet done so.

THE SOILS.

Map (3) shows the distribution of the soil types found in the
area. There are four types –

Two variations of the Freeport series,

Savilla Clay,

The Depression Soils.

The Freeport Series.

The greater part of the area is covered by two variations of
the Freeport series, one of which is called a silty sub-series. There
is no McBean present.

Chenery (1952) distinguished these two series on the basis of
texture, the McBean having a layer of top soil which is a yellowish
brown sand, while the Freeport series has a yellowish brown clay to loam top soil.

On the basis of texture, the present investigation places all the soil types with the exception of the Sevilla Series and the depression soils as types of the Freeport Series, for the texture of the top soil is that described as a silt loam. But Chenery also distinguished these two series by the depth of the yellowish brown top layer. According to his descriptions, the McBean series has a top layer of about 36" depth, while the Freeport series has a top layer of about 10" in depth.

In this survey two variations in this characteristic were found; one with a dark yellowish brown top layer descending to 8", while in the other the layer descended to 16". Both these variations agree more closely with the Freeport series than with the McBean series as described by Chenery. These two types are fairly readily distinguishable from one another.

Chenery regarded the McBean and Freeport series as being closely related, and he mapped considerable areas as a complex of the two. The fact that in so small an area these occur to variations of the same series indicates that there may be very many variations of these two series. There may be a case for the amalgamation of the two series, and the recognition of several subseries of one series. Whether this should be done is not a question that it is possible to answer after a short investigation of this sort. To answer it, other investigations should be carried out, including detailed laboratory work, and field experimentation with crops and livestock. One thing that would be necessary is a detailed investigation into the textural variations present in the soils.

There follows a description of the two Freeport types present, and the analysis of two of the profiles.

**Freeport Series: General Description.**

The soil is a dark brown to yellowish brown silt loam. It is found beneath savannah and tangle. The structure is subangular blocky and a macrostructure of cracks is clearly visible in the profile during
the dry season.

The rooting zone is in the top 8", but root penetration occurs to 48". The high silt content of the soil suggests that the retentive capacity of the soil for water is low, which is borne out by the rapidity with which the grass dried out at the commencement of the dry season. During the wet season the amount of run off during the storm indicated that the permeability of the soil under savannah is not very great. This one would expect in a soil having a high silt content.

These two considerations indicate that the soil is deficient in water during the dry season.

The aeration of the top 8" is good. Below this, the presence of mottles indicates that the aeration is not so good. Yet the penetration of roots throughout the profile indicates that the aeration is not a limiting factor to plant growth. Also earthworms are very active in this soil, and a species is present that casts on the surface, but too much weight should not be placed upon this, for on the Aripo Savannah they abound, and yet the ground is waterlogged.

This is one of the best soils in the area, but considerable applications of fertilisers may be needed to obtain economic returns, as is the case on the adjacent cane lands.

Profile Description and Analysis.

Profile Pit No. B II. Vegetation — savannah.


4 - 8" Silt loam. Colour is yellowish brown. (10 YR 5/8).

8 - 18" Silty clay loam. Structure angular blocky, large cracks present. Yellow background colour. (10 YR 6/6), with reddish yellow and light grey mottles. (7.5 YR 7/6 and 7.5 YR 7/0). Roots are fewer.

18 - 36" Silty clay. Cracks larger giving coarse blocky structure, microstructure angular blocky. Colour greyer, with reddish...
yellow mottles. (7.5 YR 7/0 and 5 YR 6/8). Roots few.

36 - 50” Silty clay loam. Cracks fewer and smaller. Colour generally greyer, with yellowish red mottles. (2.5 YR 7/0 and 2.5 YR 5/8). Few roots present.

50 - 68” Silty clay. No structure. Colour is almost uniform grey, with some strong brown mottles. (7.5 YR 7/0 and 7.5 YR 5/8). Roots few to none.

At 68” standing water, not known if it is water table or rain water unable to drain.
### PROFILE PIT B II

#### Vegetation - Savannah

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>Dry %</th>
<th>V %</th>
<th>Clay %</th>
<th>Silt %</th>
<th>Coarse Clays</th>
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#### Texture (U.S.A.)

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<th>Depth (mm)</th>
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<th>Fine Loam</th>
<th>Silt</th>
<th>Fine Clay</th>
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<td>36.0</td>
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<td>0.8-1.0</td>
<td>27.7</td>
<td>23.3</td>
<td>30.2</td>
<td>25.7</td>
<td>25.7</td>
</tr>
</tbody>
</table>

#### Description

- **Vegetation - Savannah**
- **Soil Type:** Silt Loam
- **Clay Content:** 30.2%
- **Silt Content:** 33.1%
- **Sand Content:** 41.9%
- **Coarse Clays:** 25.7%
- **Depth Range:** 0-174 mm
- **Soil Structure:** Granular to blocky
- **Colour:** Brownish-yellow
- **Organic Matter:** Present
- **Roots:** Old coconut roots
- **Cracks:** Diagonal and horizontal
- **Texture:** Sandy loam
- **Water Condition:** Slightly waterlogged

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The table shows the distribution of soil components at different depths, indicating a well-drained and fertile soil suitable for Savannah vegetation.
The Freeport Silty Sub-Series: General Description.

The soil is a dark yellowish brown silt to silt loam. It is found beneath secondary forest, tangle and savannah. The structure of the soil is mainly sub-angular blocky, and cracks are plainly visible in the profile during the dry season.

The main rooting zone is in the top 8-16", but some roots extend to below 48". The general remarks concerning the water condition and aeration of the other Freeport type, apply here.

Profile Description and Analysis.

Profile Pit No. B I. Vegetation - savannah.

The textural classes were estimated by hand.

0 - 4" Silty loam. Structure is sub-angular blocky to granular.

Surface colour black to brown, becoming dark yellowish brown with depth. (10 YR 4/4). Grass roots and rhizomes are abundant. Coconut roots also abundant.

4 - 8" Colour lightens to yellowish brown. (10 YR 5/4).

8 - 16" Structure is more compacted. Colour is brownish-yellow. (10 YR 6/6). Grass roots fewer, old coconut roots the same.

16 - 24" Loam. Large vertical, horizontal and diagonal cracks present, microstructure sub-angular blocky. Background colour as above, also mottles appearing. Roots fewer.

24 - 33" Clay loam. Structure is angular blocky. Clay skins on faces of larger structural units, which are large and square.

Horizontal and vertical cracks. Light grey with red mottles. (7.5 YR 7/0, 10 R 5/8). Mainly dead coconut roots.

33 - 48" Clay to silty clay. Angular blocky structure. Colour is greyer, fewer yellowish red mottles. (7.5 YR 7/0, 5 YR 5/8). Old roots pinkish colour.

48 - 70" Clay to silty clay. No structure. Colour grey (10 YR 6/1) with reddish yellow concretions of limonite (5 YR 6/8). Few roots. At 70" some sandy material as water containing lenses.
PROFILE PIT B I.

Vegetation - Savannah.

<table>
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<tr>
<th>No.</th>
<th>Depth (ins)</th>
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<th>O.M. %</th>
<th>N %</th>
<th>C/N</th>
<th>Avail. P_{2}O_{5} (%)</th>
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<td>11.2</td>
<td>1</td>
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<td>168</td>
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<td>2</td>
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<td>2</td>
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<tr>
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<td>2</td>
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<td>171</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>172</td>
<td>48</td>
<td>4.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>173</td>
<td>70</td>
<td>4.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Profile Pit No. B III. Vegetation - secondary forest.

0 - 4" Surface leaf litter dark brown to black colour. Silt to silt loam. True crumb structure beneath individual trees; elsewhere granular, granules friable owing to sandy texture. Colour dark brown, (10 YR 4/3). Tree roots abundant, especially the laterals. Worm holes present, darker top soil has fallen down some into the lower layers.

4 - 10" Silt Loam. Structure more massive granular. Colour is light yellowish-brown, (10 YR 6/4). Fewer roots, mainly decrease in the number of laterals.


15 - 24" Silty clay loam. More cracks in soil, producing a columnar macrostructure, with medium angular blocky microstructure. Clay skins cover the structural units. General colour greyer, (2.5 YR 5/0); red mottles become deeper (2.5 YR 5/8, 7.5 YR 6/8).

24 - 36" Silty Clay. Grey colour becomes more general (7.5 YR 7/0). Fewer reddish yellow and yellowish red mottles. (7.5 YR 7/8, 5 YR 5/8).
36 - 48" Clay Loam. Number of cracks decreases. Colour grey (7.5 YR 7/0) with few yellowish red and red mottles. (7.5 YR 6/8, 2.5 YR 4/6).

48 - 70" Silty Clay. No structure. Colour grey (7.5 YR 7/0) with reddish yellow and red concretions, probably limonite. (7.5 YR 6/8, 2.5 YR 4/6).

At 70" lenses of wet sand present.
<table>
<thead>
<tr>
<th>No.</th>
<th>Depth (ins.)</th>
<th>Gray &amp; Stones</th>
<th>Int. Silt 0.02-0.002</th>
<th>Int. F.S. 0.02-0.002</th>
<th>C.S. 0.2-0.02</th>
<th>Int. Silt 0.02-0.002</th>
<th>Co.</th>
<th>Class (USDA)</th>
<th>%</th>
<th>pH</th>
<th>O.M. %</th>
<th>N %</th>
<th>C/N</th>
<th>Avail. P2O5 (ppm)</th>
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<tbody>
<tr>
<td>181</td>
<td>4</td>
<td>-</td>
<td>43.0</td>
<td>37.0</td>
<td>46.3</td>
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<td>Silt</td>
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<tr>
<td>182</td>
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<td>-</td>
<td>36.0</td>
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<td>75.8</td>
<td>14.5</td>
<td>Silt Loam</td>
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<tr>
<td>183</td>
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<td>-</td>
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<td>31.2</td>
<td>42.8</td>
<td>0.1</td>
<td>11.6</td>
<td>65.2</td>
<td>23.1</td>
<td>Silt Loam</td>
<td>4.5</td>
<td>0.6</td>
<td>0.07</td>
<td>5.2</td>
</tr>
<tr>
<td>184</td>
<td>24</td>
<td>-</td>
<td>37.3</td>
<td>20.9</td>
<td>25.3</td>
<td>3.1</td>
<td>4.4</td>
<td>58.2</td>
<td>37.3</td>
<td>Silty Clay Loam</td>
<td>4.7</td>
<td>0.3</td>
<td>0.07</td>
<td>2.8</td>
</tr>
<tr>
<td>185</td>
<td>36</td>
<td>-</td>
<td>37.3</td>
<td>14.7</td>
<td>16.4</td>
<td>0.1</td>
<td>1.7</td>
<td>52.0</td>
<td>46.2</td>
<td>Silty Clay</td>
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<td>186</td>
<td>48</td>
<td>-</td>
<td>21.7</td>
<td>23.4</td>
<td>45.8</td>
<td>0.2</td>
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<td>45.1</td>
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<td>Clay Loam</td>
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<td>187</td>
<td>70</td>
<td>-</td>
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<td>25.1</td>
<td>0.1</td>
<td>6.9</td>
<td>52.7</td>
<td>40.3</td>
<td>Silty Clay Loam</td>
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<td></td>
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<tr>
<td>188</td>
<td>70</td>
<td>Sand lens at 70&quot;</td>
<td>18.1</td>
<td>22.0</td>
<td>62.6</td>
<td>0.3</td>
<td>40.6</td>
<td>40.1</td>
<td>19.0</td>
<td>Sample of lens of sandy material at 70&quot;</td>
<td>5.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The movement of clay down these profiles is clearly demonstrated both by the mechanical analyses and the presence of clay skins over the faces of the structural units. In the silty sub-series profile (B III) that was analysed, the region of accumulation seemed to be from 16" downwards, reaching a maximum between 24" and 36". In the Freeport profile B II, the region of accumulation was from 8" to 36". These may be considered as "B" horizons.

The silty sub-species profile has a much higher content of silt in the upper 16" and correspondingly less clay, than the main Freeport type found.

The organic matter content tends to decrease more rapidly with depth beneath the forest than beneath the savannah, which one would expect, for grass roots tend to diminish in quantity more gradually with depth than do those of the forest trees. The values for the nitrogen content are usual, and little difference exists between the profiles.

The low clay content of these soils indicates low cation exchange capacity, which one might expect to be reflected in the amounts of fertiliser required to give economic yields; that is, one might expect the fertiliser requirements to be high.

THE SEVILLA SERIES.

There is present in the area a small pocket of Sevilla Clay soil. This differs from Chenery's Sevilla Clay series in that the colour is like that of the Freeport series as far as 48", whereas Chenery describes it as an olive-brown clay. This soil obviously contains more clay than the Freeport series for when it dries it tends to crack more than the others, and these tend to be larger. The diagnostic features of this soil used in the survey to distinguish it from the Freeport soils encountered are -

(a) The streaky nature of the clay material below 48", which indicates a lacustrine or mangrove swamp origin, but this is not an invariable characteristic of the soil;
(b) The presence of calcium carbonate concretions in the layer below 48". This feature immediately separates it from the Freeport soils;

(c) The clayey texture of the soil.

This soil shows signs of seasonal flooding and a perched water table in the wet season. However this may be due to the puddling effect of the stock which are grazed upon it at all times. But whatever the cause of the seasonal waterlogging, the observation agrees with Chenerfy's observations.

The Sevilla Series: General Description.

The soil is a yellowish brown loam clay loam to silty clay. It was found beneath a tightly grazed pasture in front of a house. The structure of the surface is non-existent, the heavy grazing which it receives, puddles it to such an extent that during the rainy season there is standing water present. Below the surface 2", the structure becomes sub-angular blocky to blocky. The nature of the cracking indicates the higher clay content of the soil, and it seems likely that in the wet season it is not very permeable to water, while in the dry season it would tend to become very hard and difficult to work.

The roots are stunted mainly in the top 2", where they form a sod layer, but some grass roots penetrate even to below 48". But the nature of the clay at this depth indicates that the conditions are not very favourable to root growth. The poor condition of the soil is further indicated by the absence of worm activity, but whether this is due to the soil itself or to the treatment which it receives is not known.

Thus, though the retentive capacity for water is probably high owing to the high clay content, nevertheless penetration and drainage are impeded and aeration is not good. Much tillage would be necessary if this soil were to be used.

Profile Description and Analyses.
Profile Pit D I. Vegetation - short grazed grass.

The textural estimations were made by feel in the hand.

0 - 8" Loam clay loam. Soil hard and compact, below 2" sub-angular blocky structure. Colour is yellowish-brown (10 YR 5/6), red and grey mottles present at surface. Root channels rust coloured. Grass roots abundant, forming sod at 0-2".

8-16" Silty clay. Colour brownish-yellow (10 YR 6/6).


36 - 48" Clay. Colour grey with brownish-yellow mottles (7.5 YR 7/0 and 10 YR 6/6). Roots few.

48 - 70" Clay. Structure coarse angular blocky. A layer of grey clay, with thin wavy reddish yellow streaks (7.5 YR 6/0 and 7.5 YR 6/6). A few roots are still present. Calcium carbonate concretions are abundant.

PIT NO. D I.

Vegetation - tightly grazed grass.

<table>
<thead>
<tr>
<th>No.</th>
<th>Depth (ins)</th>
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<th>O.M. %</th>
<th>N %</th>
<th>C/N</th>
<th>P2O5 (Truog) Avail.</th>
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</table>
THE DEPRESSION SOILS.

Chenery makes no mention of these, which is not surprising, as they must occupy a very small area in comparison to the whole that he covered. But in a detailed survey such as this they deserve attention.

In general they have a much darker melanised layer at the surface than the other soils mentioned, which is probably due to the influence of a higher water table which is sometimes to be found at the surface. As might be expected the root channels show rusty colourations. At 6" the usual mottling makes its appearance. In other respects they resemble the Freeport series, excepting that the material tends to become greyer at a higher level.

In certain respects these soils are artificial, for if the land were not used for rice cultivation, then the water would be allowed to run off freely, and the soils present might be typical Freeport series. Also it should be remembered that the road has a compacting effect upon the layers of soil beneath it, and thus upon the drainage of the area, so that the situation regarding these soils is by no means clear or easy to interpret.

The Depression Soils : General Description.

The soils vary considerably, but in general may be described as a very dark brown loam. They tend to have more clay in the profile than the corresponding soils at the higher level. They are found either beneath tangle, or under rice. A predominant factor in their formation is the presence of a seasonal high water table. In the dry season, the water table descends to about 4½ feet. There is little structure in the surface layers, but below 9" the structure tends to become sub-angular blocky.

The roots are to be found mainly in the surface layers, while between 30" and 40" they tend to die out.

The retentive capacity of these soils for water is better than that of the soils on the higher adjacent land, by virtue of their higher clay content.
content. The growth during the dry season was better on this land, but this might be due also to the higher water table.

The puddled surface reduces the drainage, but the structure of the lower layers indicates that if this layer were broken up, then the drainage would be good. The improvement of drainage ultimately depends upon being able to drain adequately the whole depression site, i.e., to provide good drainage across the road.

Profile Description.

Profile Pit No. B IV. Vegetation - Long grass near rice paddy.

Textural estimations done by hand.

0 - 3" Loam. Structure none. Colour very dark brown (10 YR 3/2) with red root channels. (2.5 YR 4/6). Grass roots present.

3 - 6" Loam. Structure is poorly sub-angular blocky to powdery. Colour is a mixture of dark grey brown (10 YR 4/2) and very dark grey (10 YR 3/1) with red root channels (2.5 YR 4/6). Roots present.

6 - 9" Clay loam. Large vertical cracks present, structure sub-angular blocky. Colour as above.

9 - 18" Clay to silty clay. Large cracks more numerous, structure coarse sub-angular blocky. Colour is equal mixture of yellowish-brown and grey (10 YR 5/6 and 10 YR 6/1). Roots fewer.


40 - 55" Clay. No macrostructure, but microstructure coarse sub-angular blocky. Colour grey (7.5 YR 6/0), with yellowish-brown concretions of limonite (10 YR 5/6). Patches of sand are present. Water table is at 55".

55 - 60"+ Clay. Colours same.
These data refer to the Profile Pit No. B IV of the Depression Soils.

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<th>pH</th>
<th>O.M. %</th>
<th>N %</th>
<th>C/N</th>
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</table>

Samples 293 and 294 had some concretions of calcium carbonate present. Samples 291 and 292 were highly alkaline, without calcium carbonate being present in quantities which might cause effervescence, with dilute hydrochloric acid. Possibly, the highly alkaline nature of these layers is due to the presence of sodium in the soils.

The behaviour of the lower layers in hydrochloric acid indicated the presence of an expanding lattice clay.
CONCLUSIONS.

1. The main soil of the sample strip is not McBean Series, but Freeport Series.

2. In morphology it seems very typical of the soils one finds in areas mapped as McBean, though too little work has been done to say what textural variations are present in soils of this type.

3. The soils of the sample strip No. 1 discussed above are amongst the best in the area. Also areas that are mapped as McBean and Freeport are being used by the sugar companies for cane. Thus, if this area is to be developed, then attempts should be made to locate these areas of McBean and Freeport. In the past, these areas have not been of great economic importance, and so less attention was given to their accurate mapping.

4. Some attempt should be made in the laboratory to sort out the textural variations present in the McBean and Freeport series. Probably much of the confusion regarding these soils arises from too little precise and objective laboratory work.

5. Field experimentation, pot tests, and livestock experiments should be conducted on these soils, in order to make a more accurate assessment of their value. This is the stage which should follow the location of soils.


### APPENDIX.

**LEVELS ON THE CARLSEN (EDINBURGH) FIELD ROAD.**

Distances are measured by Engineer's Chain from the first manhole cover on the Pleistocene terrace. Heights are relative to an assumed height of 100 feet at the concrete block in which the manhole cover is set.

<table>
<thead>
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<th>Distance (ft.)</th>
<th>Height (ft.)</th>
<th>Remarks</th>
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<td>First concrete cover to water system on Pleistocene Terrace.</td>
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<tr>
<td>48</td>
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- **Road bends for 107'.**
- **Junction with Caparo Valley Road.**
- **Concrete water cover by Caparo River Bridge. Inscription on side was - Hx 8.75 9.5 ft. Water was 10.80 ft. below this point.**
ACKNOWLEDGMENTS.

I would like to thank Dr. H. Vine for his help throughout the project, and Mr. G.S. Rodrigues for the interest he has shown, and for doing the analyses.
MAP I. SHOWING THE RELATIONSHIP OF THE SAMPLE STRIPS TO THE SOILS AS MAPPED BY CHENERY.

To Lonedenville.

CUNUPIA clay loam to silty clay. 17.

Mc. BEAN sands to loams. 26.

SAMPLE STRIP No. 1.

SEVILLA clay. 16.

CARPARE VALLEY ROAD.

LONG STRETCH. Fine sandy clay to silty clay. 39.

EBRANCHE clay. 19.

LAS LOMAS sands to loams. 41.
MAP 2. THE VEGETATION.

LEGEND.

- **SECONDARY FOREST**
- **RICE**
- **TANGLE**
- **CITRUS**
- **SAVANNAH**
- **SUGAR CANE**
- **MIXED CROPS**
- **SHORT GRASS**
MAP 3. THE SOILS.

LEGEND.

- FREEPORT SILTY SUB-SERIES.
- FREEPORT SERIES.
- SEVILLA SERIES.
- DEPRESSION SOILS.
MAP 4. THE DEPRESSIONS, DRAINAGE, AND DWELLINGS.

LEGEND:
- X Dwellings Place.
- → Direction of Drainage.
- Depression
  - Higher Level Ground

Scale:

100  200  300  400  500 yards.