SOILS

Prof. E. W. Hilgard,
With the author's compliments.
March 1910.

A STUDY

OF THE

AGRICULTURAL SOILS

OF THE

CAPE COLONY.

BY

CHARLES F. JURITZ, M.A., D.Sc., F.I.C.,

Senior Government Analyst of Cape Colony; President of the Chemical and Agricultural Section of the S.A. Association for the Advancement of Science; Past President of the Cape Chemical Society, &c., &c.

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PREFATORY NOTE.

The investigations into the nature and composition, from an agricultural point of view, of the soils of the Cape Colony, suggested and initiated by the writer and carried on in the Government Analytical Laboratory under his direction, constitute the only work of the character ever undertaken in this country. Previously to their commencement a few isolated analyses of Colonial soils had been made, some by Professor Hahn—amongst which are those quoted on page 124—and some by the writer himself, but these were scanty and disconnected. Never before had any systematic investigational work of the kind here recorded been attempted. Even now, having regard to the Colony's vast extent, the number of soils examined is all too small, but the work has now reached a stage from which it is well to pause and look back before proceeding further. The results hitherto obtained are therefore collated here in the hope that the utility of the work may thus be established and a desire created for its continuance and extension.

C. F. J.

Government Analytical Laboratory,
Cape Town, 12th November, 1907.

CONTENTS.

PART III.—RESULTS OF CHEMICAL ANALYSES—(*contd.*)

A STUDY OF THE AGRICULTURAL SOILS OF CAPE COLONY.

PART I.—INTRODUCTORY.

Van Helmont, three centuries ago, demonstrated, to his own satisfaction, that *water* was the sole source of plant food. Digby, fifty years later, ascribed the nutrition of plants to a mysterious principle in the *air*, and refused to consider water as anything more than a mere vehicle for the conveyance of this principle. Yet another half-century, and both these theories were rejected by Tull, who put forth the view that the *soil particles* constituted all the nutriment that the plant needed. He held, however, that, in order to be available as nutriment, these particles had to be extremely minute. Scarce a century has passed since Thaer promulgated the doctrine that the source of plant food was nothing other than *humus*,—a doctrine that commenced to be undermined by Saussure while still in its infancy, and was completely pulverised by Liebig when propounding his mineral theory half a century later. According to Liebig not the organic, but the inorganic, or *mineral constituents* of the soil served to build up the vegetable structure.

Fifty years have passed since the day of the great German chemist, and at present the tendency is to lay emphasis on no single one of the various views alluded to above, but to regard them all as partially true. The worth of the mineral constituents of plant food is almost universally accepted; but not to the entire rejection of organic matter as a valuable agent in determining a soil's fertility. The mechanical subdivision of the soil by sifting, sedimentation, or elutriation, is the modern counterpart of the views put forward by Tull. In the fixation of atmospheric nitrogen by bacteria we may trace a reflection of Digby's theory; and the recent investigations of Whitney and others in the United States of America have led them to conclusions which, in an embryonic state, lay hidden within the water theory of Van Helmont.

It is, nevertheless, erroneous to affirm—however much it may *seem* to be the case—that modern investigators have reverted to the opinions held by their predecessors two or three centuries earlier. It is not only in connection with agriculture that chemical science may appear to have moved along a circular pathway, and yet the striking theories which have resulted from the investigations into the nature of radio-activity, for instance, do not by any means imply that the scientists of our day have retreated to the alchemists' notions respecting the philosopher's stone and the transmutation of metals. We may be trending back to the same vertical line of thought, so to speak, without proceeding along the same dead level: it is not a circle but a helix that marks out the path whereby science has led its students. It is of importance to recollect this, for, unless we do so, the lay mind may be misled into thinking that, because in some respects Liebig was wrong, Van Helmont was necessarily in all respects right. The direct consequence of Liebig's mineral theory was the view that the fertility, if not the productiveness, of any soil could be inferred from a complete chemical analysis of that soil. This view, it is on all hands conceded, overstates the facts, but to conclude, *from this concession*, that chemical analysis of soils, no matter how made and applied, is valueless, would be a betrayal of ignorance in regard to the general tendency of all subsequent research.

Assuming, without argument for the present, that chemical analyses of soils have *some* value, the way along which such analyses should proceed may very pertinently be discussed. But before this can even be considered it becomes necessary to enquire more closely into the method by which nutriment is conveyed to plants. Van Helmont, as has been seen, attributed this function wholly to water, a view which was vigorously contested by Liebig, who ascribed the preparation of the food of plants from the mineral constituents of the soil to the acid excretions of the roots themselves. As hinted above, there is a strong inclination in some quarters to-day to accept the substantial correctness of Van Helmont's theory, at all events in an expanded form.

A considerable recession has taken place from some of the views which found currency when first Liebig's mineral theory became widely accepted. Thus the complete chemical analysis of a soil has, for more than a score of years, ceased to be reckoned an index of fertility. Chemists of a later day, alive to the fact that the roots of plants are not able to absorb from the soil *all* the plant food constituents there present, began to modify the character of the solvents used in the laboratory for extracting this nutriment: they accordingly directed their endeavours towards extracting from the soil only such constituents, and those only in such quantities, as the plant rootlets are actually capable of withdrawing. The proportions of plant food constituents thus removed were said to be present in the soil in a form "available" to plants. Whatever the quantity of plant food there may be in any soil, unless it was present in a form *available to the plant*, it could as well, for all practical purposes, be non-existent. As soon as this view began to be held, it became necessary, if the analysis of a soil was to have any value for agriculturists, to employ weaker solvents than those at first adopted,—solvents, obviously, that would simulate the action of the plants themselves. That was the procedure which Professor Cossa urged in 1866.

Now arose the problem of finding suitable solvents: various proposals were made, and, for the purpose of putting their adaptability to the test, constant and prolonged comparisons between laboratory and field experiments were rendered necessary. A full discussion of these would be needless here; suffice it to say that the German experiment stations adopted Hydrochloric acid diluted to a certain degree, and left in contact with a specified weight of soil, for a definite period of time, at a fixed temperature. At Halle a method of determining available phosphoric oxide in soils, by extracting it with citric acid solution, was introduced, and has since become generally recognised for that purpose, the whole scientific world over. An extension of this method was proposed by Dr. Bernard Dyer in 1894, and is now usually associated with his name. Of late years American investigators have begun to employ very small proportions of pure water, basing their practice on the view that the soil water is the only true medium for the conveyance of mineral salts to the plant.* The variable root-action of different plants rendered all the more complex the problem of discovering a solvent that would suit all cases.

Ere long one of the fundamental principles of Tull's theory was admitted to due recognition. Obviously no plant food constituents in a soil could be considered as "available" when present in compact impermeable masses: hence became clear the advisability of agreement with regard to the size of soil particles to be included in any determination. The result was a consensus of opinion that no plant food substances in any soil could be held to be available unless they were contained in soil particles not exceeding a definite maximum diameter. It therefore became customary, when analysing a soil for agricultural purposes, to pass it through a sieve of standard mesh before proceeding with the chemical analysis, disregarding for that purpose all that failed to pass through.†

Scientific progress with regard to the chemistry of agricultural soils had about reached this stage when the circumstances occurred which led to the writer's undertaking the systematic investigation of the soils of the Cape Colony. How this came about may be very briefly explained.

In 1890 the writer was engaged, in connection with the Fellowship granted him by the University of the Cape of Good Hope, in the analysis of specimens of oathay from various parts of the Colony, and, in commenting upon the results of his investigations, made use of the following words:

"Another noteworthy fact, one which our farmers should bear in mind, is this, that the oathay from the Western Province contains an exceptionally small amount of lime, this being due entirely to a deficiency of lime in the soil, a deficiency which it becomes absolutely necessary to meet by the artificial application of lime manures to the soil. . . . The sample of oathay from Port Alfred contained an exceedingly small quantity of phosphoric oxide, and to this, doubtless, is due the poor appearance of the sample, its weight being about one-fourth, or less, of what it should have been under normal conditions. I have been informed that the Veterinary Surgeon holds the opinion that the cattle diseases in this district are probably due to a deficiency of phosphates in the food, and the results of these investigations appear to confirm that view; in fact, judging from the analyses of the plants only, I should say that the soil of the Colony generally appears to be rather poor in phosphates."

In the case just quoted the oats had been found to contain so little phosphoric oxide as to cause wonder that such dwarfed and sickly-looking plants had reached maturity at all, and the natural conclusion at the time was that the soil upon which the cereal crop was grown was likewise deficient in phosphates, and that, consequently, the opinion, said to have been expressed by the Government Veterinary Surgeon, was, at any rate, likely to be correct. In addressing a public meeting shortly afterwards, the writer took occasion again to refer to the subject, and then observed: "I do not regard the matter as settled satisfactorily, and commend it to the attention of the Grahamstown Agricultural School, hoping that ere long proper investigations will be made and the mystery cleared up."

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* "It seems entirely unnecessary, in studying the question of the nutrition and yield of crops, to introduce artificial digestion media known to attack minerals very slightly soluble in water, while it seems perfectly logical to accept the nutrient solution as it exists in the soil as the basis for the support of plant life, and to investigate the question along this line. In other words, it has seemed best to consider the soil as a culture medium containing a nutrient solution—that is, to regard the soil moisture as a proper and sufficient medium for the feeding of plants, and the soil as a reservoir and distributing agent for this solution." (M. Whitney & F. K. Cameron: "The chemistry of the soil as related to crop production." 1903, p. 15).

"The delivery of water from the soil to the plant must receive more consideration in future chemical studies of soils for the reason that it is the mechanism by which the mineral nutrients are supplied to the plant, and it is evident that if the delivery be small the plant will suffer not only for water itself, but also for the mineral food which the water supplies, even though ample quantities may be present in the soil solution, and in what would usually be regarded as readily available form" (*Ibid.*, p. 55.)

† But see also page 13.

About a year later the Government Analytical Laboratory was placed under my charge, and the opportunity was thus afforded me of putting the views above expressed into practice. Almost immediately some samples of soil, from the part of the Colony particularly referred to, were received for analysis, and then was confirmed the opinion previously put forward that the soil in the neighbourhood was very poor in phosphates, and that, in consequence of this, the fodder there grown would probably be found similarly deficient, and would influence animals feeding upon it in a very serious manner, inasmuch as phosphates were absolutely necessary for the formation of bone material. Further investigations were forthwith put in hand: other soils from the Albany Division, and from the neighbouring Division of Humansdorp, were subjected to analysis, and the results served to lend additional confirmation to my previous views. The use of phosphatic fertilisers for the districts named was therefore urged, and it was also suggested that farmers round about should learn to utilise bone manure as generally as possible.

The time seemed to have come for more decided action; representation was accordingly made to the Government that the primary cause of the deficiency of phosphates in the crops lay in an almost entire absence of the former from the soil, and that this deficiency, it was at least likely, if not absolutely certain, was at the root of all the "lamziekte" that those districts of the Colony were being plagued with. It was, moreover, pointed out by me how beneficial fuller information respecting the various soils of the Colony would be, and investigations, with the object of eliciting some such information were recommended to be undertaken without delay. Assurances of support on the part of the Government were readily given, and in 1893 operations were commenced. The north-eastern portion of the Cape Division was first visited, then the Malmesbury Division: after that the Caledon and Bredasdorp Divisions were taken in hand; later on those of Robertson, Swellendam, Riversdale, and Mossel Bay, and ultimately George, Knysna, Uniondale, and Oudtshoorn; while in the meanwhile, in compliance with reiterated requests, a visit was paid to some of the Eastern Province Divisions before the work was finally stopped by the war, since when it has not yet been resumed. Along its entire course, however, the systematic investigation of the soils of certain districts has been supplemented by numerous casual analyses of specimens taken, as occasion and opportunity offered, from several localities not included up to the present in the regular soil survey.

With regard to the organisation of a comprehensive scheme of soil investigation, such as that of which we felt the desirability, it is but seldom that an opportunity offers for the satisfactory carrying out of one's ideals; the limitations of funds, of qualified assistants, and of equipment in this case precluded all hope of following up the preconceived plans otherwise than in a slow and plodding way. The work was commenced by the writer entirely single-handed, but as, with the building up of a then newly-established laboratory, calls on his time increased, a great portion of it had, of necessity, to be performed by deputy; never at any time was it possible to spare more than one person for the investigation, so that all that is here recorded may be taken as representing, from first to last, including the minutest details, one man's work during the period comprehended therein.

PART II.—AGRICULTURAL CHEMICAL METHODS.

It was assumed, without argument, on a previous page, that the chemical analysis of soils had *some* value. Just what that value is, and on what conditions it depends, may to a limited extent be discussed later; but it may here be convenient to allude to the fact that there are those who would deny that it possesses any practical utility whatever. Thus Wallace* remarks:—

"No analyst, using the ordinary processes for soil analysis, can determine whether or not such infinitesimal amounts as are required by the crops are present or are not present in an available form in the soil."

Professor Whitney† again observes:—

"It appears, further, that practically all soils contain sufficient plant-food for good crop yield; that this supply will be indefinitely maintained, and that this actual yield of plants adapted to the soil depends mainly, under favourable climatic conditions, upon the cultural methods and suitable crop rotation . , ... and that a chemical analysis of a soil, even by these extremely delicate and sensitive methods, will in itself give no indication of the fertility of this soil or of the probable yield of a crop, and it seems probable that this can only be determined, if at all, by physical methods, as it lies in the domain of soil physics."

On the other hand, Professor Hilgard§ has the following:—

"Whitney (Bull. 22, U.S. Bureau of Soils) claims, on the basis of a large number of (three minute) extractions of soils made with distilled water, that these solutions are essentially of the same composition in all soils; that all soils contain enough plant-food to produce crops indefinitely, and that the differences in production are due wholly to differences in the moisture supply which he claims is, aside from climate, the only governing factor in plant growth. The tables of analytical results given in Bull. 22 fail to sustain the first contention; the second is pointedly contradicted both by practical experience and by thousands of cumulative culture experiments made by scientific observers; the third fails with the second, except, ot course, in so far as an adequate supply of moisture is known to be an absolute condition both of plant growth and the utilization of plant-food. It is, moreover, well known that it is not water alone, but water impregnated more or less with humic and carbonic acids, that is the active solvent surrounding the plant root."

Granting that the chemico-agricultural analysis of soils is not an absolute but a relative method of estimating their fertility—a point that will be reverted to later—it will at once be seen that such a survey of this Colony's soils as was proposed necessitated the adoption of uniform, or, at least, of comparable methods of procedure throughout. In order, furthermore, to enable comparisons to be drawn between our results and those obtained in other parts of the world, or with those arrived at by other analysts in this country, it becomes requisite fully to describe the actual mode of procedure adopted. From the first it was realised that the investigations would extend over many years, even without the unforeseen interruptions which were subsequently caused by war and financial depression. It was practically certain also that, with the advance of scientific knowledge, there would be improvements in manipulation during the course of the survey, and it was therefore recognised as most desirable to adopt stated methods at the outset, and to adhere to them in all essentials throughout the whole series, a course without which results could not be strictly comparable amongst themselves. The great obstacle in the way of this was the fundamental differences which exist between agricultural methods of operation in this country and those practised in the northern hemisphere, where alone opportunity has hitherto offered of comparing laboratory results with field experiments. To do this as it really needed to be done would have involved years of preliminary work; not to do it might waste years in the employment of unsuitable analyti-

* "Rural Economy and Agriculture of Australia and New Zealand," p. 169.

† "The Chemistry of the Soil as related to crop production," 1903, p. 64.

§ "Soils: Their formation, properties, composition, and relations to climate and plant growth," 1906, pp. 321, 322.

cal methods: some sort of compromise accordingly became inevitable, and a standard method was adopted and compared from time to time with one or two other methods, which will also be fully delineated in the sequel. How well the method taken as a standard has fitted in with the climatic conditions of the country is shown by the repeated agreement between laboratory results and the recorded experiences of the practical farmer. The alternative course which was open was to adopt improvements in analytical methods as they arose, and thus ensure in all respects up-to-date modes of manipulation, but coupled with an inevitable unconformity to the earlier results of the series.

In describing the methods employed the collection of soil samples claims first attention. Dr. Wiley rightly says:—"The sole object in taking a sample of soil should be to have it representative of the type of soils to which it belongs. Every precaution should be observed to have each sample measure up to that standard. The physical and chemical analyses of soils are long and tedious processes, and are entirely too costly to be applied to samples which are not representative." It will be understood that analyses of soils from cultivated fields, whatever value they may have for the owner of that particular plot, cannot, as a rule, be comprised in an investigation relating to the country at large, or even to the surrounding district; for a soil that is modified by repeated cropping and manuring, and altered by human agency, cannot be looked upon as typical or representative of any extended area. The scheme of investigation which the writer had in view aimed, for the greater part, at ascertaining the comparative agricultural values of soils over wide tracts of country, and it was accordingly sought to collect, as far as possible, only virgin soils which had not been subjected to modifying influences; in a country such as this, a most difficult and well-nigh hopeless task.

In the actual taking of the samples for ordinary agricultural chemical analysis the practice has been as follows:—The surface of the selected spot is lightly scraped with a trowel or other sharp tool, so as to clear away the top growth and surface accumulations of semi-decayed vegetable matter not forming a part of the true soil. A hole with vertical sides is then dug to a depth of twelve inches, and from the sides of this hole thin slices of soil, aggregating from five to ten pounds in weight, are removed, in as uniform a manner as possible, and placed in a suitable bag of canvas, cloth, or other impervious material through which the fine soil will not sift out on transport during conveyance to the laboratory.

On arrival in the laboratory the sample is allowed to become air-dry by being spread out in a thin layer, protected from dust, for some days. Any lumps of soil that there may be are then gently broken down by means of a wooden pestle or rolling-pin, care being specially taken to avoid crushing any mineral fragments.

Subsequent treatment of the soil thus prepared varies according as a complete mechanical or a more purely chemical analysis is desired. It had been intended to combine the former with the latter in systematically investigating the country's soils, but the exigencies of circumstances rendered such a course, though desirable, quite impracticable. In connection with the soil survey, therefore, only a restricted form of mechanical analysis was adopted, and the few instances in which the more complete mechanical differentiation was made will be dealt with separately at a later stage, where the method employed for that purpose will be outlined. At this point we shall confine ourselves to the operations more closely connected with the purely chemical analysis.

As previously remarked, the importance of finely divided particles in a soil, at first vaguely grasped by Tull, has been definitely recognised during the last quarter-century. It is now understood that, for agronomic purposes, the finer the particles which compose a soil, within limits, *cæteris paribus*, the better the soil will be for general agricultural purposes. Hence although, as above remarked, a complete mechanical analysis was not, as a rule, included in these investigations, a partial sifting out of the soil has invariably preceded the chemical analysis proper, so that any plant food material that may have been locked up within the coarser soil particles has been left out of account in reckoning up the proportion of "available" plant food present in the soil.

In preparing a soil for the chemical analysis, the "field sample" is first of all freed from pebbles by dry-sifting a sufficient quantity through a brass-bottomed sieve with circular perforations 3 mm. in diameter. All that passes through this sieve is denominated "true soil." 250 grammes of this "true soil" are placed in a porcelain dish; about half a litre of distilled water is poured on, and the dish is allowed to digest on a water bath for at least two hours, the contents being stirred at frequent intervals. When the soil has thus been sufficiently softened, it is sifted in the following manner:—A special sieve (Kahl's "Messingdrahtsieb" No. 50), having meshes of diagonal measurement ·45 to ·50 mm. and ·35 to ·39 laterally, is held over a dish containing distilled water; the moistened soil is placed in the sieve, and the latter is then immersed with the bottom about an inch or more below the water level in the dish. By the aid of a small brush the soil is now stirred until particles no longer pass through, after which the residue in the sieve is thoroughly washed with distilled water. The material which passes through the sieve is dried, together with the wash-water, on a water bath, and the weight is then recorded in percentage of the "field sample." The residue thus obtained by evaporation of the sifted soil and water is called "fine earth," and is subsequently utilised, according to the standard method of chemical analysis adopted, for the determination of lime, potash, and phosphoric oxide.

Another sufficient portion of the "field sample" is dry-sifted through a brass-bottomed sieve with circular perforations 1 mm. in diameter. That which passes through is termed "earth," and is employed in determining the amounts of moisture, organic matter, chlorine, and nitrogen.

The chemical analysis proper has now to be considered. As already indicated, the proportions of soil-constituents mentioned in all the subsequent tables of analysis by the standard method are calculated and stated in terms as below:—

"Moisture" "Organic matter" "Chlorine" "Nitrogen"	in percentage of "earth."
"Lime" "Potash" "Phosphoric oxide"	in percentage of "fine earth."

"Fine earth" in percentage of "field sample."

Details are appended of the methods followed in determining these constituents. Two separate portions of soil are used, prepared as already described (the "earth" by sifting through a 1 mm. sieve, the "fine earth" by sifting through what is practically a ½ mm. sieve); these are, after treatment, allowed to become air-dry and bottled.

Moisture.—Ten grammes of "earth" are weighed in a tared platinum crucible, heated in an air bath from three to four hours, at a temperature from 105° C. to 110° C., allowed to cool in a desiccator, and rapidly weighed again.

Organic and volatile matter.—The crucible containing the perfectly dry soil used in the determination of moisture is heated to redness until all organic matter has been burnt away. It is then cooled in a desiccator and weighed, the difference in weight indicating organic matter, water of combination, ammonium salts, etc. If the soil contain appreciable quantities of carbonates, the contents of the crucible, before weighing, are moistened with a few drops of a saturated solution of ammonium carbonate, dried, and heated to dull redness, after which the crucible is placed in the desiccator to cool previous to weighing.

Chlorine.—Fifty grammes of "earth" are boiled in a marked 500 c.c. flask, with about 300 c.c. of distilled water, for half an hour. Cold distilled water is added until the level nearly reaches the mark, and after cooling it is filled up, shaken thoroughly, and filtered, by means of a Berkefeld candle filter, into a flask holding about 500 c.c., whence 50 c.c. are removed for titration with $\frac{N}{100}$ Silver nitrate, using Chlorine-free Potassium chromate as indicator.

Nitrogen.—Five grammes of "earth" are placed in a 150 c.c. oxidation flask; a globule of mercury weighing ·8 or ·9 of a gramme is dropped in, and a small fragment of solid paraffin to prevent frothing. 20 c.c. of concentrated sulphuric acid, free from nitrogen and nitrogen compounds, are then added. The flask is closed with a loosely fitting glass stopper, and the mixture heated over a Bunsen flame, gently at first, but more strongly afterwards, until colourless. When cool, the stopper is removed, and the flask is cautiously three-fourths filled with distilled water. It is then gently shaken, and the contents are washed into a 600 c.c. Erlenmeyer flask, washing the oxidation flask three times, each time with about 30 c.c. of distilled water: a small quantity of granulated zinc is added, and 75 c.c. of soda-lye, prepared by dissolving 35 grammes of potassium sulphide in 200 c.c. of water, and adding the solution to 1150 c.c. of caustic soda solution of 1·375 specific gravity. The distillation flask is closed with a rubber stopper carrying a bulb tube which is bent above the bulb at a sharp angle and terminates in a condensing tube 70 cm. long. This is connected, by means of rubber tubing, with another glass tube, dipping into 20 c.c. $\frac{N}{2}$ Sulphuric acid mixed with 50 c.c. of water in an Erlenmeyer flask as receiver. After the mixture in the distillation flask has been heated to boiling, the flame is so regulated that in 15 minutes' time the liquid in the receiver is at boiling point. The boiling is then continued for an additional five minutes. When the distillation is complete the contents of the receiver are washed over into a 250 c.c. flask, filled up, and 50 c.c. are titrated with $\frac{N}{10}$ Barium hydrate, using Rosolic acid as indicator.

Extraction of the inorganic plant food constituents from the soil.

The chemical analysis of a soil, if the object be to gain information with respect to its agricultural qualifications, differs widely from what it would be if the aim were to settle mineralogical or geological questions. In the latter event the endeavour would naturally be to ascertain the *total* quantities of mineral constituents present in the soil, quite irrespective of their adaptability as plant nutrients; but in the former case the determination of these aggregates may be of very trifling assistance, inasmuch as it is highly probable that, of the total quantities of plant food constituents present, only small proportions may be available to plants.

The chemist, desiring to estimate the amount of available plant food in a soil, generally tries to imitate, as closely as possible, the action of the plant itself upon the soil particles. A close copy of this natural action is difficult almost to the point of impracticability, and the difficulty is not rendered any the less by the fact that certain plants have a greater facility of withdrawing the nutrient compounds from the soil than others have. It is essential to note the distinction between "plant food constituents" and "plant food." A plant food *constituent* remains such no matter where or how it may exist; it only becomes plant *food* when it is present in the soil, and then only when it is present there in the very condition in which the plant growing upon that soil can withdraw it and turn it to its own account. The expression "plant food constituent" is accordingly used throughout these pages with the specific meaning above implied, and to the term "plant food" likewise a very definite signification is assigned. Bearing this in mind, it will directly follow that a chemical analysis of the soil, in order to be of value to the farming community, should tell, not the quantities of plant food *constituents* present, but the proportion of plant *food*. It becomes obvious, then, that we are to distinguish between at least two kinds of chemical analyses of soil, one of which supplies the farmer with information of value, while the other does not; it will, however, be more convenient to look upon soil analyses as capable of sub-division into three classes or grades. First of all the plant food constituents may be present in the soil in such a condition as to be quite incapable of being absorbed by the plant; remembering that we are considering the subject from the agriculturist's standpoint, we may be justified in calling these the plant food constituents of the third or lowest grade. The chemist who wishes to include these in his determination of the *total* quantity of plant food constituents in the soil, needs to employ the strongest chemical reagents, or the energetic action of fluxes at a high temperature in order to attain his object, for the plant food constituents of the third grade are usually silicates or aluminates, and do not respond to any less radical treatment: in any case they are not plant *food*. Needless to say, that the acids generally employed by the agricultural chemist fail to extract these compounds from the soil, and hence do not give the utterly misleading results occasionally attributed to them. The first and second grades of plant food constituents differ from the third in being available for plants; that is to say, they are actually plant food. These are extractible from the soil by mineral acids, such as hydrochloric acid. The plant food constituents of the first grade are readily, or immediately, available to the plants, and the chemist can extract them from the soil by means of water or weak organic acids, such as a dilute solution of citric acid; those of the second grade are less soluble, less readily available for plants, and may be extracted in the laboratory by strong mineral acids, but not by water or weak organic acids. They are not immediately removed by the crops, but continue in the soil as a "reserve stock"—a term that we shall have occasion to use again; let it be remembered, therefore, that whenever it is employed in the course of these remarks it signifies plant food of the second grade.

Thus we have these three grades of plant food constituents in the soil:—

I. Soluble in water and in weak organic acids:
Immediately or readily available for plants.

II. Soluble in strong mineral acids:
Available for plants only as a reserve stock.

III. Insoluble in ordinary acids, and extracted only by fusion or by specially powerful reagents like hydrofluoric acid.
Not available for plants.*

Obviously the agriculturist has little, if any, interest in non-available plant food constituents, and chemical analyses—be they of a single soil sample, or of a whole series of representative soils from various parts of the country—which give only figures showing the amounts of plant food

* The following figures, adapted from Bulletin No. 41 of the Minnesota Agricultural Experiment Station, illustrate the fact that soils contain considerable amounts of plant-food constituents which are not available for plants :—

	Wheat Soil.		Heavy Clay Soil.		Grass and Grain Soil.	
	Grade II.	Grade III.	Grade II.	Grade III.	Grade II.	Grade III.
Lime	2·44	·36	·48	·16	·51	·35
Potash	·54	2·18	·21	3·46	·30	1·45
Phosphoric Oxide	·38	—	·12	·08	·23	·05

In the case of the clay soil, it will be noticed, as much as 96% of the potash was in a form unavailable for plants.

constituents present, and afford no indication as to the quantity of *available* plant food—whatever interest they may possess for the geologist—have none for the farmer. It is true that, by mechanical disintegration and chemical decomposition, plant food constituents of the third grade may ultimately become available, as they very slowly change into those of the second, but the process is so gradual as practically never to have any value for the generation in occupancy. The constituents of grades I and II, on the other hand, possess great interest for the farmer; they comprise the actual plant food: the former affect the land's immediate productiveness, the latter its permanent value. In an investigation such as that under review, then, we may dismiss grade III from further consideration. The first grade, or immediately available plant food, is of less account than in a country where agricultural lands are usually held upon short tenancy; and, in any case, where the object is to gain information respecting the agricultural potentialities of extended areas, insufficient data would be afforded by determinations of the readily available plant food in the soil: individual farmers may profit by such investigations, but even then, to be of lasting value, they would have to be constantly repeated, and upon very much more comprehensive lines than the utmost range of practicability, if they are to meet all needs.

So we are brought to this conclusion, that, if a chemical investigation of a country's soils is to be made, it is the reserve stock of plant food in the soil (that is to say, the constituents of the second grade) that calls for first attention. They are continually changing into plant food of the first grade, and are being removed from the soil by plants very much more rapidly than they can be produced from the third grade constituents. It may be of some value, either incidentally, in certain cases, or subsequently to a thorough investigation of the reserve stock of plant food in the soils of the whole country, to inquire into the conditions and quantities of the other two grades as well, but the immediate and pressing necessity is to proceed with all speed along the line just indicated as demanding prime attention.

Different plants have, as already remarked, different absorbing powers, and hence we may almost say that the immediately available plant food in a soil varies in amount with the crop to be cultivated. If, therefore, we ascertain the maximum amount of plant food that can become available to *any* plant from a given soil we shall gauge the utmost limits of that soil's natural fertility, as far as it is affected by chemical considerations. If that be his purpose, the chemist should employ as a solvent not one which will simulate a single crop of weak extractive power, that is to say, a solvent that will take out little more than the constituents of grade I, leaving the bulk of those of grade II untouched. Of course, he is well aware that the soil which contains a large stock of plant food of the first class will in any case be chemically rich; it will therefore be fertile, provided that other factors—the physical character of the soil, the supply of water, and so on—are not defective. But he knows equally well that if the maximum of available constituents fall below a certain limit, the soil must of necessity be poor, whatever other conditions may be favourable. Hence the first object of a systematic soil survey along chemical lines should be to ascertain the maximum proportions of plant food likely to be available to average crops within a reasonable period of time in the area under examination. For this reason, especially in a country like this, consisting of immense tracts of virgin soil, amongst which there are many poor soils, the writer considers that a great deal more information will be gained by the extraction of soils by means of Hydrochloric acid than by applying Dyer's citric acid solution. The latter may be employed subsequently, as supplementary, but the former method should certainly take precedence.

Professor Hilgard makes some incisive observations with regard to the threefold differentiation of plant food constituents in soils, which bear directly on what we have said above. In order to appreciate his remarks in this connection, some extracts, leading up to them, from his work already quoted are essential. He says:—*

"While the obvious importance of the physical soil-conditions has long ago rendered them subjects of close study by Schübler, Boussingault, and others, the chemistry of soils was very generally neglected for a considerable period, after the hopes at first entertained by Liebig that chemical analysis would furnish a direct indication and measure of soil fertility had been sorely disappointed in respect to the only soils then investigated, viz. the long-cultivated ones of Europe. The results of chemical analysis sometimes agreed, but as often pointedly disagreed, with cultural experiences; so that after the middle of the nineteenth century but few thought it worth while to occupy their time in chemical soil analysis. . . . . . Among the few who, during the middle of the past century, maintained their belief in the possibility of practically useful results from direct soil investigation were Drs. David Dale Owen and Robert Peter, who prosecuted such work extensively in connection with the geological and agricultural surveys of Kentucky and Arkansas; and the writer, who carried out similar work in the States of Mississippi and Louisiana, with results in many respects so definite that he has ever since regarded this as a most fruitful study, and has later continued it in California and the Pacific North-west. This was done in the face of almost uniform discouragement from agricultural chemists until within the last two decades, with occasional severe criticisms of this work as a waste of labour and of public funds. All this opposition was largely due to the prejudices engendered by the futile attempts to deduce practically useful results from the chemical analysis of *soils long cultivated*, without first studying the less complex phenomena of *virgin* soils; and these prejudices persisted longest in the United States, even though in Europe the reaction against the hasty rejection of chemical soil work had begun some time before, as is evidenced by the methods employed at the Rothamsted Experimental Farm in England, the Agricultural College of France, the Russian agronomic surveys, and at several points in Germany. . . . . . In the United States as well, the ancient prejudices have now gradually given way before the urgent call for more definite information than could otherwise possibly be given to farmers by the experiment stations, most of whose cultural experiments, made without any definite knowledge of the nature of the soil under trial, were found to be of little value outside of their own experimental fields. . . . . . In many existing treatises so much emphasis is given to the alleged proofs of the inutility of chemical soil examination in particular that a special controversion of these arguments seems necessary. . . . . . *In all these discussions the difference between* the ascertainment of the *permanent productive value of soils*, as against that of their *immediate producing capacity*, must be strictly kept in view. The former interests vitally the permanent settler or farmer; the latter concerns the immediate outlook for crop-production, the 'Düngerzustand' of the Germans. The methods for the ascertainment of these two factors are wholly distinct, even though the results and their causes are in most cases intimately correlated. The failure to observe this distinction accounts for a great deal of the obloquy and reproach that has in the past so often been heaped upon chemical soil-analysis and its advocates. . . . . . The abundant *presence* of the plant-food ingredients, as shown by analysis, will not avail, unless at least an adequate portion of the same exists in a form or forms accessible to plants. Of course this condition would seem to be best fulfilled by the ingredients in question being in the *water-soluble* condition. But . . . substances in that form would be very liable to be washed or leached out of the soil by heavy rains or irrigation. . . . . . It is therefore clearly desirable that only a relatively small proportion of the useful soil-ingredients should be in the water-soluble or physically-absorbed condition, but that a larger supply should be present in forms not so easily soluble, yet accessible to the solvent action which the acids of the soil and the roots of plants are capable of exercising. This *virtually* available supply we may designate as the *reserve food-store*."

Hilgards' remarks† have been quoted thus lengthily because his book on the subject has all the qualities of a standard work of reference, embodying, as the work of no other writer in recent years has done, in the clearest language, the most reasonable present-day theories on the subject dealt with. Following out his line of reasoning, it will be seen at once that, in a series of investigations of the nature, and carried on under the circumstances of those that have been performed in the Government Analytical Laboratories here, quantitative determinations of the ingredients of

* Hilgard: *Op. cit.*, pp. 313, 316–320.
† See also Snyder: "The Chemistry of Soils and Fertilisers," pp. 69, 70.

grade III possess little more than academic interest, while the readily-available or water-soluble constituents of grade I do not urgently need investigation so long as vast fields of exploration have to be entered upon in respect of the reserve stock, or, as Hilgard terms it, the reserve food store, in the various soils of the Colony. It is this programme that we have been endeavouring to fulfil, as far as opportunities and circumstances permitted, during the earlier portion of the past dozen years.

In the investigations conducted in the Government Analytical Laboratories one method of soil extraction has been adopted as a standard, but it has been supplemented by sundry others for comparison. In deciding upon a standard method, a solvent had to be chosen—bearing in mind what has already been said—that would represent, not the slight action of a single crop, nor a dissolving capacity far in excess of any action that successive crops could exert during many years to come. The aim was rather to make use of a solvent that would extract from the soil just as much of the materials composing the food of plants, as lies ready to hand for conversion into constituents of the first grade as fast as the latter are withdrawn by cultivation. Obviously an adoption of such a *via media* necessitates the rejection, on the one hand, of comparatively weak solvents, such as pure water, which would extract only the directly or readily available plant food, and, on the other, such powerful reagents as boiling *aqua regia* or sulphuric acid, which would, in addition, dissolve out substances totally unavailable as plant food.

Investigations have, it is true, been made in our laboratory with dilute citric acid, but simply to compare its action as a solvent with the standard method.

We have yet to face the question of the actual solvent to be employed in extracting the soil; having decided what *not* to use; *e.g.*, any that would stop short with the extraction of readily available constituents, on the one hand, or that would include in their action constituents that are not available at all, it still remains to fix on what may be termed a reserve stock solvent; and here again discrimination is necessary. "Of all the mineral acids available," says Dr. Wiley,* "no one possesses solvent powers for soils in a higher degree than hydrochloric." That acid has accordingly long been used by analysts for the purpose, and it was also resorted to in these investigations for a similar reason. In this connection, however, three points awaited settlement, namely, the strength of hydrochloric acid to be employed, the length of time the acid should remain in contact with the soil, and the temperature at which it should be allowed to act. Loughridge found† that hydrochloric acid of 1·115 sp. gr. exerted a greater dissolving effect upon the soil than either a stronger or a weaker acid; this strength of acid had also been adopted in our investigations. He also found that the solvent action continued to increase for five days and then ceased. Upon the above basis the standard method generally employed in the Government laboratories has been formulated; it is the first of the methods outlined below. One respect in which this method differs from that of Hilgard and Loughridge is in respect of temperature. In the warm sunny climate of this Colony it would appear that root action is more energetic than in colder lands. It has been found, for instance, that proportions of phosphoric oxide which would be considered inadequate in Europe, in this country often suffice to yield satisfactory returns. But this greater root action results in a more rapid depletion of the reserve stock of plant food in the soil: that reserve stock, therefore, is rendered relatively smaller than under circumstances of lesser root activity. To represent this fact in the laboratory when a soil is to be analysed, it accordingly becomes necessary to employ a weaker solvent so as to indicate a relatively lower maximum

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* **Principles and Practice of Agricultural Analysis," Vol. I., p. 345.**

† **American Journal of Science," Vol. VII., p. 20.**

limit of plant food in reserve; no direct experiments to test the validity of this theory have been made, but the substitution of the ordinary temperature for that of the steam bath in the hydrochloric acid extraction method seems to fit in exactly with the conditions of this Colony, and the results thereby obtained tally closely with the practical experiences of farmers.

It must again be observed that although every soil which may yield large quantities of soluble plant food to this method of extraction is not thereby proved to be fertile, yet, as the method represents a maximum, we may definitely consider all soils that show *small* proportions of soluble constituents under its treatment, to be unmistakeably poor, and in need of replenishment. To a certain extent, also, we may assume the fertility of a soil which yields good results not only by that method, but also when treated according to the citric acid method of extraction outlined below.

Two other extraction methods by Hydrochloric acid have been used in several of the analyses; they are the second and third of the methods described below, the former being that of the German Experiment Stations, and the latter one stated to have been devised by Professor Maercker, of the Halle Experiment Station.

Method I.—Standard Method of Soil Extraction with Hydrochloric Acid.

Two hundred grammes of the air-dried "fine earth"* are placed in a large rubber-stoppered flask, and treated with 400 c.c. of hydrochloric acid of specific gravity 1·115 (plus any needed for neutralising carbonates in the soil); allowed to remain for five days at the ordinary temperature, shaking thoroughly from time to time. After the prescribed period of digestion has expired, the extract is filtered, through a dry pleated filter, into a dry flask. 250 c.c. of the clear filtrate, representing 125 grammes of soil, are evaporated to dryness in a shallow porcelain dish, at first over a small open flame, then on the water bath, and finally on a sand bath, or in an air oven, at 120°C, until perfectly dry. During the evaporation a few cubic centimetres of strong nitric acid are added to the extract. The dry residue is moistened with strong nitric acid, and again evaporated to dryness; to expel the nitric acid, the residue is moistened with hydrochloric acid, and evaporated on the water bath to as near dryness as possible, taking care to stir towards the end of the evaporation, so as to prevent the formation of crusts. This final residue, after warming in the air bath for an hour at 105°C to 110°C, is treated with warm water and a 20 per cent. solution of hydrochloric acid, and is then washed over into a 250 c.c. flask, boiled for 15 minutes, allowed to cool, filled up to the mark with distilled water, and filtered into a suitable bottle. This filtered soil extract is then employed for the actual estimations of lime and potash.

Determination of Lime.—50 c.c. of the extract (equivalent to 25 grammes of "fine earth"), obtained as described in the preceding paragraph, are removed, by means of a pipette, into a 250 c.c. boiling flask:

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* As more than once indicated, only soil grains below a certain size are included in the material submitted to extraction. Loughridge (Proceedings of the American Association for the Advancement of Science, Vol. 22, p. 81) has found that, of all the grades into which soils are usually separated by mechanical analysis, the "clay," *i.e.* the finest grade, is by far the richest in mineral constituents, and that the quantity of acid-extractible matter in the grades of soil particles of over ·04 mm. diameter was practically negligible. Hence it follows that soil sifted through a ½ mm. sieve will contain all the mineral constituents available for plants. The first requisite in selecting a standard method is to utilise for extraction only the soil passing the ½ mm. sieve. Hence, too, the method *e.g.* of sifting the soil through a 3 mm. sieve and pounding the sifted portion for extraction must be rejected as furnishing misleading results.

after adding two or three drops of rosolic acid solution (made by dissolving one gramme of rosolic acid crystals in 100 c.c. of 96 per cent. alcohol), ammonia is added, very cautiously, by means of a dropping tube, until a permanent pinkish colour is produced in the supernatant liquid. The mixture is then boiled until the pink colour almost disappears again, the alumina and oxide of iron being thus precipitated. After cooling, the flask is filled up to the mark, thoroughly shaken, and the contents filtered into a 300 c.c. bottle. 100 c.c. of this clear filtrate (equal to 10 grammes of fine earth) are removed by a pipette into a 300 c.c. Erlenmeyer flask; three to five drops of acetic acid are added, which should render the mixture feebly acid; the liquid is then heated to near boiling, and treated with 20 c.c. of a four per cent. ammonium oxalate solution. The mixture is placed on a water oven for six hours, and the precipitate is then collected, ignited, weighed, and the lime calculated as CaO.

Determination of Potash.—Other 50 c.c. of the filtered soil extract (equivalent to 25 grammes of fine earth) are placed in a 300 c.c. Erlenmeyer flask and boiled. 5 c.c. of a ten per cent. Barium chloride solution are added, and the mixture is boiled for another five minutes for the precipitation of sulphates as Barium sulphate. After filtering into a marked 250 c.c. flask, a few drops of rosolic acid are added, and boiling with ammonia is proceeded with as in the case of the lime determination. When partly cooled down, two or three grammes of crystalline ammonium carbonate are thrown in, and the temperature is once more raised to the boiling point, in order to separate calcium and barium. After complete precipitation of these, the liquid is cooled, the flask filled up to the mark with distilled water, and the contents filtered. Of this filtrate 100 c.c. equivalent to 10 grammes* of fine earth) are placed in a platinum basin, and evaporated to dryness on a water bath. The dish containing the residue is heated, at first on asbestos sheet, and then carefully over a small open flame, until all ammonium salts have been expelled. By means of boiling water the residue is then washed through a filter into a glass dish: 2 c.c. of a 10 per cent. solution of platinic chloride are added, and the mixture is evaporated to dryness on the water bath. After cooling, some dilute alcohol (81 to 82 per cent.) is added to the residue, and it is allowed to stand for at least half an hour. It is now filtered through a Gooch crucible by the aid of a filter pump, washed, at first, with 96 per cent., and then with absolute alcohol, and dried for two hours in a water oven. The weight of the crucible containing the Potassium platino-chloride having been taken, the precipitate is washed through the filter with boiling water, and the crucible, after again washing with alcohol, is dried and weighed. The difference between the two weighings, multiplied by ·193, gives the quantity of potash (K_2O) in the ten grammes of fine earth taken.

Determination of Phosphoric oxide.—25 grammes of fine earth are placed in a marked 500 c.c. flask, 25 c.c. of concentrated nitric acid are added, and the mixture is thoroughly shaken. 50 c.c. of concentrated sulphuric acid are next added, and the mixture is again carefully shaken up. It is then gently heated, shaking at frequent intervals. If this does not lead to complete oxidation, more nitric acid is added, and the heating continued. Finally the mixture is cooled, and diluted to the mark with distilled water; it is then well shaken and filtered. 200 c.c. of the filtrate (equivalent to ten grammes of fine earth) are placed in an Erlenmeyer flask of suitable size, and very nearly neutralised with strong ammonia solution, a few drops of nitric acid being used to acidify the mixture in case the limit is overstepped. 200 c.c. of Molybdic solution—prepared by dissolving 150 grammes of ammonium molybdate in a litre

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* In the citric acid extraction process (see post) this quantity will be equivalent to 20 grammes of the soil taken.

of water, and, when completely cool, adding this to a litre of nitric acid of specific gravity 1·20—are added, and the mixture is heated to a temperature of 50°C for three hours in a water oven, and allowed to cool completely. The liquid is decanted through a small filter, and the precipitate remaining in the flask repeatedly washed with diluted (1 : 1) molybdic solution. It is then dissolved, on the filter, with warm 5 per cent. ammonia, and to the resulting solution, while still warm, hydrochloric acid is added at once, but gradually, until the precipitate at first formed dissolves only after long agitation. After cooling 20 c.c. of Magnesia mixture* are added from a burette, drop by drop, at the rate of one drop every five seconds, and then 25 c.c. of 5 per cent. ammonia. The mixture is allowed to stand for twelve hours at least, after which the precipitate is collected in a weighed Gooch crucible, and washed with 5 per cent. ammonia. It is then dried on a heated iron plate, and ignited in a furnace for fifteen minutes. The crucible is then cooled and weighed with the magnesium pyrophosphate.

Method II.—Hydrochloric Acid Extraction as Practised by the German Experiment Stations.†

To 200 grammes of dry-sifted "true soil" are added 400 c.c. of a 25 per cent. hydrochloric acid solution, the quantity of acid being increased, if necessary, when the soil contains an excess of carbonates. The mixture is allowed to stand at the ordinary temperature for 48 hours, with frequent shaking, and is then filtered.

Determinations of lime and potash are made in definite quantities of the filtered extract (prepared as in Method I), exactly as in the first method.

Determination of Phosphoric oxide.—20 c.c. of the filtered extract (which has been treated in a similar manner to the extract in Method I), equivalent to 10 grammes of "true soil," are placed in a dish and evaporated almost to dryness. The residue is taken up with a little nitric acid, washed into a suitable Erlenmeyer flask, and nearly neutralised by means of strong ammonia solution, a few drops of nitric acid being used to acidify the mixture should the neutral point be passed. Molybdic solution is then added, and the rest of the process conducted as in the first method.

Method III.—Extraction of Ignited Soil by means of Hydrochloric acid, aided by Nitric acid. (Maercker's method.)

Twenty grammes of "fine earth" are weighed in a platinum dish, and heated on asbestos wire gauze until all organic matter has been expelled. The dish is then cooled and the contents carefully transferred by the aid of a brush into a porcelain dish. 100 c.c. of concentrated hydrochloric acid and 10 c.c. of concentrated nitric acid are now added, and the mixture is evaporated on a water bath, and dried for three hours at 120° C. Warm water is next added, together with some dilute hydrochloric acid, and the whole is washed into a marked 500 c.c. flask, in which it is boiled for 15 minutes. The mixture is then cooled, filled up to the mark with distilled water, and filtered.

Determination of Lime.—100 c.c. of the filtered extract (equivalent to four grammes of fine earth) are placed in a 200 c.c flask, two or three drops of rosolic acid are added, and the determination is proceeded with similarly to that in Method I.

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* This Magnesia mixture is prepared by dissolving 110 grammes of magnesium chloride, and 210 grammes of ammonium chloride, in 700 c.c. of 24% ammonia solution filtering the mixture, if turbid, and diluting with distilled water to two litres.

† Land. Versuchsstat, Vol. 38, p. 311.

Determination of Potash.—Other 100 c.c. of the filtered extract (equivalent to four grammes of fine earth) are boiled in a 300 c.c. Erlenmeyer flask, and 5 c.c. of a ten per cent. solution of barium chloride are added, after which the determination is continued as in the first method.

Phosphoric oxide is determined exactly as in Method I.

METHOD IV.—EXTRACTION BY HYDROCHLORIC ACID AT STEAM TEMPERATURE. (HILGARD'S AND LOUGHRIDGE'S METHOD.)

Fifty grammes of air-dried "fine earth" are placed in a porcelain beaker of sufficient size, 500 c.c. of hydrochloric acid of 1·115 specific gravity are added, and 2 c.c. of nitric acid, and, after covering the beaker with a clock glass, the mixture is digested on the steam bath for five days. The solution is then filtered, the residual earth is thoroughly washed with distilled water, the filtrate and washings are evaporated to dryness, as in Method I, with nitric acid in a shallow porcelain dish, and finally made up to 250 c.c.

Determination of Lime.—100 c.c. of the extract (equivalent to 20 grammes of fine earth) are placed in a 200 c.c. boiling flask, and precipitated by ammonia, as in Method I; the flask is then filled up to the mark with distilled water, and the contents filtered. 100 c.c. of the filtrate (equivalent to 10 grammes of fine earth) are precipitated with ammonium oxalate, as in Method I.

Determination of Potash.—100 c.c. of the extract (equivalent to 20 grammes of fine earth) are treated with barium chloride solution in the same way as in Method I, and filtered into a 200 c.c. flask; after passing through the usual processes 100 c.c. of this (equivalent to 10 grammes of fine earth) are taken, as in Method I, for the actual potash determination.

METHOD V.—EXTRACTION OF THE SOIL BY MEANS OF CITRIC ACID. (DYER'S METHOD.)

The solution here used is that recommended by Dr. Bernard Dyer, in the "Journal of the Chemical Society," March, 1894, p. 141, which is an adaptation of that previously used at the Halle Experiment Station, and published by Maercker and Gerlach in 1892. In a rubber-stoppered three litre flask are placed 200 grammes of dry-sifted "true soil" (*i.e.*, as sifted through a 3 mm. sieve), together with two litres of distilled water containing in solution 20 grammes of pure citric acid. This solution is left in contact with the soil, at the ordinary temperature, for seven days, shaking the mixture thoroughly about fifty to sixty times each day. At the end of the seven days the solution is filtered, by the aid of a filter pump, through a porcelain funnel with a flat perforated base, or through a Berkefeld candle filter; 500 c.c. of the filtrate would be required for each of the determinations described below.

Determination of Lime.—500 c.c. of the filtered soil extract (equivalent to 50 grammes of soil) are placed in a 1,000 c.c. flask, and a few drops of rosolic acid are added, followed by ammonia, as in the previously described lime determinations. The mixture is boiled, and, after filling to the mark, it is filtered, and 500 c.c. of the filtrate, equivalent to 25 grammes of soil, are warmed with a few drops of acetic acid in an Erlenmeyer flask, and then treated with 50 c.c. of 4 per cent. ammonium oxalate solution, the precipitate being collected, as before, after warming for six hours.

Determination of Potash.—500 c.c. of the filtered extract (equivalent to 50 grammes of soil) are evaporated to dryness in a platinum dish, and cautiously ignited. The residue left in the dish is dissolved in hydrochloric acid, filtered into a 300 c.c. Erlenmeyer flask, and boiled. 5 c.c. of 10 per cent. barium chloride solution are added, and the determination is proceeded with as in the method already described in connection with the extraction by hydrochloric acid.

Determination of Phosphoric Oxide.—500 c.c. of the filtered soil extract (corresponding to 50 grammes of true soil) are evaporated to dryness in a platinum dish, carefully ignited, and taken up with hydrochloric acid, again evaporated, ignited, and extracted with hydrochloric acid; the extract is filtered and washed, and the filtrate and washings concentrated. The concentrated solution is allowed to cool, and then 200 c.c. of a solution of ammonium molybdate in nitric acid—prepared as already described—are added, and the rest of the procedure outlined under the method of determining phosphoric oxide in the "fine earth" (see method I.) is followed.

It now becomes a matter of interest and importance to agree upon the interpretations that are to be placed upon the figures obtained by analysis from a soil that has been extracted according to one of the foregoing methods. In this Colony absolutely no investigations have yet been made to show what quantities of plant food are necessary in order to render fertile a soil that is in other respects well circumstanced; for it must be remembered that a brack or arid soil, or one physically unfit for cultivation, cannot be otherwise than unproductive even when it is amply supplied with the needful chemical constituents.

Maercker, of the Halle Experiment Station, graded soils, on the plant food basis, as follows, the extraction being made with strong acid:—

	Potash %	Phosphoric oxide %	Lime % in clay soils.	Lime % in sandy soils.	Nitrogen %
Poor	< ·05	< ·05	< ·10	< ·05	< ·05
Medium ...	·05 — ·15	·05 — ·10	·10 — ·25	·05 — ·15	·05 — ·10
Normal ...	·15 — ·25	·10 — ·15	·25 — ·50	·15 — ·20	·10 — ·15
Good	·25 — ·40	·15 — ·25	·50 — 1·00	·20 — ·30	·15 — ·25
Rich	> ·40	> ·25	> 1·00	> ·30	> ·25

This classification Professor Hilgard declares to be in remarkable agreement with his own, with the proviso that, in the presence of high lime percentages, relatively low proportions of phosphoric oxide and potash may, nevertheless, prove adequate. Many of the results tabulated in the following pages may incidentally throw light upon the subject, but until it has been directly investigated, and sufficiently so to enable limits to be laid down for different parts of this Colony, it will probably prove most convenient and satisfactory provisionally to judge of soils by Maercker's limits, and such, in fact, has been my practice hitherto, nor has it, as already observed, been found to lead to conclusions inconsistent with practical experience.

According to Dyer's investigations, a soil extracted with his citric acid solution is sufficiently supplied with potash and phosphoric oxide for immediate purposes when the former shows over ·005 and the latter over ·010 per cent. The investigations upon which these conclusions were based, it should, however, be said, had been conducted upon well-studied and productive soils at Rothamsted.

Just here one point calls for special emphasis: Liebig enunciated the law that the growth and development of plants is regulated by the amount of that particular plant food constituent which is present in the soil in smallest proportion: if one element of plant food is deficient in the soil, no excess, however great, of any of the others will atone for the defect. If a soil contain abundance of lime, potash, and nitrogen, but lacks phosphoric oxide, no crop can reach perfection. Liebig's law of the minimum, thus briefly set forth, must now be extended so as to fill our widened vision. We know that, chemically, a soil may be all that is desired, and yet prove unproductive; a mechanical analysis may elucidate the cause of this; or, if that too result satisfactorily, the soil may be otherwise physically defective, for instance, in porosity; or perhaps it may lack moisture. The various chemical constituents of plant food do not comprise the *whole* chain of contingencies upon which a soil's fertility, and still less its productiveness, depends, but they *do* form links in that chain, and, as the strength of a chain is measured by that of its weakest link, so the potential fertility of a soil well provided chemically may be dependent upon, and therefore limited by, defects along other lines. Hence chemical analysis does not test the strength of the *chain*, but only that of *certain of its links*. The fact that the links thus tested prove to be sound does not render the entire chain sound. A soil which yields to acid extraction a large reserve stock of all plant food constituents may be deficient in other respects: even if physical unfitness or alkalinity do not affect its fertility, defective water supply, or unfavourable situation, or many other agencies, may cause it to be unproductive,* no matter how fertile it may be. On the other hand, if by chemical analysis certain links in this chain are found to be defective, then, no matter how excellent the condition of the remaining links, the defects must be remedied ere the chain can be fit for use.

The results of the analyses detailed in the sequel show that there are many soils in the Colony which are thus weak in certain respects, and if the investigations here described do no more than point out the districts and areas where such weakness exists, they will have served a useful purpose. A chemically-poor soil invariably needs working up, and such investigations as these can show where soils answering to that description are to be found. The fact that soils rich in plant food† are not invariably fertile, or, if fertile, do not produce an adequate return, is no argument against the worth of analysis. In brief, chemical analysis can designate bad soils even if it does not aim at pointing out good ones; and yet even this it is at times capable of doing, as the following analyses more than once witness. Hilgard may here again be quoted. He says:—‡

"It seems to be generally true that virgin soils showing high percentages of plant food, as ascertained by extraction with strong acids (such as hydrochloric, nitric, etc.), invariably prove highly productive: provided only that extreme physical characters do not interfere with normal plant growth, as is sometimes the case with heavy crops or very coarse sandy lands. *To this rule no exception has thus far been found.*"

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* "Fertility and crop production are different terms. Fertility is a property inherent in the soil: it is what the soil is capable of doing if it is under the best possible conditions. The yield of crops, on the other hand, is not dependent upon the fertility alone. . . . If your seed is not properly selected, if your planting season is too early or too late, if the soil is not properly cultivated, if the climatic conditions are not favourable, your crop yield may be affected, but the fertility of the soil—that inherent power of the soil, under the best conditions, to produce a crop—will not necessarily be impaired." (Whitney: "Soil Fertility," 1906, pp. 5, 6.

"The productivity of a given piece of land depends upon a large number of agencies, any one of which may be the limiting factor in the crop yield. We may enumerate, for example, temperature and water supply, both determined by the climate, by the natural physical structure of the soil, and by modifications in its texture induced by cultivation; there are, further, the aëration and the actual texture of the soil, the initial supply of plant food of various kinds, and, again, the rate at which this last item is rendered available to the plant by bacterial action or by purely physical agencies. All these factors interact upon one another, to all of them, and not merely to the nutrient constituents does Liebig's law of the minimum apply, so that any one may become the limiting factor and alone determine the yield. It is of no use, for example, to increase the phosphoric acid content of a soil, however deficient it may be, if the maximum crop is being grown that is consistent with the water supply, or if the growth of the plant is being limited by insufficient root range caused by bad texture and the lack of aëration in the soil." (A. D Hall: "Recent Developments in Agricultural Science." Brit. Assn. Rep., 1905, p. 275.)

† *i.e.*, yielding large proportions to strong hydrochloric acid.

‡ *Op. cit.*, p. 343.

Field Operations.

Professor Whitney, Chief of the Division of Soils in the United States Department of Agriculture, opened his report on the field operations of his Division during 1899 with these words:—

"During the season of 1899 three well-organised parties were in the field for from six to eight months, each equipped according to the most modern methods for surveying investigations and mapping the soils of several important agricultural districts."

That division was established in 1894, with a personnel of 10 persons; by the end of 1904 the number had increased to 127. Up to the middle of 1900 about 3,500 square miles of country had been mapped out in connection with the soil survey; within the succeeding four and a half years 85,500 square miles had been mapped,—a fact which shows the rapid increase in the work of an institution that commenced operations a year after our own soil investigations had been started.

At no time have we, in this Colony, been able to spare more than one solitary unassisted individual for both field operations and laboratory work in connection with our soil investigations, so that, while the collection of samples was going on the operations in the laboratory had to cease, and *vice versa*. This is a circumstance that must be continuously borne in mind to account for the comparative paucity of result hitherto obtained.

The equipment of the soil collector has, as a rule, been little else than a stock of canvas bags, a spade, a supply of census maps of each district traversed, a small pocket compass, and a trocheameter. By the aid of these implements samples have been taken from some 27,000 square miles of country.

The soils whose analyses are tabulated in the following pages fall into three classes according to the circumstances of their collection:—

(1) First of all must be mentioned the specimens taken in pursuance of the survey scheme to which reference has already been made. In each case these samples were collected by one of the analysts attached to the Government Analytical Laboratory, who had been specially detailed for the work. The following is a list of the samples so taken from each of the Divisions of the Colony visited for the purpose:—

Division.	No. of samples collected.	Area of Division. in square miles.
Cape	25	663
Malmesbury	54	2,329
Caledon	30	1,772
Bredasdorp	21	1,577
Swellendam	37	2,362
Robertson	27	1,526
Riversdale	24	1,712
Mossel Bay	17	707
George	19	979
Knysna	13	810
Uniondale	12	1,690
Oudtshoorn	19	1,653
Worcester	30	2,623
Ladismith	16	1,256
Paarl	23	610
Komgha	27	546
Cathcart	28	995
Queenstown	4	1,749
Butterworth	7	311
Idutywa	1	—
Willowvale	4	—
St. Marks'	4	471

The total area from which these 442 samples of soil were collected embraces about 27,000 square miles, *i.e.*, about one-tenth of the entire Colony, so that, on an average, one sample was taken from every sixty square miles of country.

(2) Apart from this scheme of soil investigation, samples were taken from time to time, at various spots of special interest, as occasion offered, by one or other of the analytical staff, while advantage was taken of sundry journeys into different parts of the country by Mr. A. C. MacDonald, subsequently Assistant Director of Agriculture in the Transvaal, Dr. E. A. Nobbs, and other officials of the Agricultural Department, to procure additional specimens. Means were thus afforded for the analysis of many soils collected within the following Divisions of the Colony:—Albany, Aliwal North, Barkly West, Cape, Gordonia, Hopetown, Humansdorp, Kenhardt, Kimberley, Prieska, Robertson, Somerset East, Stellenbosch, Steynsburg, Taungs, and Tulbagh.

(3) We are also indebted for the collection of many of the samples whose analyses appear in the following tables to unofficial persons, farmers and others, who, in many cases, kindly responded to requests conveyed to them to send specimens of particular soils which, for some reason or another, it was thought desirable to analyse. For several reasons, most of which are obvious, it is not possible to give as much detail regarding these soils as in the case of those collected in pursuance of the systematic survey scheme. Amongst the soils which were thus procured were samples from the following Divisions:—Albert, Barkly West, Beaufort West, Bredasdorp, Caledon, Cape, Ceres, Clanwilliam, Colesberg, Elliot-Slang River, Fort Beaufort, George, Graaff-Reinet, Hanover, Kenhardt, Kimberley, King William's Town, Knysna, Kuruman, Maclear, Mafeking, Malmesbury, Mossel Bay, Mount Currie, Mount Frere, Namaqualand, Paarl, Piquetberg, Port St. John's, Queenstown, Richmond, Robertson, Stellenbosch, Steynsburg, Stockenstrom, Tulbagh, Uitenhage, Umtata, Umzimkulu, Victoria East, Vryburg, Willowmore, and Worcester.

The soils included under this category have been separately tabulated and are distinguished from the others by being marked "privately collected," inasmuch as it has not always been absolutely certain that in every case the samples so taken, however specific previous instruction on the point may have been were thoroughly representative, or that they were collected in the manner officially prescribed. For these reasons the soils known to have been taken according to the specific directions have been distinguished as "officially collected."

PART III.—RESULTS OF CHEMICAL ANALYSES.

It may be convenient at this stage, before passing on to enumerate in detail the actual analytical results arrived at, to tabulate the soils examined, grouping them according to the various divisions and districts of the Colony whence they were collected, and in regard to the particular methods by which they were analysed; this is done in the list below:—

Division or District.	Method I., Standard.	Method II., German.	Method III., Maercker's.	Method IV., Hilgard's.	Method V., Dyer's.	Total.
Albany	—	3†	—	—	3†*	3
Albert	3	—	—	—	—	3
Aliwal North	4	—	—	—	—	4
Barkly West...	13	—	—	—	—	13
Beaufort West	1	—	—	—	—	1
Bredasdorp	1	21	—	—	—	22
Butterworth...	7	—	—	—	—	7
Caledon	6	34	—	—	—	40
Cape	23	46	—	—	—	69
Carnarvon	2	—	—	—	—	2
Cathcart	28	—	—	—	—	28
Ceres	7	—	—	—	—	7
Clanwilliam	—	7	—	—	—	7
Colesberg	6	—	—	—	—	6
Elliot-Slang River	4	—	—	—	—	4
Fort Beaufort	4	—	—	—	—	4
George	20	6	3	—	—	29
Gordonia...	2	—	—	—	—	2
Graaff-Reinet	3	—	—	—	—	3
Hanover	—	6	—	—	—	6
Herbert	3†	—	—	—	3†	3
Hopetown	2	—	—	—	—	2
Humansdorp	—	4	—	—	—	4
Idutywa...	1	—	—	—	—	1
Kenhardt...	4	1	—	—	—	5
Kimberley	6	2	—	—	—	8
King William's Town ...	1	—	—	—	—	1
Knysna	16	3	—	—	—	19
Komgha	27	—	—	—	—	27
Ladismith	16	—	—	—	—	16
Maclear...	—	1	—	—	—	1
Mafeking...	2	—	—	—	—	2
Malmesbury...	7	64	—	—	—	71
Middelburg...	1	—	—	—	—	1
Mossel Bay...	—	3	17	—	—	20
Mount Currie	2	2	—	—	—	4
Mount Frere	2	—	—	—	—	2
Namaqualand	—	3	—	—	—	3
Oudtshoorn	19	—	—	—	—	19
Paarl...	51	5	—	—	—	56
Piquetberg	1	1	—	—	—	2
Port St. John's...	1	—	—	—	—	1
Prieska	4	—	—	—	—	4
Queenstown	6	—	—	—	—	6

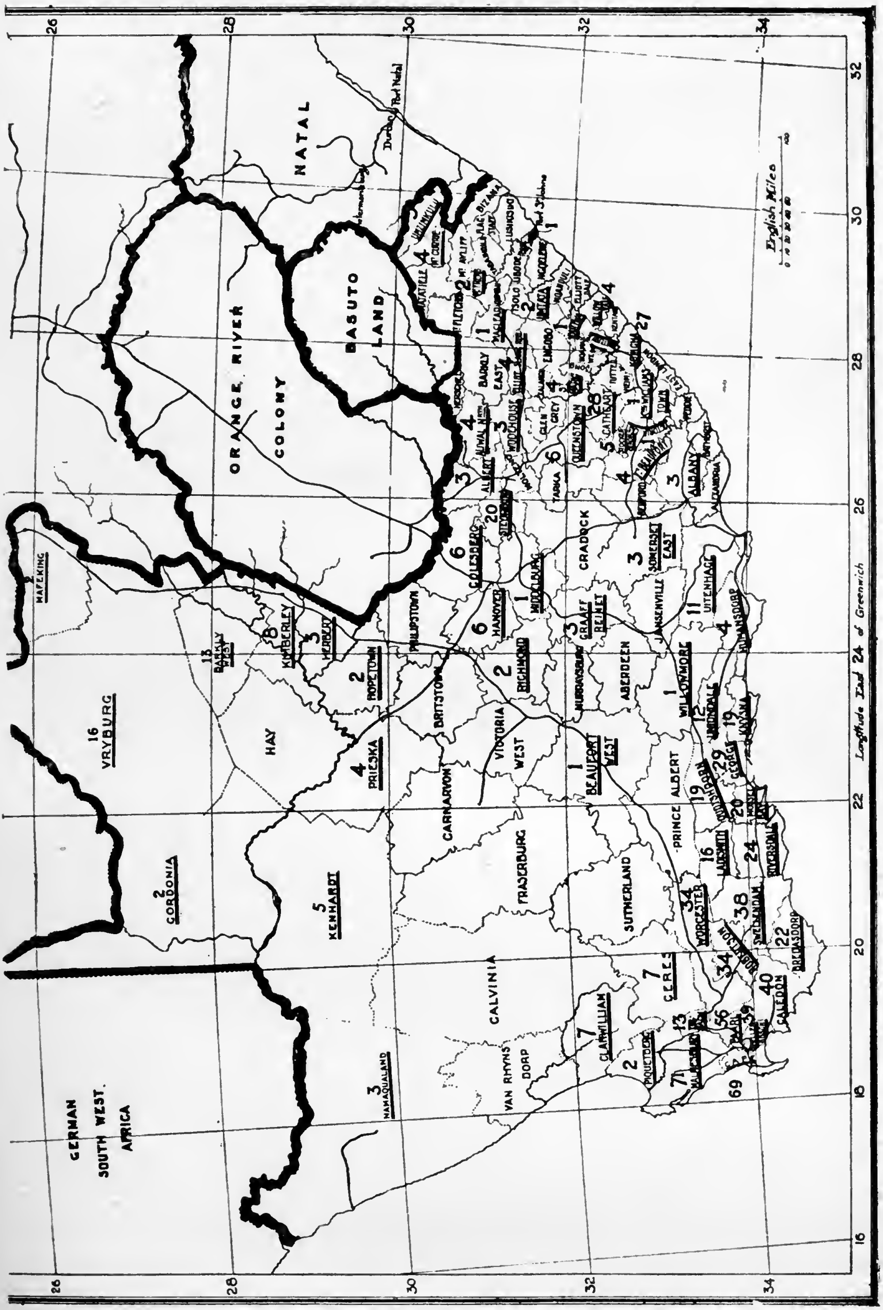
* Phosphoric acid determinations only.

† Same samples examined by different methods.

Division or District.	Method I., Standard.	Method II., German.	Method III., Maercker's.	Method IV., Hilgard's.	Method V., Dyer's.	Total
Richmond	2	—	—	—	—	2
Riversdale	—	—	24	—	—	24
Robertson	22†	12	—	4†	4†	34
St. Mark's	4	—	—	—	—	4
Somerset East	2	1	—	—	—	3
Stellenbosch	26†	13	—	—	1†	39
Steynsburg	9	11	—	—	—	20
Stockenstrom...	—	5	—	—	—	5
Swellendam	9	29	—	—	—	38
Tulbagh	9	4	—	—	—	13
Uitenhage	10	1	—	—	—	11
Umtata	2	—	—	—	—	2
Umzimkulu	2	1	—	—	—	3
Uniondale	12	—	—	—	—	12
Victoria East	1	—	—	—	—	1
Vryburg	16	—	—	—	—	16
Willowmore	—	1	—	—	—	1
Willowvale	4	—	—	—	—	4
Wodehouse	3	—	—	—	—	3
Worcester	34	—	—	—	—	34
Totals	473	290	44	4	11	807

In the following pages are tabulated the results of each individual chemical analysis; as a matter of convenience, the soils of each division or district of the Colony are dealt with separately. In respect of each area some preliminary remarks are offered regarding the collection of the samples therefrom, and, as previously indicated, it has in all cases been noted whether this sampling had been officially conducted, or through private media. In every case, too, the method of analysis has been specified, and in most instances a few comments are added on the general characteristics of the soils of the district, or of such localities as may seem to call for special observation.

† Same samples examined by different methods.



MAP OF CAPE COLONY.

Showing Divisions (underlined) from which samples of soils were collected for Agricultural Chemical Analysis, and number of samples analysed in each case.

ALBANY.

(Officially collected.)

No.	Field Cornetcy.	Farm or Place.	Collector.
1.	Lower Riebeek.	Langley Park.	A. C. Macdonald.
2.	,,	,,	,,
3.	,,	Highlands.	,,

The three soils examined were collected in the Highlands district. Sheep running on the two farms whence the samples were taken had been found to be greatly benefitted by giving them a regular supply of bone-meal mixed with salt. Lamziekte had been prevalent on the same farms, indicating apparently an insufficient supply of phosphates in the food. The theory prevailed, due, in part, to the foregoing facts, that the soil of the Zuurveld generally lacked phosphatic material. The lands on the farm Langley Park, whence the first sample was taken, were being employed as grazing ground for some of the sheep above referred to; the second sample, which is distinctly poor in lime, was taken from the same farm, but from a portion on which sheep which were not habitually and specially provided with salt in their food were stocked; such a provision did not appear to be so much needed there as in the former place. The third sample was taken from the veld near Highlands Railway Station. No. 1 contained a fair reserve of phosphates, but both the other soils were lacking in this respect. The analytical results were as follows:

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide
1.	·88	5·62	·0064	—	·12	—	·084
2.	·62	2·53	·0167	—	·065	—	·036
3.	·59	5·97	·0106	—	·11	—	trace

Determinations of the readily available phosphoric oxide resulted as follows:

(Method V.)

No.	Percentage.
1	·026
2	trace
3	trace

Magnesia and sulphuric oxide were also determined in these soils, with the following results per cent.:—

No.	Magnesia.	Sulphuric oxide.
1	·023	·062
2	·029	·075
3	·024	·052

Research has shown that nitrifying bacteria need phosphates for their development; hence lack of phosphates is apt to go hand in hand with retarded nitrification. This latter process is also stopped by soil acidity, so that the neutralising effect of carbonate of lime not only improves sour soils, in that it removes the cause of their acidity, but it also promotes the production of the soil nitrogen by affording the bacteria facilities for nitrogen-fixation. The supply of nitrogen to the plant is thus dependent upon a sufficiency of lime and phosphates in the soil.

The soils of a great part of the Albany Division, and of the adjacent divisions of Bathurst and Willowmore, are apparently derived from the quartzites of the Zuurberg Range in the Witteberg geological series, a formation lying over the Bokkeveld series, which forms a large portion of the Ladismith Division. Like the soils derived from the somewhat similar Table Mountain series in the George Divison, these sands, or sandy loams, as they become in certain localities, are agriculturally poor, and would be greatly improved by the admixture of clay, especially if vegetable mould were added simultaneously, and the further addition of lime, either as burnt lime, or, less expensively, as crushed limestone would vastly augment the soil's adaptability for agriculture.

ALBERT.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Lower Groot River.	Odendaalstroom.	A. Struben.
2.	"	"	"
3.	"	"	"

These samples were collected by an officer of the Public Works Department from irrigable lands on the bank of the Orange River below Odendaalstroom. No. 1 was a brown silt, rich in lime, but of medium quality as regards nitrogen; No. 2 a stiff red, sandy clay; and No. 3 a red sandy clay. These red soils are apparently derived from the red shales and clays of what have been termed the Burghersdorp beds.* These beds consist of fine-grained sandstones, but their fertility seems to be due to the still finer clays with which they are associated.

The chemical analyses† resulted as follows:—

(Method I.)

No.	Percentage of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	100	3·46	4·42	·0071	·070	1·372	·042	·149
2.	94·6	2·44	3·71	·0071	·056	·540	·048	·138
3.	95·2	2·10	2·68	·0089	·014	·424	·051	·089

Of these three soils, the silt, as frequently proves to be the case, is chemically the best, and No. 3, the most sandy, is the worst, being poor in nitrogen and potash, with only a moderate amount of phosphates. No. 2 is well supplied with lime, although inferior to No. 1 in this and other respects. All these soils are lacking in potash, but it must be remembered that the good all round supply of lime compensates for other chemical defects.

ALIWAL NORTH.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Aliwal North.	Municipal area.	E. A. Nobbs.
2.	"	"	"
3.	"	"	"
4.	"	"	"

* Ann. Rept., Geological Commission, 1904, pp. 75 and 77.

† For mechanical analyses of these soils see under the head of "Physical Composition of Soils," Part VII.

In texture the above soils were all fine grained, and in many respects resembled those from the adjoining Division of Albert. The geological formation here too almost entirely consists of Burghersdorp beds. All the samples were taken from the municipal area; the first from a rich wide level flat flanking the Orange River, the last at a spot lying some distance back from the river. Nos. 2 and 3 were taken along the banks of the tributary Kraai River, the latter at some distance from the water side.

The results of the analyses are as follows:—

(Method I.)

No.	Percentage of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	99·5	3·23	3·66	·005	·098	·376	·079	·088
2.	99·4	4·07	4·32	·004	·028	·276	·123	·087
3.	98·0	3·61	4·17	·004	·113	·192	·128	·057
4.	97·7	5·08	4·73	·003	·098	·036	·123	·056

It had been anticipated that the first of these four soils would prove to be chemically of good quality, and the analysis confirmed this view, the proportion of lime being satisfactory, although potash and phosphates are present in only moderate amount. Taken all round, these soils possess the chemical and physical requirements of good fertility.

BARKLY WEST.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Hebron.	Brady's.	E. A. Nobbs.
2.	,,	,,	,,
3.	,,	Patrys Kraal.	,,
4.	,,	,,	,,
5.	,,	H.V. 75.	,,
6.	,,	,,	,,
7.	,,	Ganzepan.	,,
8.	,,	Zwartputs.	,,
9.	,,	,,	,,

These nine samples were collected by Dr. E. A. Nobbs from different farms intended to be irrigated from the Harts River by means of a canal and furrows. The idea was to bring some twenty to thirty thousand acres under irrigation in this way. The specimens were selected with a view to securing types of considerable area below the line of furrow. The first sample, a red loamy alluvial soil, was taken on Brady's farm, at a point, just above high flood level, 2¾ miles above the railway bridge, and 200 yards north of the banks of the Vaal River. The sub-soil is of similar character to that at the surface. The area appeared to be traversed by dolerite dykes, which would probably cause great variation in the depth of the soil, and hinder free drainage. On land adjacent to No. 1 mealies have been grown without manure, at frequent intervals, although not continuously, since 1874. No 2 was a red porous, friable, gravelly loam soil, of somewhat similar type; it was collected on the same farm, about half a mile north of the homestead, and 1¾ miles from the border: this sample is representative of the higher-lying undulating veld in the neighbourhood.

The soil depth is about 30 inches, and the sub-stratum consists of water-worn gravel. The only crops grown here are mealies and Kafir corn: these crops are raised continuously for three or four years, after which the land is allowed to lie fallow for a similar period of time. On the lands represented by both samples 1 and 2 the Vaalbos, *i.e.*, Atriplex, or Salt bush, is to be seen.

No. 4 was taken from rising ground to the south of Patryskraalvlei, and is typical of a light fine-grained brown loam of an average depth of fifteen inches: the subsoil consists largely of dolerite, and boulders frequently show on the surface. No. 3 was also collected on the farm Patryskraal, to the south-east of the proposed reservoir. The sample represents a stiff red clay-loam, very level and undrained, and generally shallow, although varying in depth from place to place, and resting upon a stiff blue clay, which in turn lies upon limestone. Here too the Vaalbos grows. Further up the slopes towards Grecian Kopje, the clay subsoil disappears, and a red sandy loam surface soil rests directly on the limestone.

The western slopes of the low hills to the east of Patryskraal possess a soil, apparently very much the same all along, rising from the flats where sample No. 3 was collected, and running up to rocky summits. This soil, represented by No. 9, is a very characteristic fine-grained rich-red loamy sand, free from stones, and uniform to a depth of over thirty inches. Due west of the place where that sample was collected, but on the wide flat below the site of the suggested dam walls sample No. 5 was taken. This represents a shallow, fine-grained, red sand, on which Mimosas grow. It rests upon limestone, which every now and again appears on the surface. The sample is typical of a wide stretch of land. No. 6 resembles No. 1 from Salisbury (see Vryburg list), and proves the uniformity of this wide tract of country, which extends from the low ridges lying some 2,000 yards to the east of the railway up to Ganzepan, and from the boundary of the farms Zwartputs and H.V. 75 to Iddesleigh. These sandy flats appear to continue down to quite near the Harts River: the soil is a very even-grained brown sand, free from stones, and of considerable depth. The red colour is characteristic of weathered surfaces, for, when the ground is turned over with a spade, the brown always shows.

At Zwartputs a limited area of different type is met with, represented by sample No .8. The soil is a deep humus, brown in colour, and sandy at the surface, but it becomes very dense at a depth of about twelve inches.

Sample No. 7 shows a difference in physical character. As distinct from the poor red sand found elsewhere, the soil of the upper portion of the lower levels between Ganzepan and Putsfontein or Blauwboschputs, is a brown loam about one foot deep, with a yellow clay-loam subsoil. This type of soil may possibly extend over some five hundred acres, according to Dr. Nobbs, from whose report on the tour the greater part of the above description has been compiled.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
10.	Hebron.	—	J. E. Fitt.
11.	,,	H.V. 67.	—
12.	,,	H.V. 63.	H. C. Litchfield.
13.	Daniel's Kuil.	Koopmansfontein.	J. Spreull.

Nos. 10, 11, and 12 were also collected from the area proposed to be irrigated by the Harts River; Nos. 10 and 12 represent surface soils. No. 10 was collected from Government land in the Harts River valley, and Nos. 11 and 12 from two farms in the Burg Pits valley.

No. 13 was collected on the Government farm Koopmansfontein from flat country abounding in Vaalbos, sour karree, a sort of ganna bush, reeds, and long grass, and formed a fair type of the grazing ground in the vicinity. The ground is of a rocky nature and the soil shallow, with a gravelly subsoil. Fragments of limestone lie strewn about the land, which in the spot whence the sample was taken had never been under cultivation.

The following are the results of the chemical analyses* of the soils comprised in the foregoing lists:—

(Method I.)

No.	Percent of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of soil sifted through ½ mm. Sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime	Potash.	Phosphoric oxide.
1	92·2	·94	1·78	·004	·028	·044	·050	·031
2	84·4	1·16	2·80	·004	·042	·020	·112	·045
3	93·4	3·33	4·19	·003	·098	·240	·123	·031
4	83·4	2·02	2·98	·005	·070	·082	·056	·038
5	97·3	·66	1·47	·003	·028	·020	·046	·013
6	94·6	·63	1·31	·003	·063	·036	·035	·014
7	94·6	4·74	10·90	·004	·134	3·768	·187	·101
8	98·3	2·57	3·03	·003	·084	·084	·141	·023
9	96·8	·79	1·69	·002	·056	·020	·037	·022
10	98·2	1·44	2·87	·0107	·098	·112	·023	·104
11	96·6	6·82	5·64	·0089	·070	1·037	·054	·195
12	97·6	6·03	4·98	·0089	·098	·461	·027	·154
13	91·3	2·51	8·20	·0028	·094	3·338	·125	·066

No. 1, from a chemical point of view, is poor all round: No. 2 is fairly well supplied with potash, but poor in other respects. Of the two Patryskraal soils, No. 4 is below normal in all plant food constituents, but No. 3 has a better supply; both soils, however, are lacking in phosphates. Nos. 5 and 9 are two soils which are chemically very poor. No. 6 has a moderate proportion of nitrogen, but its mineral plant food is deficient. The Zwartputs soil, No. 8, which was recognised by external appearance as a soil of different type from the preceding, also proved to be superior upon analysis; it possesses a fair supply of all plant food, phosphoric oxide excepted. The brown loam No. 7 is altogether the best of the entire series: chemical analysis shows the amounts of nitrogen, potash, and phosphoric oxide to be normal, lime being present in abundance. It does not seem impossible that the doleritic rocks in the vicinity may have contributed greatly to the chemical constituents of this soil.

The farm represented by No. 13 is about sixty thousand acres in extent, and, in view of the fact that the cattle whose grazing ground it constitutes are prone to attacks of "lamziekte," the scantiness of phosphatic material in the soil deserves attention. At the same time one soil sample can scarcely be taken as typical of so extended an area, and if it were, the difficulty presented of remedying a lack of phosphates in so wide a tract is undoubtedly enormous.

* For mechanical analyses of Nos. 10, 11 and 12, see under "Physical Composition of Soils."

BEAUFORT WEST.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Nieuwveld.	Roos Plaats.	W. C. Rose.

On the farm Roos Plaats, formerly known as Bronkhorst Vlei, and adjoining Doordrift and Spitskop, in the Nieuwveld district, a sample of soil was taken from a valley in the neighbourhood of a perennial stream between two ridges. The soil had a light, sandy appearance, but the subsoil was of a clayey nature. Upon analysis the following results were obtained:—

(Method I.)

No.	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Fine earth.	Water	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	94·0	2·57	5·15	·008	·196	·356	·300	·114

The chemical analysis bears out the opinion of the occupant of the farm, that the soil left nothing to be desired. During its present tenancy, which had lasted ten years, the soil had received no manure of any description, while other lands, lower down the river on the same farm, produced very indifferent crops until manured with guano.

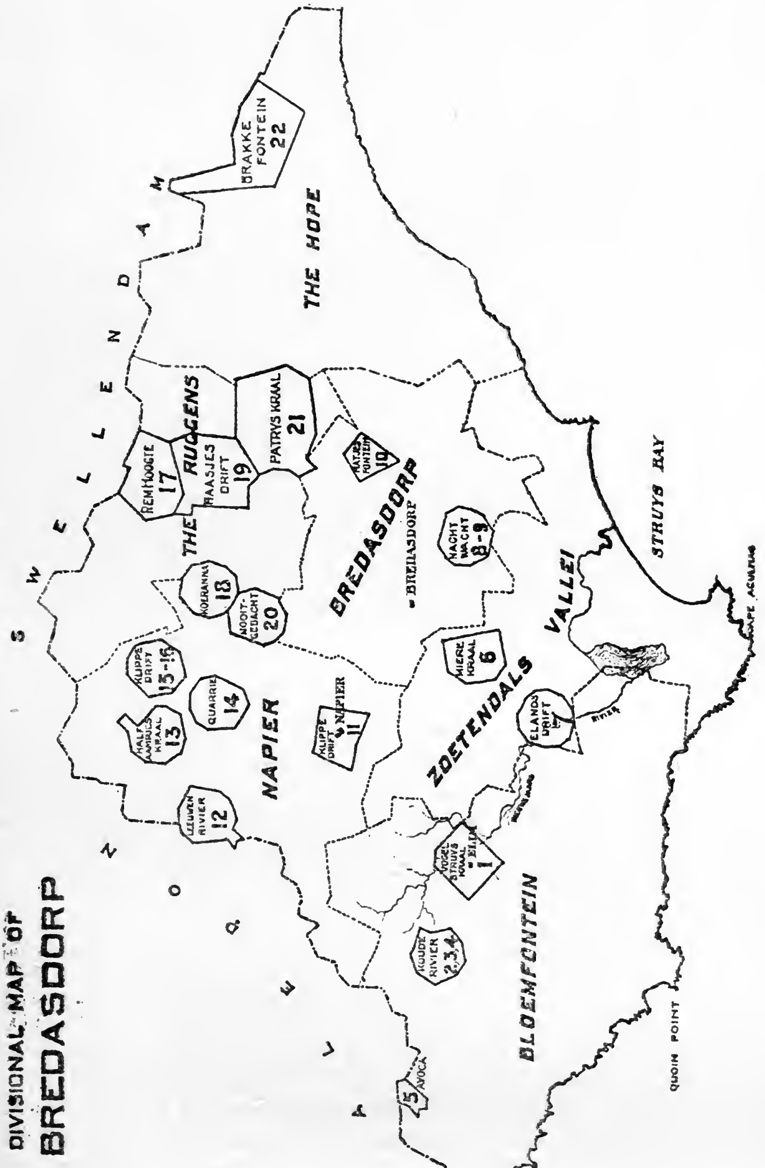
It is probable that this fertility is largely due to the calcareous tufa which forms a characteristic feature of this part of the country, and is evidently the result of the disintegration and decomposition of the dolerite which abounds in the Karroo. As a rule, soils thence derived appear to be well supplied, not only with lime, but also with potash, while even the proportion of phosphoric oxide is fairly high.

BREDASDORP.

(Officially collected.)

No.	Field Cornetcy.	Farm or Place.	Collector.
1.	Bloemfontein.	Vogelstruis Kraal.	J. Muller.
2.	,,	Koude Rivier.	,,
3.	,,	,,	,,
4.	,,	,,	,,
5.	,,	Avoca	,,
6.	Zoetendals vallei.	Miere Kraal.	,,
7.	,,	Eland's Drift.	,,
8.	Bredasdorp.	Nachtwacht.	,,
9.	,,	,,	,,
10.	,,	Matjesfontein.	,,
11.	Napier.	Klippe Drift.	,,
12.	,,	Leeuwen Rivier.	,,
13.	,,	Halfaampjes Kraal.	,,
14.	,,	Quarrie.	,,
15.	,,	Klippe Drift.	,,
16.	,,	,,	,,
17.	The Ruggens.	Rem Hoogte.	,,
18.	,,	Koeranna.	,,
19.	,,	Haasjes Drift.	,,
20.	,,	Nooitgedacht.	,,
21.	,,	Patrys Kraal.	,,

The soils of the Bredasdorp Division are for the most part of two broad classes; the larger portion of the Division is covered by the Ruggens or shaly soils of the Bokkeveld geological series, while to the south lie the soils of the Downs. In the adjoining Division of Swellendam a third



belt—the sandstone soils, already noticeable in the Caledon Division on the journey eastwards from Cape Town—again begin to acquire prominence, and further east, in the Riversdale Division, these three parallel belts, running east and west, are distinctly recognisable.

Sample No. 1, a stiff white clay, was taken from the slope of the hill east of the village of Elim. About six miles W.N.W. of that village, Nos. 2, 3 and 4 were collected on the farm Koude Rivier: they represent respectively a sandy clay, a sandy loam, and an alluvial sandy humus soil, and were taken from lands S.W., south, and east of the homestead. Although the subjacent rocks are those of the Malmesbury series, these four soils had evidently been largely influenced by the Table Mountain sandstone and quartzites from the ranges about Elim. Basic slag had, to some extent, been used on this farm. Proceeding some nine miles to the west of Koude Rivier, a sandy soil, No. 5, was taken from a small granite outcrop on the farm Avoca, which is the chief tobacco growing farm in this district: here the surrounding hills are composed mainly of Table Mountain sandstone. On the farm Miere Kraal, about 13 miles east of Elim, a loose sandy clay, No. 6, was collected. A chain of recent limestone hills crosses the south-eastern part of this farm. Eland's Drift, a fairly large grain farm, was next visited: it is situated on the right bank of the Nieuwjaars River, about 6½ miles S.W. of Miere Kraal. On this farm. No. 7, a stiff red clay soil, was taken.

From Nachtwacht, the farm of Mr. D. Albertyn, about 5½ miles south-east of the village of Bredasdorp, No. 8, a sandy loam, and No. 9, a loose clay soil, were taken from lands situated respectively south-east and south of the homestead. Mr. Albertyn considers that in the dry season the former soil is the better of the two. Between this farm and the village, the compacted limestone which, intermingled with blown sea-sand, forms about six hundred square miles of coast belt, appears on the surface. No. 10, a loose gravelly clay, was taken from the farm Matjesfontein, situated on the boundary of the Ruggens and the Downs, about 8½ miles E.N.E. of Bredasdorp.

Sample No. 11, a loose clay soil, was taken from lands about half a mile north-east of the village of Napier. Proceeding thence to the farm Leeuwen Rivier, another loose clay soil, No. 12, was obtained from lands on a hill N.N.E. of the homestead. This, and all the remaining samples of the series, were taken from the Bokkeveld area, and are consequently types of Ruggens soils. The next sample, No. 13, from the farm Halfaampjes Kraal, 6½ miles north-east of Leeuwen Rivier, was a gravelly clay. On a portion of this farm the earth of the soil is very considerably interspersed with large fragments of clay slate. This is also the case at Quarrie, where a loose clay, No. 14, was taken from lands lying northeast of the dwelling-house. From Klippe Drift, about four miles N.N.E. of Quarrie, two samples of soil were collected: No. 15 represents a loose, gravelly clay from elevated lands, and No. 16 a soil of more Karroo type, from low lands devoid of fragments of clay slate such as those noticed at Halfaampjes Kraal and Quarrie. Gravelly deposits, of the nature of that just alluded to, are frequently met with scattered about the high lands in this and the adjoining divisions, for example, at Zwartklip, in the Swellendam Division, to which reference will be made later. Regarding the two soils last referred to, Mr. Wessels, one of the occupants of the farm, was of opinion that during wet seasons No. 16 proved the better.

At Rem Hoogte, just about eleven miles east of Klippe Drift, No. 17, a loose clay soil, was obtained: another such soil, No. 18, was collected 6½ miles south-west of this, on the farm Koeranna, while at Haasjesdrift, seven miles east of the last, No. 19, a loose gravelly clay soil, was taken. The next farm visited was Nooitgedacht, or Zout Rivier, about four miles S.S.W. of Koeranna, where No. 20, a light loose clay, was collected. No. 21, a loose red clay, was taken from the farm Patrys Kraal, about four miles south of Haasjesdrift.

On account of long continued drought the crop returns of the three consecutive years preceding this visit to the division had been very scanty; some farms, in the neighbourhood of those mentioned, had, in fact, been totally deserted owing to scarcity of water.

(Privately collected.)

No.	Field Cornetcy.	Farm or Place.	Collector.
22.	The Hope.	Brakkefontein.	C. Marais.

On the farm Brakkefontein samples of surface soil were collected from five different spots, at the foot of the Potteberg Range, and just below the Potteberg Trigonometrical station. The five lots of soil were thoroughly mixed and an average sample was then taken for analysis. This surface soil is rather loose and sandy, and, as may be expected under the dominating influence of the sandstone range, proves to be poor in plant food. About five feet below the surface there is a deposit of water-worn pebbles mixed with yellowish clay, from twelve to eighteen inches thick, overlying a very dark loamy water-bearing stratum from five to ten feet in thickness. Under that lies another layer of very fine yellowish clay. Lucerne and vegetables of all kinds, especially root crops, have been found to flourish luxuriantly on this soil.

The analyses of all the foregoing soils of this Division are given below:—

(Method II.)

	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. sieve.		
No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	0·67	3·27	·0099	·15	·11	·063	·0092
2.	1·80	8·08	·045	·16	·26	·045	·016
3.	0·74	3·45	·012	·13	·12	·036	·0082
4.	0·71	4·06	·0092	·12	·14	·016	·022
5.	0·38	2·36	·015	·17	·32	·071	·013
6.	0·95	5·14	·014	·15	·28	·13	·026
7.	1·18	3·58	·0085	·15	·11	·10	·013
8.	0·54	2·83	·011	·15	·25	·076	·028
9.	1·10	5·65	·018	·16	·40	·12	·015
10.	0·92	5·30	·011	·16	·31	·23	·0038
11.	1·25	7·95	·0096	·18	·20	·062	·011
12.	1·63	9·65	·019	·18	·15	·18	·026
13.	1·39	6·94	·011	·15	·18	·19	·032
14.	1·27	7·01	·029	·17	·16	·11	·026
15.	0·95	5·86	·021	·16	·37	·13	·028
16.	0·91	4·23	·028	·17	·094	·089	·019
17.	1·32	6·91	·017	·15	·15	·19	·038
18.	1·43	7·19	·043	·077	·15	·15	·030
19.	1·65	6·34	·0071	·15	·16	·12	·024
20.	0·71	3·96	·0064	·19	·094	·15	·022
21.	1·02	2·89	·017	·16	·20	·098	·010

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
22.	90·6	1·75	5·35	·022	·147	·064	·017	·045

Nearly all these soils contain satisfactory quantities of Nitrogen, but they are almost uniformly lacking in phosphoric oxide. Those of the Bloemfontein Field-cornetcy are badly supplied with potash, but the rest of the Division is apparently better off in this respect. Most of the soils contain a fair amount of lime, although less than those of Robertson and Swellendam.

BUTTERWORTH.

(Officially collected.)

No.	Field Cornetcy.	Farm or Place.	Collector.
1.	'Nhlambe.	'Nhlambe.	St. C. O. Sinclair.
2.	,,	,,	,,
3.	Butterworth.	Butterworth.	,,
4.	,,	,,	,,
5.	,,	,,	,,
6.	,,	,,	,,
7.	,,	,,	,,

Samples 1 and 2 of this Division were collected on the farm 'Nhlambe, the former Residency, now the property of Mr. Burgersheim. They were taken from lands lying along the Gcua River, and may be considered to represent the soil derived from the sandstones of the Kentani beds belonging to the Karroo system, which lie S.S.E. of Butterworth. Fruit trees thrive here, and oats also do well. No. 3, a black soil, was collected about six miles from Butterworth, in the same direction as the previous samples. It represents a doleritic soil, but, contrary to what has been found elsewhere, the chemical analysis (*vide* table below) shows it to be an all-round poor soil, as far as mineral plant food goes. No. 4 is a sample of black soil overlying sandstone, collected at a point about two miles E.S.E. of Butterworth village. No. 5 was taken from a spot two miles N.N.W. of Butterworth, and is typical of the soil found on the hillocks—studded with doleritic boulders—which are common in this part. The subsoil is a red, somewhat coarse, gravel, which rises to within eighteen inches of the surface. Samples 6 and 7 represent the Government plantation at Butterworth village. The former, a black, micaceous, somewhat clayey soil, typifies the surface soil to a depth of about nine inches. No. 7 represents the second nine inches of the soil. These soils appear to be the result of the decomposition of the micaceous sandstone and black shales that constitute a portion of the sedimentary rocks to which the name of Idutywa beds has been assigned by the Geological Commission. On the plantation represented by the last named soils grains of all sorts thrive well; so also do wattles, blackwoods, and sneezewoods, and varieties of cypress. Pines, on the other hand, do not seem to thrive.

The following table shows the results of the chemical analyses:—

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	94·5	3·89	6·61	·0071	·175	·202	·029	·026
2.	97·0	3·24	6·89	·0340	·189	·094	·071	·023
3.	94·4	2·82	5·91	·0283	·168	·080	·023	·015
4.	87·1	3·77	8·67	·0233	·203	·146	·130	·033
5.	96·4	4·77	10·04	·0290	·217	·106	·085	·052
6.	94·4	2·60	6·31	·0276	·189	·090	·134	·036
7.	94·6	1·74	3·69	·0248	·056	·066	·205	·033

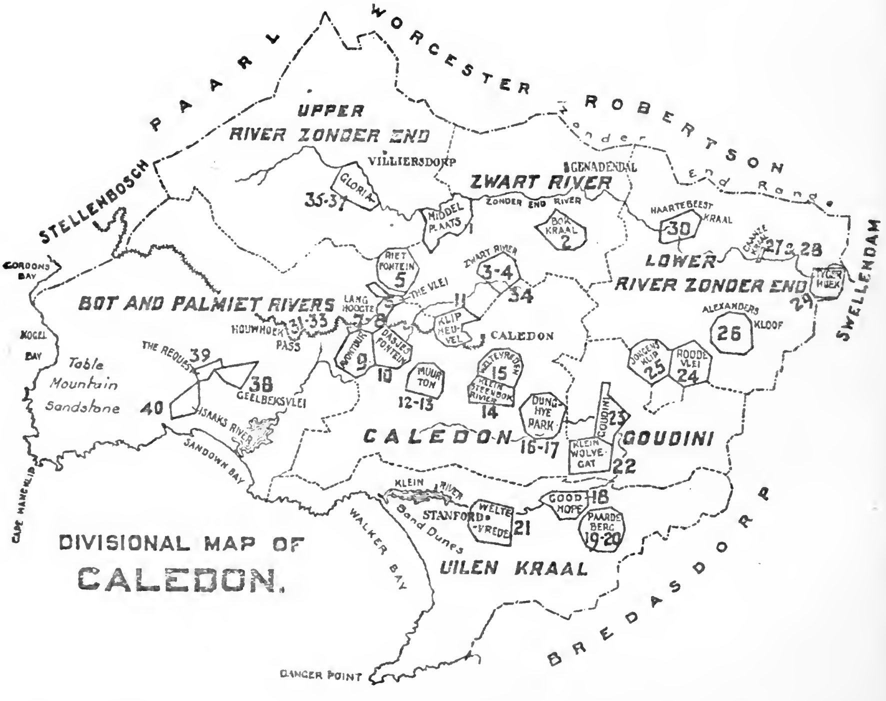
All these soils exhibit a deficiency of phosphoric oxide, nor can they be said to be well supplied with lime and potash; indeed, the former plant food constituent is lacking in many of them. On the other hand, most of the samples show a fair proportion of nitrogen.

CALEDON.

(Officially collected.)

No.	Field Cornetcy.	Farm or Place.	Collector.
1.	Upper River Zonder End.	Middelplaats.	J. Muller.
2.	Zwart River.	Bok Kraal.	,,
3.	,,	Zwart River.	,,
4.	,,	,,	,,
5.	Bot and Palmiet Rivers.	Rietfontein.	,,
6.	,,	The Vlei.	,,
7.	,,	Langhoogte.	,,
8.	,,	,,	,,
9.	,,	Avontuur.	,,
10.	,,	Dasjesfontein.	,,
11.	Caledon.	Klipheuvel.	,,
12.	,,	Muurton.	,,
13.	,,	,,	,,
14.	,,	Klein Steenboks River.	,,
15.	,,	Weltevreden.	,,
16.	,,	Dunghye Park.	,,
17.	,,	,,	,,
18.	Uilen Kraal.	Good Hope.	,,
19.	,,	Paarde Berg.	,,
20.	,,	,,	,,
21.	,,	Weltevreden.	,,
22.	Goudini.	Klein Wolvegat.	,,
23	,,	Goudini.	,,
24.	Lower River Zonder End.	Roode Vlei.	,,
25.	,,	Jongens Klip.	,,
26.	,,	Alexanders Kloof.	,,
27.	,,	Ganze Kraal.	,,
28.	,,	,,	,,
29.	,,	Tygerhoek.	,,
30.	,,	The Oaks.	,,

The collection of soil samples in this Division commenced with a visit to the farm Klipheuvel, $2\frac{3}{4}$ miles W.N.W. of the village of Caledon; here sample No. 11, a sandy clay soil, was taken. About $6\frac{1}{2}$ miles northwest of this farm, sample No. 5, a loose clay, was collected on the farm Rietfontein; the soil represented by this sample had not been cultivated for ten years. Proceeding thence about three miles to the south, No. 6, a sandy clay, was taken from Mr. J. le Roux's farm The Vlei. Neighbouring farmers stated that there is a noticeable difference between the crops raised at that place, and those at Langhoogte, a farm lying nearly a mile south of The Vlei. Samples Nos. 7 and 8 were accordingly collected at Langhoogte, both of them sandy clays; No. 8, however, is more of a Karroo type, and was considered to show greater fertility than No. 7. As will be seen from the table below, the only chemical superiority



that the former of these two soils shows over the latter is in respect of the phosphoric oxide contained; in the same respect it is also better than the soil taken at The Vlei.

The next place visited was the farm Avontuur, about $5\frac{1}{2}$ miles southwest of Langhoogte; and here a stiff clay, sample No. 9, was collected. Proceeding about two miles in an easterly direction along the Zwart River, another stiff clay soil, sample No. 10, was obtained on the farm Dasjesfontein—a soil that had not been cultivated during the last four years, and quite different in character from any of the former samples. It will be noticed that analysis shows it to contain a very much larger proportion of phosphoric oxide. From the farm Muurton, or Klein Zwart River, about $4\frac{1}{4}$ miles south-east of Dasjesfontein, two samples,—No. 12, a stiff clay soil, and No. 13, a loose clay from an alkaline or brack land—were taken. The soil represented by the latter of these two samples had not been cultivated for about five years; as will be observed from the analyses below, it proved to be exceedingly poor in lime. The farmers in this neighbourhood used, as a fertiliser, lime obtained from the sea-shells of the Bot River Strand, scattering it along with the wheat when sowing. They had also commenced employing artificial fertilisers in small quantity, principally Basic slag.

On the farm Klein Steenboks River, about six miles east of Muurton, a ferruginous clay soil, No. 14, was procured, and about three miles N.N.E. of this farm, No. 15, a sandy clay, was obtained on the farm Weltevreden: it had not been cultivated for the last seven years. The soil here is very shallow, extending to a depth of about six inches only, below which a layer of coarse gravel is met with. Four miles south-east of this, samples of two varieties of clay soils were taken from Dunghye Park, the farm of Messrs. De Villiers Bros., perhaps the largest and richest farm in this part of the Division. No. 16 represents a stiff clay soil adjoining the vineyard, while No. 17, a loose clay, was taken from brack land on the other side of the river. The former was considered preferable to the latter for sowing purposes during dry seasons. As only imported seed was sown, rust did not appear in the crops. At Klein Wolvegat, about six miles south-east of Dunghye Park, No. 22, a loose clay soil, was obtained from the mountain side. Proceeding south from here along the Klein River, the farm Good Hope was touched at, and a stiff clay soil, sample No. 18, was taken from brack land. The next place visited was the farm Paardeberg, about three miles south-east of Good Hope. Here two samples were collected; No. 19, a sandy, clay soil, which had not been under cultivation for nineteen years, and which the owner of the farm considered to be very poor, and No. 20, a very stiff clay, which practical experience had proved to be very fertile. This sample represents the only stiff red clay in the vicinity. The physical and chemical differences between samples 19 and 20 are mainly these: No. 20 is finer in texture and retains moisture better; it contains more organic matter, and has fifty per cent. more nitrogen and about six times as much potash; these facts apparently more than compensate for its low proportions of lime and phosphates: it would no doubt be improved by Basic slag. No. 19, on the other hand, which is a purely sandstone derived soil, notwithstanding its possessing more lime and phosphoric oxide than No. 20, exhibits an all-round poverty, without any redeeming feature whatever; hence it does not surprise one to be told that when it is put under cultivation it fails to bring its crops to perfection, the ears of corn generally shrivelling up before attaining maturity. Sample No. 21, a sandy clay, was taken from the farm Weltevreden, about a mile north-east of the village of Stanford. Further south blown sands, similar to those which cover the Cape Flats, are met with: these sand dunes consist of finely divided particles of sea-shells and quartz sand, with occasional compacted limestones.

Eastwards from Caledon a sandy clay, No. 23, was obtained from Goudini, the farm of Mr. D. H. Kleyn, about 4½ miles north of Klein Wolvegat. As a fertiliser Mr. Kleyn was in the habit of using principally bone manure, from which he obtained very good results. This is by no means surprising, for the analysis shows the soil to be very deficient in lime, while its phosphoric oxide is not much better. Proceeding about seven miles in a north-easterly direction, the farm Roode Vlei was visited, and a stiff clay, No. 24, was sampled. On the farm Jongens Klip, 3½ miles further W.N.W., sample No. 25 was taken, representing a sandy clay, of somewhat stony character. Sample No. 26, also a sandy clay soil, was procured from the farm Alexanders Kloof, about seven miles E.N.E. of Jongens Klip, and said to be more fertile than the soil represented by the sample taken at the latter spot. From a chemical point of view, however, there is no practical difference between these two soils, nor are they very different physically. Crossing the River Zonder End, about 6½ miles N.N.E. of Alexanders Kloof, the samples numbered 27 and 28 were taken from the farm Ganze Kraal, on the northern bank of the River Zonder End, and south of the Zonder End Range. The latter of these two samples is a stiff clay, while the former is a loose alluvial clay, darker in appearance than the other, on account of the larger proportion of organic matter contained. The distance between the two points is not 160 yards, the boundary line being very distinct. Both soils are planted with vines and fruit trees, while the grain lands are all on the south side of the river. Proceeding about 5½ miles eastwards, all along the river, Tygerhoek, the farm of the Misses Vynes, was reached, and here sample No. 29 was obtained on the south side of the river; it represents a stiff clay, light yellow in appearance. The next farm to be visited was The Oaks, or Hartebeest Kraal, nearly seven miles from Ganze Kraal, higher up the river in a west-north-westerly direction. Here sample No. 30, a stiff clay, was collected.

North of Caledon the first place visited was Bok Kraal, about four miles south of Genadendal. Here sample No. 2 was collected, also a stiff clay soil. From the farm Zwart River, about 6½ miles south-west of the last one, Nos. 3 and 4 were obtained: the former, a sandy clay, rather stony, was taken from a hill slope, whereas the latter, more sandy, was collected from the low lying lands in the valley: as the table of analytical results will show, the sandier soil is in all respects the poorer of the two. The last sample collected on this tour, No. 1, was taken from the farm Middelplaats, about five miles north-west of Zwart River.

With the exception of samples 5, 10, 13, 15, and 19, none of which had been under recent cultivation, all the above represent virgin soils.

(Privately collected.)

No.	Field Cornetcy.	Farm or Place.	Collector.
31.	Bot and Palmiet Rivers.	Houw Hoek.	C. E. Pillans.
32.	,,	,,	,,
33.	,,	,,	,,
34.	Zwart River.	Zwart River..	J. W. Hartford.
35.	Upper River Zonder End.	Kale Ruggens.	C. Lange.
36.	,,	,,	,,
37.	,,	,,	,,
38.	Bot and Palmiet Rivers.	Geelbeks Vlei.	C. Lindholm.
39.	,,	The Request.	,,
40.	,,	Isaaks River.	,,

Three samples, Nos. 35, 36, and 37, were taken from a valley near the Upington Bridge, on Mr. Charles Leonard's stud farm, Kale Ruggens, now known as Gloria, which is situated about five miles south-west of Villiersdorp, on the River Zonder End. The estate is almost encircled by sandstone hills, and Mr. Lange, the manager, declares that his best efforts have followed the use of guano from the Government islands, with a top-dressing of nitrate in the case of oats, and lime and sheep manure in the case of lucerne, which, under such conditions, thrives very well indeed. The surface soil at the locality where these samples were taken is a sandy loam, with a clay subsoil; the slopes adjacent to the valley consist of the usual alluvial soil, locally known as "klippers grond."

Nos. 38, 39, and 40 were collected from farms situated on the Table Mountain sandstone, of which the Paardeberg Mountains are composed. As may be anticipated, therefore, they are, generally speaking, poor. In the case of the soil from The Request it appears likely that the sample is not sufficiently typical—in other words, that the soil it represents had undergone some artificial improvement whereby it had been rendered chemically richer than the average soil in the vicinity. Nos. 31, 32, and 33 were collected at Houw Hoek, from the orchard of the late Mr. Aspinall: the plot of land whence they were taken lies across the road from the house, on the north-west side of the main road to Caledon. Here also, the soil is, as a rule, poor, being derived largely from the sandstone of the Table Mountain series, whereof the Houw Hoek Mountains are built up.

Sample No. 34 was collected on the farm Zwart River, adjoining the farm Sergeant's River, on the Genadendal road, about ten miles from Genadendal. The soil is poor all round, like the sandy soil No. 4, officially collected on the same farm.

The analyses of the foregoing forty soils are tabulated below:—

(Method II.)

No.	Percentage of Soil sifted through 1 mm Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	·73	2·67	·55	·084	·27	·13	·033
2.	1·06	3·85	·0061	·13	·034	·076	·038
3.	1·24	6·69	·0086	·15	·034	·13	·059
4.	·51	2·15	·093	·091	·018	·043	·038
5.	1·60	6·57	·0038	·17	·093	·050	·058
6.	1·44	6·33	·0040	·15	·028	·056	·036
7.	2·04	11·71	·0038	·25	·083	·073	·032
8.	1·42	6·60	·0056	·15	·030	·038	·058
9.	1·48	7·57	·017	·15	·026	·098	·049
10.	1·27	6·43	·0034	·13	·098	·060	·12
11.	2·05	8·30	·0031	·19	·080	·078	·077
12.	·87	4·36	·0042	·11	·039	·036	·056
13.	1·37	5·25	·018	·10	·018	·055	·038
14.	1·27	4·94	·0042	·15	·15	·076	·056
15.	1·56	6·14	·0050	·15	·024	·073	·056
16.	1·49	5·81	·0021	·14	·038	·048	·072
17.	1·67	7·42	·0055	·20	·045	·087	·059
18.	1·28	5·21	·0070	·15	·040	·044	·051
19.	·88	3·37	·0049	·091	·054	·041	·046
20.	1·57	5·21	·0055	·13	·029	·24	·032
21.	·84	3·22	·0027	·11	·038	·024	·056
22.	1·38	6·57	·0097	·17	·025	·045	·036
23.	1·58	7·88	·0058	·20	·016	·072	·036
24.	1·93	7·98	·0034	17	·058	·068	·13
25.	1·93	7·04	·0064	·18	·032	·071	·051
26.	1·87	7·19	·0034	·20	·045	·078	·061
27.	2·10	8·20	·014	·22	·058	·049	·061
28.	1·37	4·39	·0049	·098	·030	·061	·041
29.	·95	4·60	·0042	·13	·026	·042	·038
30.	1·19	6·04	·0037	·16	·041	·045	·056
31.	5·22	11·45	·005	—	·45	·066	·022
32.	1·25	2·46	·066	—	·021	·033	·067
33.	·89	3·64	·022	—	·022	·012	·014
34.	—	—	—	—	·091	·036	·013

(Method I.)

	Per cent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
35.	73·5	·47	1·77	·010	·101	·010	·017	·037
36.	64·3	·86	2·92	·008	·087	·006	·008	·028
37.	52·5	·34	1·26	·008	·080	·008	·008	·015
38.*	81·6	·58	3·36	·0099	·098	·044	·014	·0089
39.	—	·81	—	·009	·15	·18	·24	·06
40.	—	1·01	—	·007	·16	·014	·09	·05

No. 1 of the foregoing soils is undoubtedly brack or alkaline, and it is significant that the alternative name of the farm Middelplaats, whence it was taken, is Brakfontein: the high proportion of chlorine in this sample will be noticed.

It is not at all surprising to find how poor in all inorganic plant food the primary sandstone soils of this Division prove to be. In the tables of analytical results illustration hereof is afforded by the soils from Dasjesfontein (No. 10), Klipheuvel (No .11), Dunghye Park (No. 16), Paardeberg (Nos. 19 and 20), and Klein Wolvegat (No. 22).

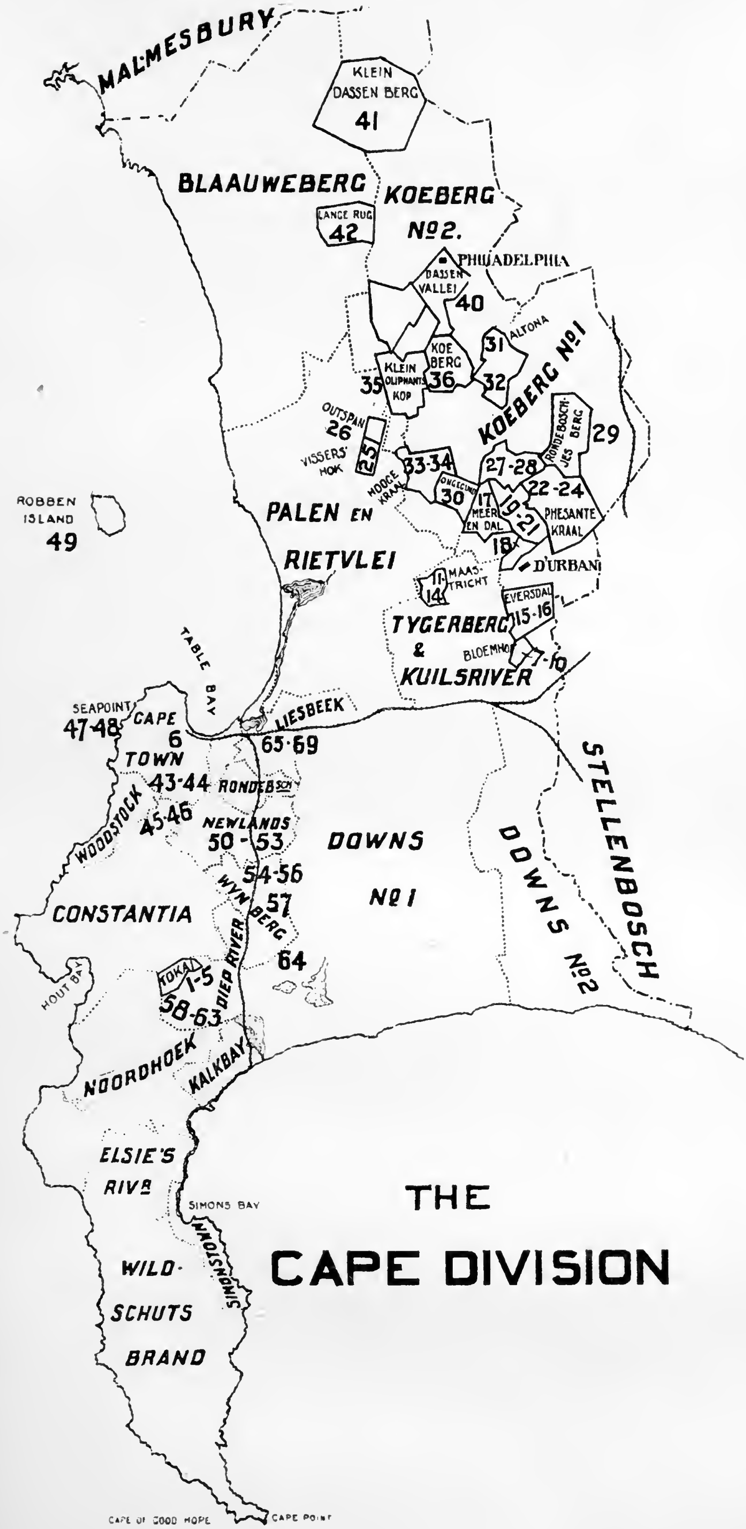
It will be seen that very many of the soils of this part of the Colony are distinctly deficient in lime: the area in which they lie is almost entirely hemmed in by sandstone. Further east, in the Bredasdorp Division, and in the western portion of the Division of Swellendam the influence of the sandstone ceases, and accordingly the soils in those parts contain more lime.

CAPE.

(Officially collected.)

No.	Field Cornetcy.	Farm or Place.	Collector.
1.	Diep River.	Tokai.	J. G. Rose.
2.	,,	,,	,,
3.	,,	,,	,,
4.	,,	,,	,,
5.	,,	,,	,,
6.	Cape Town.	Parliament House grounds.	A. Simons.
7.	Tygerberg and Kuils River.	Bloemhof.	J. Muller.
8.	,,	,,	,,
9.	,,	,,	,,
10.	,,	,,	,,
11.	,,	Maastricht.	C. F. Juritz.
12.	,,	,,	,,
13.	,,	,,	F. Blersch.
14.	,,	,,	,,
15.	,,	Eversdal.	C. F. Juritz.
16.	,,	,,	,,
17.	Durban.	Meerendal.	F. Blersch.
18.	,,	Johannesfontein.	,,

* For mechanical analysis of No. 38, see under "Physical composition of soils," Part VII.



THE

CAPE DIVISION

No.	Field Cornetcy.	Farm or Place.	Collector.
19.	Durban	Diemersdal	F. Blersch.
20.	"	"	C. F. Juritz.
21.	"	"	"
22.	"	Phesante Kraal.	"
23.	"	"	"
24.	"	"	"
25.	Palen and Rietvlei.	Vissers Hok.	"
26.	"	Government land north of Vissers Hok.	"
27.	Koeberg No. 1.	Vrymansfontein.	"
28.	"	"	"
29.	"	Rondeboschjesberg.	"
30.	"	Ongegund.	"
31.	"	Altona.	"
32.	"	Adderley.	"
33.	"	Hooge Kraal.	J. G. Rose.
34.	"	"	"
35.	Koeberg No. 2.	Klein Olifants Kop.	C. F. Juritz.
36.	"	Kalkfontein.	"
37.	"	Uitkyk.	"
38.	"	"	"
39.	"	"	"
40.	"	Dassen Vallei.	"
41.	"	Klein Dassen Berg.	J. C. Watermeyer.
42.	Blauwberg.	Lange Rug.	"

The first five samples were collected at the Tokai Convict Station: No. 1 was a very poor sandy soil from the vicinity of the camp which had been used for interning prisoners of war; it had just produced an oat crop, and a similar crop was grown some five years previously, a small quantity of guano having been applied for each crop. No. 2 represents a dark soil which it was intended to use as a vineyard, and had been cultivated for the last twelve or fifteen years with garden crops. Farmyard manure and guano had been applied at various times, and basic slag three years before the collection of the sample: the old estate vineyard used to be located here. The third sample was a moist black vlei ground, virgin soil, but interspersed with palmiet roots. The next was a brown soil from the rifle range garden cultivated for five years, and manured with farmyard manure and guano. The last of these five samples represents a brown soil from the neighbourhood of the Porter Reformatory; it had also been under cultivation, but no details regarding the manures employed could be obtained. The last two samples proved exceedingly poor in their reserve of plant food.

Within the Municipality of Cape Town, No. 6 affords an idea of a cultivated and frequently manured garden soil: the sample analysed represents the average of the soil within the grounds of the Parliament Houses. Samples were taken from different points in the grounds and well mixed together, and an average sample was then subjected to chemical analysis.

Four samples of soil from the Hon. R. P. Botha's farm Bloemhof, or The Hope, were analysed. No. 7 was a yellowish sandy vineyard soil, taken from north-east of the homestead; it had not been manured during recent years, and was found in practice to be very poor. No. 8 was taken from another part of the vineyard, north of the homestead; it was more clayey than the foregoing, but mixed with coarse gravel: it is found to be more productive than No. 7. No. 9 represents a poor and very sandy soil; the sample was taken from the vineyard north-west of the house. No. 10 was a very stiff clay, also from the vineyard west of the house, and proved to be fairly good in practice. In the collection of these four samples the soil for six inches nearest the surface was discarded, and the next twelve inches collected for examination. A glance at the analytical tables will show that the first three of these soils exhibit an all-round lack of plant food, but that No. 10 is distinctly better than those in both lime and potash: it may therefore be said that to this extent chemical analysis here again confirms practical experience.

Samples 11, 12, 13 and 14 were taken from the farm Maastricht, lying S.S.W. of the village of Durbanville. Rust had worked great havoc amongst the crops for three consecutive years, but the season previous to the collection of the samples had witnessed a remarkable immunity from attack. Samples 11 and 12 were virgin soils, taken at a distance of about $3\frac{1}{4}$ miles from Durbanville. Nos. 13 and 14 were taken from cultivated areas which had been infested with *Erysiphe graminis* in the wheat crops; these two samples were collected some time subsequent to Nos. 11 and 12, and the disease was then in full swing. The next farm visited was Diemersdal, and here too samples were taken on two different occasions. Here also a visitation of rust, similar to that experienced at Maastricht, had taken place: two years before the farm was first visited for the collection of soils the entire crop had been destroyed, but during the succeeding season the crop had not been affected at all. Nos. 20 and 21 were virgin soils taken at a mean distance of about $2\frac{1}{4}$ miles north of Durbanville. No. 19 was taken on a later occasion, and under similar conditions to Nos. 13 and 14. Nos. 17 and 18 were also collected from lands where the grain had been badly affected at the time with the above-mentioned parasitic disease. At Vrymansfontein, about $3\frac{3}{4}$ miles N.N.W. of Durbanville, samples 27 and 28 were taken, the former from a hill-side, the latter from low lying ground. No. 29 was collected from a hill-side at Rondeboschjesberg, $4\frac{1}{2}$ miles N.N.E. of Durbanville, and Nos. 22 and 23, from the farm Phesante Kraal, somewhat over three miles N.N.E. of the village: of these two soils, the first was taken from a hill slope, the second from a valley, No. 24 being taken from the same farm further east. Two soils were collected on the farm Eversdal, about $1\frac{3}{4}$ miles from Durbanville.

On most, if not on all, of these farms, the principle of applying manure in accordance with the needs of the soil and crop seemed to be entirely ignored: to the land adjacent to the homestead farmyard manure was, as a rule, applied, while guano was carted to lands at greater distances, or in less accessible localities, hillsides, for instance. It was all a question of convenience. Only in one case, that of the farm Phesante Kraal, was the use of artificial fertilisers practised. Thus sample No. 20, although a virgin soil, represents a type usually worked with farmyard manure, and No. 21 one on which guano is employed; and it is a remarkable fact that the lands represented by this latter sample were overrun with *Rumex acetosella*, or Steenbok zuuring, as the farmers call it, from which noxious weed No. 20 was entirely free. There were general complaints amongst agriculturists with regard to the trouble caused by this weed, and its marvellous persistence on certain tracts, and absence from certain others seemed to be worth investigation.

In the more northerly portion of the Division, commonly known as Koeberg, samples were taken from valleys on each of the farms Ongegund and Vissers Hok, and one from the top of a small hill on the Crown land (outspan) north of Vissers Hok. Two virgin soils were collected from hill sides on the farm Hooge Kraal, No. 33 being found by experience to be the more productive of the two. Kraalbosch—considered locally to be a sign of richness of soil—grows on the soil represented by No. 33, which is thought to be the best soil on the farm. It is a looser soil than No. 34, the latter being more stony and apt to cake when the ground becomes hard and dry: No. 34 is, however, more typical of the average Koeberg soil. No. 35 was taken from a valley on the farm Klein Olifants Kop. Of the three soils collected on the farm Uitkyk, it must be noted that the first two, in common with most of the other samples collected from this Division (with the exception, that is to say, of Nos. 1 to 10, 13, 14, 17, 18, 19 and 39) represent absolutely virgin soils, never yet cultivated, dug over, or touched by manure, No. 37 being in the occupant's opinion, the worst, and No. 38 the best ground on that particular farm. No. 39 was a sample of cultivated ground adjoining No. 38, and exactly similar thereto in nature. The analyses afford some clue as to the basis of the farmer's differentiation between these two soils: that which he described as the best soil on the farm is finer in grain than the poorer soil; it is more tenacious of moisture, contains a larger proportion of organic matter, and more potash; it has more than double the reserve of lime, and nearly six times the amount of phosphoric oxide. The cultivated soil alongside the richer of these two had apparently been exhausted of half its reserve stock of phosphoric oxide.

Klein Dassen Berg, from which the virgin soil No. 41 was collected, is not a grain farm, cereals being grown in quantity sufficient only for home consumption. The arable land of the farm is a sandy loam. The farm is subject to the inroads of blown sands from the west coast. The farm Lange Rug lies on the boundary of the Koeberg clays and the sandy soils of the coast: sample No. 42 is a sandy clay from that farm.

Of the 42 soils described above, the last 36 may be said to summarise the grain lands of the Cape Division; Nos. 7 to 24 affording an excellent representation of the grain farms surrounding Durbanville, while the remaining eighteen are typical of the Koeberg grain district.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
43.	Cape Town.	Molteno Reservoir.	—
44.	,,	Government Avenue.	—
45.	,,	Table Mountain.	—
46.	,,	,,	—
47.	Sea Point.	—	W. Gilmore.
48.	,,	—	J. M. Stephen.
49.	Robben Island.	—	—
50.	Newlands.	Fernwood.	H. Meyers.
51.	,,	,,	,,
52.	,,	,,	,,
53.	,,	,,	,,
54.	Wynberg.	Kenilworth.	B. H. Holland.
55.	,,	,,	D. E. Hutchins.
56.	,,	,,	,,
57.	,,	Cape Flats.	,,
58.	Diep River.	Tokai Forest Plantation.	—
59.	,,	,,	—
60.	,,	,,	—
61.	,,	,,	—
62.	,,	,,	—
63.	,,	,,	—
64.	Downs No. 1.	Princess Vlei.	C. E. Pillans.
65.	,,	Uitvlugt.	—
66.	,,	,,	—
67.	,,	,,	—
68.	,,	,,	D. E. Hutchins.
69.	,,	,,	,,

Sample 43 was taken from the escarpment on the upper side of the Molteno Reservoir. No. 44 was taken from a locality in the Government Avenue, Cape Town, where the oak trees were dying off. The cause of this was obvious: there was a fair amount of lime and potash in the soil, which was also well stocked with nitrogen, and although it was very poor in phosphates, this did not afford an adequate solution of the difficulty, which appeared to be physical rather than chemical, and exactly illustrates the closing sentence of Mr. A. D. Hall's remarks quoted on page 18. The soil was a stiff bluish clay, and exhaled a distinct sour odour when fresh and moist: the acidity was found to be ·06 per cent., calculated as oxalic acid. *In situ* it was a stiff, damp clay, and this fact, coupled with the presence of much organic matter, and the lack of aëration in the soil, undoubtedly accounted for the ill effects observed.

From the top of Table Mountain samples 45 and 46 were collected: they were, of course, typical Table Mountain sandstone soils. Practical experience had declared the soil there to be extremely poor; in fact, according to the Conservator of Forests, it has been found that only Pines and Acacias flourish on it, and that on a larger scale only the cluster pine has been successfully grown. Even this tree failed when planted on the soil represented by No. 46, although on No. 45 it grew well: this was attributed to the fact that the latter had the better subsoil of the two.

Two soils were collected from private gardens at Sea Point. One of these, No. 47, was taken from the surface of a piece of ground that had been trenched to a depth of three feet for the cultivation of vines: here, as in the case of the Parliament House garden soil, No. 6, several lots were taken from various parts of the area intended to be cultivated, and a thorough mixture made.

Many of the soils in the last list were collected with the idea of obtaining some information relative to the chemical composition of forest soils, and of areas proposed to be afforested. Thus, one sample was taken from the site of a projected tree plantation at Robben Island. This soil, No. 49, yielded a rather small amount of potash, but the phosphate of lime present in an available condition was unnaturally large in quantity; as this was hardly to be expected in so sandy a soil it appeared to point to the presence of a great deal of bone material: the sample was thereupon examined microscopically, and quantities of minute fragments of bones were found therein.

Four samples were collected at Fernwood, Newlands, and one, No. 54, was taken from a garden at Kenilworth: of these, Nos. 50, 51, and 53 had been under cultivation in former years, but not latterly, while No. 52 was meadow land which had been quite recently broken up. These five soils practically all lack potash and phosphates.

Two samples of Cape Flats clays, Nos. 55 and 56, were collected on the Wynberg Flats, near the Kenilworth Racecourse: of these, No. 55 was a white kaolin or China clay, and the other a plastic, dark coloured clay, which occurs, in a thin layer, above the kaolin. These beds of pure white kaolin underlie an extensive area of the Cape Flats sands; apparently, however, these Cape Flats clays do not extend very far east of the railway line. Sample No. 57 represents a similar white clay, which forms the subsoil of the forest plantation on the Wynberg Flats.

Nos. 58 to 63 represent red Constantia loams, and were collected from the Eucalypt arboretum at Tokai. The arboretum comprises several plots, containing not less than 40 six-year-old trees each, and, although never previously cultivated, the area was in former times probably overgrown with Leucodendron (Silver tree) and Mountain bushes.

One sandy soil was collected from the vine plantation lying south-east of Princess Vlei. The peculiar characteristic of this soil, and of a large area whereof it is typical, is that stone fruits are not found to do well, whereas apples and pears thrive upon it.

The clay underlying the Government Forest Plantation at Uitvlugt is represented by samples 68 and 69: these typify the portions of the estate where the tree growth is finest, No. 68 being a yellow and No. 69 a white clay. Nos. 65, 66, and 67 were sands from the Epping Forest at Uitvlugt, a Government plantation on one of the poorest parts of the Cape Flats, where an area of about 4,000 acres has been planted with Cluster Pine and Wattles.

The results of the analyses of the soils from the Cape Division are tabulated below:—

(Method I.)

No.	Percent. of Field Sample.	Percentage of soil sifted through 1 mm. sieve.				Percentage of soil sifted through ½ mm. sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	31·8	·42	1·87	·024	·042	·022	·016	·015
2.	71·7	·93	3·99	·034	·111	·046	·046	·078
3.	91·1	4·36	16·77	·068	·319	·030	·059	·066
4.	61·8	1·36	4·10	·034	·014	·012	·033	·023
5.	57·3	·60	2·59	·033	·042	·014	·021	·017
6.	62·2	2·93	5·44	·0113	·120	·532	·129	·095
7.	98·3	—	—	—	—	·080	·028	·024
8.	82·7	—	—	—	—	·088	·017	·027
9.	96·8	—	—	—	—	·086	·015	·024
10.	94·1	—	—	—	—	·160	·062	·028
33.	82·1	1·78	4·23	·0084	·448	·608	·887	·046
34.	82·4	1·33	4·09	·0142	·532	·107	·551	·035
43.	96·0	1·14	8·47	·0304	·014	·008	·011	·065
47.	66·8	2·36	7·46	·012	·103	·194	·359	·139
54.	82·4	5·76	14·97	·001	·189	·042	·010	·063
55.	57·1	1·02	8·47	·0106	·043	·086	·015	·176
56.	84·5	2·11	6·82	·0035	·057	·122	·008	·033
58.	63·0	2·28	6·77	·0057	·071	·018	·050	·046
59.	67·6	3·01	6·80	·0152	·057	·020	·047	·049
60.	63·5	2·07	7·40	·0304	·050	·024	·037	·040
61.	50·7	2·19	8·43	·0142	·078	·012	·047	·036
62.	45·2	1·96	8·31	·0230	·057	·030	·041	·063
63.	50·2	2·25	9·29	·0113	·071	·010	·035	·042

(Method II.)

No.	Percentage of soil sifted through 1 mm. sieve.				Percentage of soil sifted through 3 mm. sieve.		
	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
11.	1·33	15·50	·054	·128	·48	·045	·028
12.	2·97	10·52	·057	·201	·64	·27	·028
13.	2·09	6·44	·0091	—	·21	·157	·011
14.	·65	·26	·0090	—	·12	·125	·012
15.	1·37	6·94	·0053	·134	·39	·12	·044
16.	1·75	7·64	·0028	·134	·35	·026	·062
17.	1·05	4·15	·0024	—	·20	·152	·027
18.	1·42	7·49	·011	—	·26	·036	trace.
19.	·69	5·37	·0019	—	·18	·167	·027
20.	1·03	4·60	·021	·106	·23	·14	·028
21.	1·22	6·67	·0074	·134	·25	·27	·019
22.	1·38	5·31	·0021	·089	·23	·043	·044
23.	·63	2·84	·0021	·123	·12	·025	·032
24.	1·12	5·79	·0060	·084	·32	·023	·017
25.	1·61	4·16	·0024	—	·24	·43	·035
26.	·27	·51	·0005	·056	·046	·039	·0038
27.	·70	2·85	·0095	·056	·22	·35	·020
28.	·44	2·11	·0053	·061	·11	·12	·020
29.	·94	4·00	·0021	·044	·15	·16	·026
30.	1·19	3·92	·0064	—	·23	·24	·026
31.	1·40	4·35	·0006	—	·13	·071	·062
32.	1·60	2·05	·0026	·061	·061	·070	·019
35.	·81	1·73	·0004	·061	·095	·038	·023
36.	·62	1·64	·0018	—	·061	·036	·017
37.	·96	2·36	·021	—	·067	·065	·013
38.	1·65	4·20	·0016	—	·16	·093	·076
39.	2·04	2·57	·0028	—	·16	·098	·040
40.	·96	2·59	·0013	—	·070	·094	·026
41.	·24	·81	·0015	·035	·061	·021	·029
42.	·84	2·17	·037	·028	·057	·030	·017
44.	4·84	6·81	·053	·154	·186	·111	·008
45.	·92	5·72	·0033	·126	·033	·014	·043
46.	·35	1·89	·0034	·070	·053	·010	·035
48.	1·46	3·20	·021	·084	·154	·215	·013
49.	·78	3·19	·010	—	3·320	·085	3·370
50.	3·78	6·69	·0008	·184	·188	·044	·054
51.	2·86	5·10	·0003	·089	·065	·069	·025
52.	2·66	5·34	·0007	·117	·131	·040	·027
53.	1·82	3·26	·0005	·044	·071	·044	·045
57.	·92	6·41	·0049	·042	·076	·035	·0015
64.	·05	·17	·0010	·049	·024	·011	·012
65.	—	—	—	—	·087	·049	·012
66.	—	—	—	—	·040	·014	·007
67.	—	—	—	—	·046	·016	·009
68.	2·81	5·70	·0113	·07	·226	·028	trace.
69.	1·56	4·11	·0624	—	·130	·0079	trace.

To refer once again to the five samples of soil—Nos. 13, 14, 17, 18, and 19—collected in the Durban and Tygerberg Field-cornetcies, from areas where *Erysiphe graminis* had infested the wheat crops; the analyses indicate that the average composition of the soils from the cultivated lands where the disease had made its appearance was poorer all round than that of the virgin soils from the same locality: *vide* the following:—

	Average composition per cent. of virgin soils.	cultivated soils.
Lime	·291	·194
Potash	·133	·127
Phosphoric oxide	·031	·015

This shows to some extent the soil exhaustion that had taken place: the crops were apparently badly in need of phosphatic material, and it would not be surprising if this had a great influence upon their capacity to resist the attacks of parasitic diseases.

In this connection I may aptly quote Professor P. MacOwan, D.Sc., F.L.S., formerly Government Botanist, who was professionally investigating the fungus disease at the time when the analyses just mentioned were being made. Dr. MacOwan observed:—

"Phosphate of lime is the one thing needful as mineral food for all cereals—wheat, barley, oats, mealies, and rye. Yet, *beginning with a poor supply of it*,* there are hundreds of farms where cereals have been taking the phosphate out of the soil every year for a quarter of a century. The inevitable result has come about. Stinted in phosphates, the corn grows year by year more weakly in constitution, stools less, gives lighter ears, gives shrivelled grain. All this is the natural result of phosphate starvation. On such debilitated plants the parasitic fungi and insects make their usual attacks. The plants have so little vitality that they cannot bear the injury and live. Naturally they succumb. The cure is restoring the original percentage of phosphates, to make the land what it was before five and twenty crops had each carried away a share of this element of its fertility."

On comparing the Koeberg soils with those around Durbanville, it will be observed that many of the latter contain more available lime than the former do. The reason hereof has not yet been investigated: the underlying rock being in both cases of the same nature, it appeared improbable that this could have anything to do with the variation. Possibly the larger proportion of lime in the more southerly soils was due to the finely divided particles of blown sea-sand, which extend across the Cape Flats from the southern coast.

CARNARVON.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector,
1.	No. 5.	Jakhals Kolk.	C. McMillan.
2.	,,	,,	,,

These two soils were collected respectively from Lots 111 and 94, near Van Wyks Vlei. The former had been under cultivation for 17 years, but the latter was virgin soil. As they will be dealt with more fully in

* The italics are my own; notice the small amount of phosphoric oxide in the virgin soils.

connection with the subject of alkali in soils (see pages 185-7), the following analyses will suffice at this stage:—

No.	Percent. of Field Sample.	Percentage of soil sifted through 1 mm. sieve.				Percentage of soil sifted through ½ mm. sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	97·9	6·25	6·58	1·542	·084	·876	·399	·228
2.	94·3	2·43	3·48	·0856	·070	·116	·329	·193

These soils—as is usually the case with "brack" soils—are well supplied with plant food.

CATHCART.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	No. 3.	The Dales.	St. C. O. Sinclair.
2.	,,	,,	,,
3.	,,	Exwell Park.	,,
4.	,,	,,	,,
5.	,,	,,	,,
6.	,,	,,	,,
7.	,,	,,	,,
8.	,,	,,	,,
9.	No. 4.	Spanover.	,,
10.	,,	,,	,,
11.	,,	Side Spur.	,,
12.	,,	Anta.	,,
13.	,,	,,	,,
14.	,,	,,	,,
15.	,,	Braemar.	,,
16.	,,	,,	,,
17.	No. 5.	Stoneridge.	,,
18.	,,	,,	,,
19.	,,	,,	,,
20.	,,	,,	,,
21.	No. 4.	Inverthorn.	,,
22.	,,	Blackpool.	,,
23.	,,	,,	,,
24.	,,	,,	,,
25.	No. 6.	Sledmere.	,,
26.	,,	,,	,,
27.	,,	,,	,,
28.	,,	Clapton.	,,

As stated on page 36, the investigation of the soils of the Western Province had not progressed very far ere requests began to come in from the east for similar investigations in that portion of the Colony. It was in response to such requests that Cathcart and the neighbouring districts were visited. It had, therefore to be borne in mind, in taking samples in the Cathcart Division, that, although it was the intention that the analyses of these samples should form part of the systematic investigation of the Colony's soils, yet this area was being surveyed at the special request of the Eastern Province Fruit-growers' Association. It was found expedient, therefore, to concede, to a greater extent, at any rate, than would otherwise have been the case, to the wishes of the individual farmers of the district in visiting special localities, and in taking samples from places selected by them. At the same time, samples representative of the different types of soil occurring in the Division were also collected.

The soil of the Cathcart Division, compared with that of Komgha, which will be dealt with subsequently, is not so micaceous, but is, on the other hand, more calcareous. Dolerite, although largely present, does not appear as plentiful as in the Komgha Division. The Cathcart soils seem to be naturally derived from the upper rocks of the Karroo system.

No. 1, a sample of black loamy valley soil, was collected from the farm The Dales. It appears to extend to a depth of about eighteen inches, and rests on a subsoil of yellow clay. The veld on both sides of this valley is reported to be "sweet." No. 2 represents the hill-side soil of the same locality. These two soils, together with Nos. 17, 18, 19 and 20, are representative of the area known as the Bontebok Vlakte, the chief grain-producing portion of the Cathcart Division, and stretching over practically the whole of its south-eastern part.

Nos. 3 to 8 were collected on the farm Exwell Park. Above the homestead is a valley whence samples 3 and 4 were taken: as it was intended to use this land for an orchard, those samples were taken from the mixed contents of holes about 22 inches deep in each case. By thus departing from the usual method of soil-collecting already detailed, a better idea of the suitability of the soil for orchard purposes would be obtained. Physically No. 4 differs from No. 3 in being slightly more clayey. No. 5, a sample of clayey soil rich in organic matter, was taken from ploughed land just above a lately constructed dam. The subsoil here was of a more sandy nature. The soil represented by this sample is capable of retaining a large amount of water, due to the proportion of clay and organic matter present therein. No. 6 represents a mixture of surface and subsoil from the patch just referred to. No. 7 is a black soil taken from lands below the homestead and adjacent to the railway line. No. 8, which is also a black soil, represents the soil of the Victoria Orchard. This land had been in constant use for some years, and was reported to be very fertile, mealies, oats, and wheat being amongst the crops successfully borne during the last three years. These six soils represent the eastern portion of the Waku valley, the main fruit-producing area of the Cathcart Division. The soils of this part of the country contain a large amount of calcium carbonate, which is visible in the form of "drip lime."

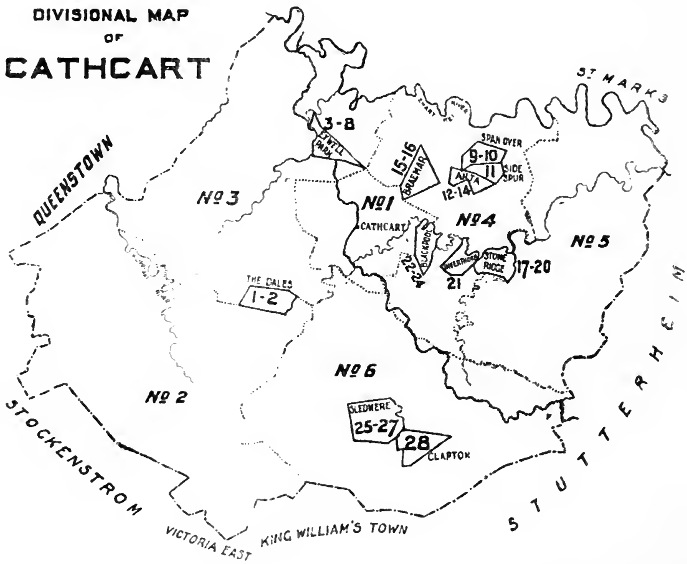
No. 19, taken from the farm Stoneridge, represents the valley soil lying between the homestead on that farm and the Thomas River. No. 18 is representative of the hill-side soil near the homestead. No. 17 was taken from cultivated land on the same farm for the purpose of comparison with Nos. 18 and 19: the land from which it was taken had borne oats and mealies and, to judge from the analytical figures, cultivation had left its mark in a diminution of the stock of available phosphoric oxide. It was intended to utilise this soil for grain, but in that event it would obviously stand in great need of a phosphatic fertiliser.* No. 20, was taken from a sandy soil, situated behind the homestead and proposed to be used as a vineyard, a purpose for which it did not appear unsuited: it proved to be rather poorly supplied with phosphates.

No. 21 was collected, on the farm Inverthorn, from one of the older river terraces of the Thomas River. No. 22, a sample of black soil, was taken on the farm Blackpool, just below a ridge of doleritic boulders on

*Cf. Prof. MacOwan's remarks relative to lack of phosphates in grain soils at Durbanville, quoted on page 45.

the slope towards the Thomas River. The subsoil was reported to be a clay. No. 23 was taken from the same slope, but beyond the influence of the doleritic ridge: it is a more sandy soil, lighter in colour than No. 22. It was stated that barley and rye did not thrive on the lands represented by it. No. 24 is a sample of doleritic soil lying further to the east.

On the farm Spanover two samples were taken, one, No. 9, representing the garden soil lying south-west of the homestead, and another, No. 10, the grain soil north-east of the latter. No. 11 was a stiff black soil, representing a very productive tract of land whereon potatoes especially were reported to do well. The soil No. 12, collected on Mr. W. H. Crout's farm Anta, was of a sandy character, and intended to be devoted to the cultivation of potatoes. No. 13, from the same farm, represents a rather stiff alluvial soil of good depth. No. 14 was taken from the same slope, but nearer to the river; the soil here is dark in colour and of a more clayey nature than where No. 13 was collected. No. 25 is a sample of



soil from cultivated land just below the homestead at Sledmere. The subsoil at this place was found to be a yellowish clay, while the surrounding surface soil is inclined to be sandy. No. 26 was taken from the same land, but nearer to the bottom of the slope. No. 27, a soil rich in organic matter, was taken at the bottom of the slope whence the previous two samples were collected. The portions of this slope represented by these three soils differ considerably in their productiveness when used for the same purpose. On the area represented by the last-mentioned sample, wheat, for instance, does not seem to thrive. No. 28 was collected on the farm Clapton. It is a stiff black soil, lying near to the homestead, in the vicinity of which doleritic boulders were noticed. This soil, together with No. 19, typifies the N.N.E. portion of the Division. Cattle are said to be in the habit of licking the watercourses in this portion of the district. This fact was thought to be due to the presence of a considerable amount of common salt in the soil; attention was not drawn to this when passing through any other part of the Division, it may, nevertheless, be the case that such a habit is prevalent throughout a much wider area, and not peculiar to the stock in the parts where it was specially noticed.

Samples 15 and 16 are dark valley soils from the farm Braemar, which lies north-east of Cathcart. The latter is the more clayey of the two. On the lands represented by these samples mealies were reported to do well.

The following analytical figures were obtained:—

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	99·0	1·50	3·77	·0244	·098	·200	·033	·040
2.	98·8	·62	1·84	·0145	·053	·014	·014	·015
3.	96·5	1·36	2·30	·0376	·070	·059	·066	·025
4.	97·1	1·52	2·99	·0334	·084	·111	·099	·038
5.	99·4	2·78	5·82	·0731	·126	·446	·172	·088
6.	99·4	2·68	5·24	·0341	·112	·295	·188	·060
7.	99·0	2·30	5·12	·0341	·112	·151	·179	·082
8.	99·3	2·70	5·88	·0721	·171	·358	·208	·128
9.	98·0	1·48	3·29	·0060	·081	·330	·121	·031
10.	93·6	1·53	3·97	·0287	·084	·162	·122	·026
11.	96·0	1·29	3·20	·0028	·133	·128	·095	·036
12.	99·0	·55	1·90	·0025	·070	·124	·162	·028
13.	99·3	·70	2·40	·0129	·084	·088	·070	·017
14.	98·8	·85	2·56	·0042	·105	·098	·078	·023
15.	99·0	1·12	3·06	·0240	·140	·054	·067	·031
16.	98·9	1·19	3·59	·0042	·133	·070	·042	·026
17.	97·6	1·60	3·35	·0325	·076	·274	·057	·018
18.	94·9	1·39	3·07	·0290	·090	·142	·070	·031
19.	98·1	1·06	2·85	·0268	·076	·152	·066	·033
20.	97·2	1·18	3·30	·0275	·056	·142	·080	·028
21.	97·7	1·13	3·05	·0197	·056	·126	·090	·027
22.	98·7	2·73	5·55	·0057	·182	·290	·175	·075
23.	97·0	·65	1·76	·0050	·028	·072	·137	·029
24.	94·8	1·87	4·72	·0176	·140	·086	·102	·033
25.	99·0	1·10	3·34	·0046	·112	·124	·160	·022
26.	97·4	1·50	3·99	·0042	·119	·116	·124	·024
27.	98·6	2·65	4·98	·0042	·091	·148	·126	·035
28.	97·3	2·57	7·60	·0127	·154	·252	·139	·040

On the whole, the plant food content in these Cathcart Division soils is more satisfactory than in the neighbouring Division of Komgha: taken all round, they possess a fair amount of available lime and potash, but the soils, which are all more or less of a clayey nature, exhibit decided poverty in respect of phosphates, if judged by European and American standards, although in this connection a remark already made must be borne in mind,* namely, that proportions of phosphoric oxide which would be deemed inadequate in Europe, in this Colony frequently suffice to yield satisfactory returns. There appears to be generally a larger amount of chlorides present in these soils than that found in the Western Province soils.

* See page 12.

In the soils of Field-cornetcy No. 3 phosphoric oxide averages better than in the rest of the Division. Of this entire series Nos. 2 and 15 are the worst; they show an all-round deficiency. The poorest soils in the Division, from a chemical point of view, are those which represent the Bontebok Vlakte: Nos. 2 and 15 have just been referred to; Nos. 1 and 16 lack potash and phosphoric oxide, and Nos. 17 and 18 are also badly supplied with phosphates.

The fertile soil of the Victoria orchard had not received any manure for three years; it is one of the best all-round soils met with in the course of these investigations. In every respect its available plant food is satisfactory: its nitrogen is good, the lime is normal in amount, and so is the potash and phosphoric oxide.

One of the sandier soils of the Division, No. 23, which represented part of the incline towards the Thomas River on the farm Blackpool, proved to be poor in nitrogen, lime, and phosphoric oxide, with but a moderate amount of potash; the failure of the barley and rye crops is thus explained, and here once more the analytical results bear out practical experience. The extent of doleritic soil to the east of this contains a larger proportion of organic matter and more nitrogen, but less potash, and is practically just as badly off for lime and phosphates. The productive potato lands represented by sample 11 are evidently fairly well supplied with lime and potash, and also show a satisfactory nitrogen content, but phosphoric oxide is low in amount. If potatoes be constantly grown on this land, its reserve of potash, unless renewed artificially, would suffer speedy exhaustion.

CERES.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Ceres.	Riet Vallei.	Dr. R. J. Reinecke.
2.	,,	,,	,,
3.	,,	,,	,,
4.	,,	,,	,,
5.	Bokkeveld.	The Oaks.	O. A. Ohlsson.
6.	,,	,,	,,
7.	,,	,,	,,

Four samples of virgin soil were collected on the farm Riet Vallei, in the outskirts of Ceres village, about half a mile east of the Dwars River. At the particular places where the samples were taken, the soil had never been cultivated or manured, and is overgrown with sour grass. The surface soil is sandy and the subsoil clayey. In the locality in question soil of this type, if well manured, is stated to have been found capable of the most liberal cultivation: vines and tobacco do well; without manure lucerne does not thrive, nor can one be surprised at this, considering the poor supply of lime in the soil.

Three analyses were made of soil from Mr. A. Ohlsson's farm The Oaks: No. 5 represents ground that had been trenched, and No. 6 was a mixture of soil collected on two different parts of the farm.

The table below gives the results of the chemical analyses of the above soils: —

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide
1.	97·0	·36	1·93	·0049	·077	·072	·015	·022
2.	80·7	·37	1·86	·0130	·091	·010	·015	·028
3.	98·3	·27	1·41	·0067	·084	·010	·012	·010
4.	98·0	·56	2·55	·0123	·112	·008	·017	·032
5.	80·5	1·33	5·48	·039	·102	·052	·024	·040
6.	80·2	·98	4·28	·019	·074	·034	·025	·041
7.	94·2	·64	2·81	·014	·074	·042	·020	·052

The areas represented by these soils are largely influenced by the presence of rocks of the Table Mountain series, and the first four, in particular, lying in a tract of country practically surrounded by sandstone mountains, can hardly be expected to be otherwise than poor in the chemical constituents of plant food.

CLANWILLIAM.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Bidouw.	Matjes Rivier.	P. Bornemisza.
2.	,,	,,	Dr. Simon.
3.	,,	Wupperthal.	P. Bornemisza.
4.	,,	Beukes Kraal.	,,
5.	,,	,,	Dr. Simon.
6.	,,	Kromme Rivier.	,,
7.	,,	,,	P. Bornemisza.

In this Division soils were collected from farms in the Bidouw Field Cornetcy, where tobacco is largely grown. The local practice has been to manure heavily, generally with goat manure, those areas which were used for tobacco cultivation.

The results of the analyses are given below: —

(Method II.)

	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted 3 mm. Sieve.		
No.	Water.	Organic. matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	—	—	·024	—	·32	·13	·010
2.	·91	4·18	·023	—	·73	·11	·067
3.	—	—	·003	—	·11	·04	·09
4.	—	—	·134	—	·80	·25	·01
5.	·67	6·42	·075	—	·34	·21	·63
6.	2·10	8·60	·170	—	·88	·78	·006
7.	—	—	·020	—	·20	·12	·03

Remembering that these represent soils under actual cultivation, and this in connection with a very exhausting crop, it may be observed that they all contain at least a fair amount of lime, and that this plant food is present in quite satisfactory proportion in most of the samples taken. The soil from Wupperthal was deficient in potash, but at Beukes Kraal the quantity of this constituent was normal, while of the Kromme Rivier sample No. 6 was very well stocked in this particular. Phosphoric oxide is either wholly inadequate, or present only in moderate proportion right through, sample No. 5 excepted: in the latter case the amount is, relatively speaking, so extraordinarily high as to suggest the inference that it is due to the method of fertilising already alluded to; in fact, seeing that in the soils of this Division the plant food constituents would not be expected to be present in any larger proportion than in the soils of the Ceres Division, where similar geological influences prevail, it is probable that nearly all these Clanwilliam soils had been altered in chemical composition by extensive fertilising agencies.

COLESBERG.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Upper Hantam.	Oorlogspoort.	W. Webb.
2.	"	"	"
3.	"	"	"
4.	"	"	"
5.	"	"	"
6.	"	"	"

Six samples of virgin soil were collected at various localities on the farm Oorlogspoort, formerly known as Zeekoegat. The surface soil of the farm is ordinary Karroo veld, the underlying formation being shale, alternating with lime. The chemical composition of the soil is apparently influenced by the rocks of the Stormberg series.

The analyses of these soils resulted as shown in the following table:—

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	91·1	2·49	3·73	·006	·064	·046	·156	·068
2.	92·7	2·67	3·69	·007	·064	·094	·165	·072
3.	93·8	2·94	3·84	·007	·071	·114	·183	·070
4.	97·6	4·40	6·51	·003	·165	·506	·203	·115
5.	98·1	2·33	3·84	·007	·101	·066	·184	·073
6.	94·7	3·51	3·81	·006	·064	·216	·136	·069

These soils, somewhat similar in their geological origin to those of the Albert and Aliwal North Divisions, are, like the soils of the Divisions named, all rather fine in texture, but better, in respect of potash, than the

Albert soils analysed. They all contain a satisfactory proportion of potash, and a fair amount of phosphoric oxide. No. 4 is well supplied with nitrogen and lime, and all the others have fair percentages of nitrogen. Lime is the only element of plant food that can be described as actually lacking in any of these soils; in this respect the soils represented by samples 1, 2, and 5 were defective.

ELLIOT-SLANG RIVER.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	—	Lutha.	S. L. Hart.
2.	—	,,	,,
3.	—	,,	,,
4.	—	Ettrick.	W. F. Beadon.

Three samples of soil taken at Lutha, in the Elliot District, midway between Elliot and Indwe, were analysed. In the valleys the surface soil is usually black, with a pot-clay subsoil commencing about twelve inches below the surface: this black surface soil is represented by No. 2. On the hill-sides the soil is either light and sandy, or deep red, according as the ledges above consist of sandstone or ironstone. Samples of both these types of soil were collected. No. 1 on the list was a fine sandy soil collected from a hill; practical experience had found it fairly good, *when fertilisers were applied,** but the deep red soil—of which No. 3 was a specimen—is said to be the best. The subsoil, in both cases, is a clay, commencing from one to ten feet below the surface. Most of the cultivated farm lands are on the hills; the soil there is cooler, more retentive of moisture, and stands drought better. The valleys provide heavier crops during good seasons, but the valley soils, being very shallow, need frequent rains if a fair crop is to be ensured. Where available, the alluvial deposits of old river beds are best of all. As for the valley soils, it has been found necessary to abandon them for cereal crops, and devote them to lucerne, as the continual ploughing and heavy rain storms denude them very rapidly and form large "sloots," a condition which does not result in the higher and sandier localities.

It may be remarked that the geological formations in the neighbourhood of Ida ('Mbokotwa Commonage), near to which the farm whence these samples were taken is situated, belong principally to the Stormberg series; that is to say, they are chiefly composed of Molteno sandstones, and of red beds resembling the Burghersdorp beds. The former are naturally poor in plant food, and the first sample on the list is a type hereof; the Red Beds, on the other hand, have a better reputation, while the dykes of dolerite which intersect in the sandstones, would also tend to improve the soil by the addition of lime.

Another sample of soil was taken from dry agricultural lands on the farm Ettrick, and represented fairly the soil in the neighbourhood, on which, it is said, nothing will grow. Chemical analysis shows it to be practically as poor as the sample of sandy soil from Lutha, and thus fully confirms the agriculturists' views.

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*Chemical analysis shows the natural condition of the soil to be poor all round.

The following are the analyses of the above mentioned soils:—

(Method I.)

No.	Percent of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	98·1	1·25	2·72	·0035	·073	·036	·043	·020
2.	97·7	8·20	19·67	·0187	·263	·482	·153	·110
3.*	90·8	3·31	10·60	·0057	·170	·154	·111	·088
4.	98·0	·99	4·38	·006	·074	·056	·049	·038

FORT BEAUFORT.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Fort Beaufort.	Fort Beaufort Asylum.	Medical Superintendent.
2.	”	”	”
3.	”	”	”
4.	”	”	”

The only samples of soil from this Division that have been analysed are four from the grounds around the Fort Beaufort Asylum. Nos. 1 and 2 were taken from the garden at the male asylum, and Nos. 3 and 4 from the female asylum garden. The site is in a valley which receives the drainage of surrounding hills about a quarter of a mile distant: the subsoil is red, with fragments of limestone, and overlies a blue shale. All the subsoil water in the valley is reputed to possess a sulphurous odour.

The analyses of these soils resulted as below:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic. matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	87·4	2·20	4·05	·009	·102	·154	·188	·070
2.	87·8	3·24	5·45	·008	·147	·190	·189	·077
3.	89·7	2·40	4·66	·005	·132	·444	·263	·191
4.	77·6	3·49	10·50	·007	·442	1·058	·197	·536

As these soils have evidently been affected by cultivation and fertilising, very little in the way of general conclusions regarding them can be drawn. Apparently in their original state they were not well supplied with phosphates, for in Nos. 1 and 2 the amount of phosphoric oxide is still low. The lime, organic matter, and nitrogen in No. 4 are unusually high, no doubt as a result of treatment with fertilisers; for the rest it is scarcely possible to tell whether the plant food constituents found are due to natural causes or to manipulation, so that the practical inutility of basing general conclusions upon analyses of cultivated soils is once again

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*For mechanical analysis of this sample see under heading "Physical composition of soils" (Part VII.).

exemplified. Taking the soils, however, as they stand, none of them can be said to be really deficient in any form of plant food, and No. 4, as already indicated, is rich in nitrogen, lime, and phosphates, and is moreover satisfactorily stocked with potash. No. 3 is likewise rich in lime and well supplied with potash and phosphates, the proportion of nitrogen being normal. The remaining samples, with the exceptions noticed, are satisfactorily supplied with all the principal plant food constituents.

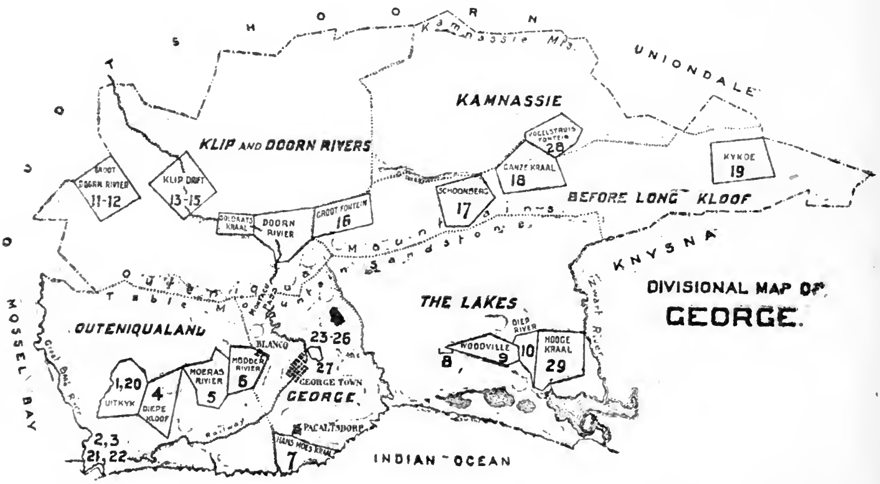
GEORGE.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Outeniqualand.	Uitkyk.	J. Muller.
2.	,,	Greak Brak River.	,,
3.	,,	,,	,,
4.	,,	Diep Kloof.	C. F. Juritz.
5.	,,	Palmiet.	,,
6.	,,	Modder River.	,,
7.	George.	Hans Moes Kraal.	,,
8.	The Lakes.	Outspan Reserve	,,
9.	,,	Woodville.	,,
10.	,,	Diep River.	,,
11.	Klip and Doorn Rivers.	Groot Doorn River	,,
12.	,,	,,	,,
13.	,,	Klip Drift.	,,
14.	,,	,,	,,
15.	,,	,,	,,
16.	Before Long Kloof.	Grootfontein.	,,
17.	,,	Schoonberg.	,,
18.	,,	Ganze Kraal.	,,
19.	,,	Kykoe.	,,

The hamlet of Great Brak River is distant about 2½ hours' cart journey from the town of George, in a south-westerly direction: a typical sample of the intervening area is No. 1 in the above list, a "sour" soil taken from Uitkyk, a farm in the George Division, but near to the Great Brak River, which forms the natural boundary between the division named and that of Mossel Bay. No. 2, a red and more sandy soil, typifies another portion of the area referred to; it was selected from new lands on Mr. H. Barnard's farm, quite close to the main road, on the heights above Great Brak River. From the lands of Mr. C. Searle, M.L.A., on the left bank of the river, No. 3, in appearance a very similar soil, was secured.

After leaving Great Brak River for George a short extent of granitic soil is passed over, speedily, however, succeeded by a red pot-clay. Later on this in turn gives place to a blacker and looser clay, of which a sample, No. 4, was collected on the farm Diep Kloof, about four miles by road from Great Brak River. This sample is typical of the soil of the surrounding farms; by practical farmers it is considered to be rather poor, and chemical analysis quite bears out this testimony: when manured it answers well, a fact which tends to show that its defects are wholly chemical. Another sample of the same class, although somewhat lighter and sandier, No. 5, was collected four miles further on, at Palmiet, part of the farm Moeras River. Between these two points there are a few patches of granite soil, but the predominating clay is soon reached again. Sample No. 6 was procured at Modder River, near the entrance to the village of Blanco. This soil, which is chemically poor except as regards nitrogen, appears to be derived from the band of slate which stretches eastwards, north of Blanco: it is typical of the stiffer clay soils which skirt the southern slopes of the Outeniqua Mountains, between the Great Brak River and George, the coast soil being of a sandy nature and sweet, whereas the intermediate belt, from which samples 3 and 4 were taken, is a mixture of the two classes of soil. Of the sandy belt a sample, No. 7, was taken from the granite formation near Pacaltsdorp, on the farm Hans Moes Kraal, at a distance of about five miles by road from George: this also is an all-round poor soil. A sample of sandy clay, No. 8, resembling the soil taken at Blanco, and lying on an extension of the band of slate already referred to, was collected from the Outspan Reserve about 12 miles by road east of George. Another similar sample, No. 9, was



taken about three miles nearer Knysna, from Woodville, the farm of Mr. J. Stevens. Tobacco has been cultivated here to some extent, and good results are said to have been achieved as regards potatoes by the use of basic slag. At Diep River, three miles from Woodville, sample No. 10 was collected. This soil, together with Nos. 1 and 2 of the Knysna Division soils, are representative of what has been called the intermediate belt of soil.* According to the analysis the soil of which No. 10 was a sample is apparently well supplied with nitrogen, but poor in other respects.

Returning to George, and crossing the Montagu Pass, where Table Mountain sandstone is entered upon, a sandy tract of country is passed over on the farms Doorn Rivier and Soldaats Kraal overgrown with rhenoster bush, alternating further on with proteas. Here we touch the western end of the long valley known as the Long Kloof, which stretches between the sandstone mountains for a distance of over one hundred miles, through this division and the adjacent division of Uniondale into

* See also page 29.

the Humansdorp Division beyond. The soils in this valley are mostly derived from Table Mountain sandstone, and are only saved from extreme poverty by the presence of the Bokkeveld beds which here and there increase the amount of lime otherwise in the soil. On the farm Klip Drift two samples of soil were collected; No. 15 an alluvial (vlei) soil, and No. 14, a soil from the hill behind the homestead and about 400 yards from No. 15. This is succeeded by a Karroo soil, extending westwards to the farm Groot Doorn Rivier, where another sample, No. 11, was collected, the ground being here of a more stony nature: this accounts for the small proportion of "fine earth" found. The farm, it may be mentioned, takes its name from the mimosas which abound in the neighbourhood. Of the Karroo soil, a sample, No. 12, was taken on the return journey to Klip Drift, about two miles back, and another, No. 13, half-a-mile from the homestead on the last-named farm.

On the road to Uniondale a series of samples representative of the Long Kloof soils was taken, covering a stretch of about seventy miles. The first of these was on the farm Grootfontein, 13¾ miles from Klip Drift, No. 16, a loose though somewhat stony soil, where rhenoster bushes prevail. The latter remark applies equally to the farm Schoonberg, seven miles further E.N.E., where No. 17 was collected. Covering another five miles, Ganze Kraal was reached; here there is less rhenoster bush and more mesembryaceæ; at this place sample No. 18 was taken. About 13¾ miles lower down the Long Kloof, sample No. 19 was collected on the farm Kykoe. These four samples, Nos. 16, 17, 18, and 19 represent the soils of the Upper Long Kloof in the George Division. Together with the samples 4, 5, 6, 7 and 8, of the Uniondale Division soils, taken subsequently in the Middle and Lower Long Kloof, they make up our series of samples representative of the Long Kloof.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
20.	Outeniqualand.	Uitkyk.	T. Searle.
21.	„	Great Brak River.	„
22.	„	„	„
23.	George.	Govt. Forest Plantation.	C. R. Ross.
24.	„	„	Distr. Forest Officer.
25.	„	„	„
26.	„	„	„
27.	„	The Island.	P. Bornemisza.
28.	Kamnassie.	Vogelstruisfontein.	„
29.	The Lakes.	Lancewood.	„

Nos. 20, 21, and 22 were collected from as nearly as possible the identical spots where Nos. 1, 2, and 3 respectively had been taken on a former occasion. The analyses of the latter samples had been conducted according to Method III., and as it seemed probable that the results so obtained were too high, it was deemed desirable to procure fresh samples and to analyse them by Method I. for comparison, in order to ascertain, as far as that could be done, what differences of results could be detected between the two methods: it may be said that about three years had elapsed between the taking of the first and of the second set of samples.

Of the samples taken from the Forest Plantation at George, No. 23 bore close resemblance to the other alluvial soils from that Division as regards texture and general physical condition, its content of moisture and organic matter, and its almost all-round poverty in plant food. Nos. 24, 25, and 26 were taken from different parts of a site on which it was proposed to establish a forest nursery.

Soils intended to be employed for the cultivation of tobacco were also procured for analysis. One of these was obtained from Vogelstruisfontein, another from the farm Lancewood or Hooge Kraal and a third from the Ven. Archdeacon Fogg's farm The Island, situated to the north of George town and adjoining the town commonage.

The results arrived at by chemical analysis are given in the tables below: —

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
4.	94·7	·97	3·51	·0138	·140	·028	·034	·020
5.	90·5	·56	2·52	·0123	·098	·020	·031	·013
6.	98·1	·87	4·03	·0212	·161	·042	·015	·031
7.	97·8	·47	2·24	·0216	·091	·028	·017	·019
8.	97·8	1·62	6·57	·0283	·203	·034	·016	·022
9.	98·2	1·41	6·02	·0127	·189	·024	·010	·015
10.	97·0	1·12	5·94	·0481	·168	·026	·016	·031
11.	35·0	·86	7·41	·0835	·168	·028	·102	·083
12.	75·8	·86	5·44	·0913	·168	·052	·122	·090
13.	90·9	1·35	6·09	·5008	·168	·096	·095	·067
14.	73·5	·80	5·59	·0679	·189	·040	·136	·079
15.	79·6	·60	2·17	·0626	·112	·068	·066	·028
16.	66·8	2·78	8·06	·0580	·245	·040	·041	·095
17.	81·9	2·84	7·37	·0569	·168	·030	·066	·068
18.	42·6	1·22	4·35	·0948	·154	·062	·043	·038
19.	76·7	·44	2·87	·0212	·098	·012	·068	·058
20.	94·3	—	—	—	—	·050	·023	·012
21.	93·6	—	—	—	—	·094	·061	·015
22.	91·0	—	—	—	—	·044	·017	·008
23.	96·6	2·27	8·96	—	·02	·072	·027	·097

(Method II.)

	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
24.	1·43	6·73	—	—	·28	·21	trace.
25.	1·27	5·04	—	—	·318	·019	·038
26.	1·06	6·51	—	—	·24	·24	·014
27.	·56	14·89	·019	—	·11	·44	·10
28.	·74	8·61	·008	—	·92	·23	·028
29.	1·05	5·51	·034	—	·96	·77	·12

(Method III.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm Sieve. Lime.	Potash.	Phosphoric oxide.
1.	92·4	1·67	3·89	·011	·026	·25	·14	·11
2.	89·2	2·37	5·48	·0097	·044	·19	·25	·029
3.	85·0	·68	1·74	·058	·030	·25	·27	·055

It will be noticed that Nos. 1, 2, and 3 show much larger proportions of lime and potash than Nos. 20, 21, and 22. Making full allowance for the fact that the one set of samples was collected a long time after the other, and taking due account of their having been collected by different persons, and possibly not from the identical spots in each case, and of their having been analysed by different analysts, it still remains clear that the one method yields much higher results than the other, as indeed one would expect from the inherent differences between the respective solvents used. From the nature of the soils examined one could not otherwise than conclude that by Method III. a large amount of plant food constituents was extracted from the soil which it would not be proper to consider as plant food in the sense to which the term has been restricted in the course of the present discussion. That such a conclusion would be just seemed clear from a comparison of the above results, and further proof of this will be forthcoming when the Divisions of Mossel Bay and Riversdale have to be dealt with.

The southern part of the George Division, that is to say, the portion lying between the Outeniqua Range and the sea, cannot, from a chemical point of view, be considered as very promising: the samples examined, which come from that area, are, almost without exception, poor in all the important elements of mineral plant food. The soils are very fine grained, and there is a good quantity of nitrogenous material in the soil, but with the lack of lime, and the acid nature of the soil, it is exceedingly doubtful whether much of it is capable of conversion into a form in which it could be absorbed by plants.

On a later page, in connection with the soils of the Malmesbury Division, allusion is made to the clay slate beds which constitute the oldest sedimentary rocks of the south-western part of the Colony; above these lies the sandstone formation with which not only the Outeniqua Mountains are capped, but also all the mountain ranges stretching from Table Mountain in the Cape Division to Cape St. Francis, including the Hex River Mountains and the Langeberg Range. This sandstone, by disintegration, forms a loose sand, very poor for agricultural purposes, producing a vegetation of little more than sour grass. Firs, and similar forest trees may, nevertheless, find sufficient nourishment in such soils, though unsuited for ordinary crops.

North of the Outeniqua Mountains the potash in the soil shows some improvement: the five soils collected on the farms Klip Drift and Groot Doorn Rivier all contain a fair amount. This is also the case in regard to phosphoric oxide, except as far the alluvial soil No. 15 is concerned. This soil is poor in phosphates, and is also poorer than any others in the neighbourhood in respect of potash. In all these soils lime is still very deficient, although not to the same extreme as south of the Outeniquas.

The Long Kloof soils, extending from Grootfontein in the George Division to Krakeel River in the Division of Uniondale, and represented by samples 16, 17, 18, and 19, in the above list, together with Nos. 4, 5, 6, 7, and 8 of the Uniondale Division soils, are uniformly poor in lime, and just escape a poor potash average. The soils from the western part of the Long Kloof showed a fair amount of phosphates, Ganze Kraal excepted, but further east there appeared a decided deficiency.

To summarise in broad terms, the soils of the George Division are, taken as a whole, poor in lime and phosphates, but contain a fair proportion of potash, and are rich in nitrogen.

GORDONIA.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	No. 1.	Upington.	Dr. E. A. Nobbs.
2.	”	”	”

The above were two very finely-grained soils collected from lands under irrigation at Upington. The samples were very typical of the alluvial lands along the banks of the Orange River at that point. The soil had been under cultivation for twenty years, and had been periodically enriched by deposits of silt from flooding. Soils of a similar nature will be referred to in connection with the Prieska Division.

The analyses of the above soils resulted as follows:—

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide
1.	100	3·23	3·49	·0209	·052	·582	·093	·061
2.	100	1·68	2·05	·0184	·022	·400	·065	·052.

It will be noticed that the nitrogen content of these soils is low, but they are rich in lime, and fairly well provided with potash and phosphatic material.

GRAAFF-REINET.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Graaff-Reinet.	Graaff-Reinet Town.	C. Mayer.
2.	”	”	”
3.	”	”	”

These three samples were taken from different depths at a locality in the township of Graaff-Reinet where vines were dying off from some unknown cause. Local vignerons had been greatly perplexed in consequence. Diligent inspection had revealed neither insects nor fungoid growth, and in all cases decaying roots and a dead root stem indicated that dying had commenced from below, and had worked its way upwards to the surface of the soil. It was thought that brackishness of the irrigation water had contributed to the affection, but analysis of the water did not confirm this view: it appeared, however, that excessive irrigation was the chief cause, and imperviousness of the soil to air owing to its compact nature and deficient drainage. In any case, the affected vines were invariably associated with the free practice of irrigation: the soils were usually irrigated once every month.

The chemical analyses* resulted as follows:—

(Method I.)

No.	Percent of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	94·8	2·56	3·80	·0120	·154	1·148	·300	·079
2.	95·5	2·72	4·10	·0150	·231	1·288	·318	·072
3.	95·4	2·93	3·32	·0067	·175	1·364	·318	·073

The first of these samples was taken at the surface, No. 2 at a depth of 10 inches, and No. 3 at from 18 to 24 inches from the surface. The soil is of far finer texture than those generally associated with the cultivation of the vine in the Western Province: the three samples are all rich in lime, well supplied with nitrogen and potash, and have a fair reserve of phosphoric oxide: apparently, therefore, it was not deficient storage of plant food that was the cause of vine-failure. The amount of chlorine in the soil was no higher than has been found to be the case in several soils of the Paarl and Worcester Divisions. Hence it seemed to be a just inference that the causes were physical rather than chemical. This was evidently an instance where the weak link of the chain was not lack of plant food.†

HANOVER.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Hanover.	Hanover.	Forest Officer.
2.	„	„	„
3.	„	„	„
4.	„	„	„
5.	„	„	„
6.	„	„	„

These soils were taken from the Government Forest Plantation at Hanover. The plantation forms part of Hanover Commonage, and is about ten miles distant from Hanover Road Railway Station. Nos. 1, 2, and 3 represent surface soils, and Nos. 5 and 6 clay subsoils. No. 4 was a specimen of the limestone which underlies the soil at this locality.

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*For mechanical analysis see under "Physical composition of soils" (Part VII.).

† *Vide* remarks in this connection on pp. 17 and 18.

The results of the analyses of the above samples are stated in the following table:—

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Water.	Organic matter.†	Chlorine.	Nitrogen.	Lime.	Potasch.	Phosphoric oxide.
1.	4·25	23·29	—	—	22·75	·26	·010
2.	3·94	25·31	—	—	15·41	·13	·089
3.	1·94	3·21	·0049	—	1·62	·21	·0036
4.	5·09	29·27	—	—	32·46	·12	·124
5.	5·83	27·03	·0191	—	26·60	·15	·096
6.	7·35	24·22	·0104	—	19·00	·21	·052

All of these samples contained an abundance of lime, largely in the form of calcium carbonate: they are all well supplied with potash, but the proportion of phosphoric oxide varies considerably, ranging from the extreme of poverty, in one case, to a fairly satisfactory amount in others.

HERBERT.

(Privately Collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Lower Albania.	Backhouse.	A. C. Martin.
2.	„	Erf No. 5.	„
3.	„	Erf No. 36.	„

The three samples enumerated in the above list were taken from the area proposed to be brought under irrigation in connection with the Douglas irrigation works. The first sample was taken from the farm Backhouse, near the main canal, at chainage 4 miles 30 chains. No. 2 was collected on Douglas Commonage from the middle of Agricultural Erf No. 5, and is fairly representative of all the erven lying along the river bank. No. 3 was taken from Agricultural Erf No. 36, also on the commonage, near the main canal, at chainage 6 miles 10 chains, and may be considered as a type of the erven along the route of the canal.

In every case the samples represent virgin soils, and were carefully collected so as to typify the surface soil to a depth of twelve inches. They were each analysed according to Method I. and also by Method V., and the results of these analyses are tabulated below.*

(Method I.)

No.	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	96·1	1·79	3·24	·0566	·049	·174	·061	·058
2.	99·0	1·80	3·76	·0707	·042	·552	·103	·105
3.	87·9	3·00	6·01	·0283	·098	2·128	·053	·070

†This also includes carbon dioxide combined as calcium carbonate.

*For the results of determinations of alkaline salts in the above soils see under the head of "Alkalinity of soils" (Part VI.).

(Method V.)

No.	Percentage of Soil sifted through 3 mm. Sieve. Potash.	Phosphoric oxide.
1.	·010	·016
2.	·018	·037
3.	·009	·008

It will be seen that in each case about six times as much potash was extracted from these soils by Method I. as by Method V., and in two cases the quantity of phosphoric oxide extracted by Method I. was about 3 to 3½ times that obtained by Method V. In the third soil the directly available phosphoric oxide was only one-ninth the available reserve.

On the basis of the minimum limits suggested by Dr. Dyer, viz., ·005 per cent. of potash and ·010 per cent. of phosphoric oxide, the first two soils, at all events, are sufficiently well supplied with these elements of plant food in a state ready for immediate use.

HOPE TOWN.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	North Middenveld.	Fluitjes Kraal.	Dr. E. A. Nobbs.
2.	"	"	"

Two fine-grained soils were collected from the farm Fluitjes Kraal: No. 1 had the characters of a good Karroo soil, and was typical of a considerable area. No. 2 was taken from what is known as vlei land.

The analyses of these two samples resulted as below:—

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	96·2	3·96	3·02	·0035	·050	·478	·085	·019
2.	95·7	7·20	4·24	·0014	·057	·332	·275	·033

The proportion of phosphoric oxide in these soils is low, nor are they particularly well supplied with nitrogen; on the other hand, they are both rich in lime, in this respect resembling many of the soils of the neighbouring Divisions of Albert, Aliwal North, and Colesberg.

HUMANSDORP.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	—	—	A. C. Macdonald.
2.	—	—	"
3.	Zitzikama.	Lot 7,899	H. G. Fourcade.
4.	"	Lot 7,897.	"

Two soils, Nos. 1 and 2, were taken in this Division from localities badly affected with "lamziekte," and where great mortality had resulted amongst the sheep: the soils, as will be seen from the table below, were found to be almost devoid of phosphoric oxide, although one was well stocked with lime and potash, and the other fairly so. Taken in conjunction with the analyses of the soils from the Albany Division,* it would appear that lack of phosphates rather than lack of lime is one of the fundamental causes of lamziekte. Almost throughout this Division the soil is entirely the result of the disintegration of the great ranges of Table Mountain sandstone, which extend along the south coast from George, and eventually die out in the Zitzikama Range. This sandstone contains practically nothing capable of affording nutriment to plants.

Samples 3 and 4 represent the average virgin soil of Storms River to a depth of twelve inches, and were taken from upland plateaux. The soil consists chiefly of fine quartz silt. The opinion of scientific agriculturists with regard to acid soils of this type is that plant food constituents are rendered available to such an extent by liming or cultivation that excellent crops are raised with moderate application of fertilisers.

The following are the analytical results obtained:—

(Method II.)

	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	4·12	7·46	·024	—	·09	·07	trace.
2.	3·74	4·48	·005	—	·54	·13	trace.
3.	1·36	4·07	·053	·140	·101	·018	·005
4.	2·43	6·72	·060	·168	·089	·013	·008

IDUTYWA.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Ibeka.	Ibeka.	St. C. O. Sinclair.

One sample of soil was taken from, and may be considered as representative of, the sandy tract of country near Ibeka. It is, in all probability, similar in origin to the two soils, Nos. 1 and 2 on the Butterworth list,† taken in the vicinity of the old Residency at 'Nhlambe, in that district.

The results of the analysis of the soil from Ibeka are as follows:—

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1	97·6	2·44	5·18	·0474	·133	·074	·027	·006

* Vide page 23. † See page 32.

KENHARDT.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Kenhardt.	Rooiberg.	Dr. E. A. Nobbs.
2.	,,	,,	,,

These two samples were collected from irrigable lands between the dam and the village of Kenhardt: the land consists, for the most part, of a fine red sand, of which No. 1 is an example, varying in depth, and passing into a red silt of even finer grain, No. 2.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
3.	Kenhardt.	Rooiberg.	Engineer, Pub. Wks. Dept.
4.	,,	,,	,,
5.	,,	,,	A. G. Strong.

Nos. 3 and 4 were collected respectively from the front third and from the centre of the Rooiberg Dam. No. 5 had previously been taken from the site of the dam, as representative of the lands proposed to be irrigated.

The analyses of these samples are recorded in the following tables:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	55·9	1·90	2·88	·0039	·071	·454	·296	·051
2.	100.	2·24	2·85	·0025	·050	·320	·207	·069
3.	94·7	4·31	4·32	·1387	·057	·290	·348	·134
4.	95·0	4·60	4·54	·1146	·043	·420	·341	·145

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
5.	5·80	5·22	·0038	—	·999	·154	·156

KIMBERLEY.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	No. 2.	Schoolplaats.	Dr. E. A. Nobbs.
2.	,,	,,	,,
3.	,,	,,	,,
4.	,,	Waterfall.	,,
5.	,,	Warrenton.	,,
6.	,,	,,	,,

As in the case of the Barkly West soils, the majority of the samples from the Kimberley Division were collected by Dr. E. A. Nobbs from a large extent of country proposed to be irrigated by means of water conveyed from the Harts River. Three samples were taken on the farm Schoolplaats. No. 1, a tough black alluvial clay, lying on a subsoil of silt, represents a heavy piece of land situated close to the Vaal, obviously very rich, but unfortunately limited in extent to a narrow strip along the banks of the river. No. 2 represents the eastern side of a wide low-lying bight of land on the same farm: it is a yellow fine-grained sandy soil. The central and western portions of this bight consist of a stiff loamy marl, grey in colour, typified by No. 3. On the farm Waterfall occurs a stretch of some 800 acres of a red gravelly loam, about 145 feet above river-level. The owner of the farm proposes to irrigate this land —whereof No. 4 is a sample—by pumping up water from the river below. Two samples of fine-grained brown alluvial soil were collected at Warrenton, No. 5 a garden, and No. 6 a virgin soil: both of these are from time to time enriched by flooding and deposits of silt.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
7.	No. 1.	Kimberley Borough.	Supt. Sanitary Dept.
8.	"	"	"

Nos. 7 and 8 represent land within the area controlled by the Borough Council of Kimberley.

The following tables comprise the results of the chemical analyses of the soils collected within the Kimberley Division:—

(Method I.)

No.	Percent of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	98·2	4·77	5·32	·006	·134	·168	·161	·119
2.	95·0	·59	1·17	·002	·035	·018	·039	·031
3.	94·5	4·83	9·01	·003	·171	2·860	·125	·068
4.	79·4	2·23	4·07	·002	·013	·142	·161	·064
5.	91·5	2·50	3·34	·003	·120	·278	·108	·074
6.	88·2	6·29	5·07	·006	·106	·346	·094	·070

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
7.	—	—	·032	—	·98	·18	—
8.	—	—	·036	—	3·24	·63	·07

No. 1. proves to be well supplied with every class of plant food, the analytical results thus confirming the opinion previously formed of the soil. The sandy soil No. 2 turns out to be far below No. 1 in chemical composition. The area whereof No. 3 is a type contains lime—largely carbonate—in abundance, it is well provided with nitrogen, and has a moderate supply of potash and phosphates. The Waterfall gravelly loam, represented by No. 4, lacks nitrogenous constituents, but has a satisfactory amount of potash, and a fair provision of lime and phosphoric oxide. The Warrenton alluvial soils may be described as chemically of medium quality.

KING WILLIAM'S TOWN.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	No. 8.	Evelyn valley.	J. S. Anderson.

The only sample collected for analysis within this Division was a black loam, taken from some lands at Evelyn Valley, a forest station in the Eastern Forests Conservancy. The soil was stated to be so poor that nothing except trees will grow on it. The forest station is situated near the top of the Pirie Mountain, 4,200 feet above sea-level, and 40 miles from the coast almost due north of King William's Town. The surrounding farms all lie at much lower altitudes, ranging from 1,700 to 2,300 feet below Evelyn Valley. The soil at these lower levels, where the annual rainfall ranges from 18 to 32 inches, has the reputation of being much more fertile than that at the forest station, which has a mean annual rainfall of 60 inches. The ground where the sample was taken had been broken up from the veld two or three years previously; the site of the sample was a gentle slope about 200 yards from the foot of a steep kopje rising to a height of 250 or 300 feet: the surface soil goes to a depth of from 12 to 14 inches, below which lies a red porous clay. Nearer the foot of the kopje the surface soil increases to two feet or more in depth.

The analysis of this soil resulted as follows:—

Method I.

	Percent. of Field	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	97·5	6·26	16·60	·0205	·315	·050	·082	·105

The soil was fine in grain and contained a large quantity of nitrogenous organic matter; the proportion of phosphoric oxide was satisfactory, but lime was deficient, and the reserve of potash was not much better.

KNYSNA.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Zwart River.	Geelhoutboom.	C. F. Juritz.
2.	,,	Roode Kraal.	,,
3.	Gouwkamma.	Millwood.	,,
4.	,,	Portland Heights.	,,
5.	,,	Balmoral.	,,
6.	,,	Portland.	,,
7.	Plettenberg Bay.	Ashby.	,,
8.	,,	Ganze Vallei.	,,
9.	,,	Holt Hill.	,,
10.	,,	Witte Drift.	,,
11.	Paarde Kop.	Witte Drift.	,,
12.	Keurbooms River.	Matjesfontein.	,,
13.	,,	,,	,,

On the road from George to Knysna the first sample collected in the latter Division, No. 1, was taken on the farm Geelhoutboom, or Olyvenhout Kraal, about six miles E.N.E. of Diep River, in the George Division; No. 2 being taken from Roode Kraal, some 5½ miles further eastwards. At Sour Flats, called also Balmoral, No. 5 was collected, from a spot N.E. of the locality where the last mentioned sample was taken, and distant therefrom about ten miles by road. The soil is a light clay, fairly loose in texture; analysis shows it to be poor in all mineral plant food. As a matter of fact, these three soils are all derived from rocks of the Table Mountain series, and the exceedingly poor analytical results are only what one can expect under the circumstances: however, on a small farm, a few hundred yards nearer Knysna, good crops are stated to have been cultivated for ten years without manure. At Portland, between Balmoral and Knysna, lying about four miles south of the former place, and 19½ N.W. of the latter, a similar light clay, sample No. 6, was collected. Here again the analysis yielded poor results, for Portland too lies on Table Mountain sandstone. No samples were taken between this point and Plettenberg Bay. At the latter place a rather loose clay predominates, but the underlying rock is Table Mountain sandstone. There is a quantity of rhenoster bush in the vicinity of the local accommodation house, and here a sample

of soil, No. 7, very light in colour, was collected from a hill top. About a mile and a half lower down in the valley a sample of "vlei" ground, No. 8, was collected on the farm Ganze Vallei. Here and there large patches of conglomerate show through the soil and along the hillsides. Another sample of vlei ground, No. 12, looser and much darker than the last, and an all-round better soil, was taken on the farm Matjesfontein, just after crossing the Keurbooms River, four miles from Ganze Vallei. The organic matter—which, moreover, contains a good deal of nitrogen—in this sample is higher than in any previously collected in this Division. The soil is well supplied with lime, and has a satisfactory store of potash and phosphoric oxide. Further east on this farm Matjesfontein, the soil becomes lighter in colour and sandier, and the vlei ground is to a large extent intermingled with blown sand from the sand dunes along the coast. Of one of these mixed soils a sample, No. 13, was taken, a mile intervening between this and the previous sample: another sample—to outward seeming of the same class—No. 11, was collected on the farm Witte Drift, about five miles west of No. 13. On all these vlei grounds general cultivation is carried on, with fair success, over a large area. At Witte Drift the rhenoster bush is again met with, growing on a rather stiff brown clay soil: of this a sample, No. 10, was obtained. All these latter soils yielded noticeably lower results by analysis than No. 12. After traversing a distance of four miles and rejoining the main road, a sample, No. 9, was taken from a plateau covered with reeds and extending westwards for miles, up to the borders of the forest. The soil here is almost all-through deficient.

Below Millwood a sample of black loamy soil was collected, No. 3 in the list. This class of soil extends southwards right down to the forest, where it gives place to more clayey soil of a lighter nature. Of this latter, a sample, No. 4, was taken in the forest on the way from Millwood to Balmoral, at a distance of 2½ miles from the point where No. 3 was taken. Neither of these two soils is chemically well provided.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
14.	Zwart River.	Sidgefield.	J. Grant.
15.	,,	Lot B (2).	A. Bibbey.
16.	,,	Salisbury.	P. Bornemisza.
17.	Gouwkamma.	Belvidere.	A. V. Duthie.
18.	Knysna.	Bracken Hill.	P. Bornemisza.
19.	Keurbooms River.	Matjesfontein.	,,

Sample No. 14 was collected on the farm Sidgefield, at Groen Vallei. Nos. 16, 18, and 19 were taken on the farms Salisbury, Bracken Hill (Lot R.R.), and Matjesfontein, respectively, from lands intended to be utilised for tobacco cultivation. The farm Salisbury adjoins Olyvenhout, or Hollywood, on the boundary of the George Division. North-west of Hollywood, and nearer the George boundary, a sample of soil, No. 15, was collected from Lot B (2).

The analytical results obtained from the soils of this Division are comprised in the following tables:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	96·0	1·17	6·55	·0237	·203	·032	·012	·020
2.	98·5	·86	4·19	·1068	·161	·044	·011	·013
3.	96·6	1·59	8·86	·0672	·287	·074	·017	·031
4.	95·6	3·84	12·21	·0813	·413	·032	·028	·056
5.	94·7	·97	5·01	·0163	·154	·050	·014	·018
6.	98·2	1·27	5·81	·0347	·196	·028	·014	·046
7.	97·0	·66	2·80	·0262	·105	·028	·023	·010
8.	99·5	2·19	6·31	·0707	·231	·116	·054	·045
9.	98·0	1·20	5·39	·0651	·126	·082	·030	·018
10.	90·8	1·60	6·42	·0198	·175	·112	·069	·044
11.	82·9	·98	4·19	·0113	·154	·052	·040	·044

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
		Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
12.	97·1	3·05	11·92	·0453	·399	·544	·105	·110
13.	84·4	1·33	5·16	·0130	·161	·112	·039	·078
14.	96·4	·56	1·71	·0297	·067	·090	·050	·051
15.	95·8	3·28	11·25	·0117	·462	·040	·029	·012
17.	96·8	1·25	4·41	·214	·140	·098	·036	·0051

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
16.	1·54	4·79	·023	—	·65	·13	·13
18.	1·00	4·10	·001	—	·36	·09	trace.
19.	·76	14·14	·010	—	·75	trace.	·06

Of the soils, Nos. 7 to 13, collected around the mouth of the Keurbooms River, it will be noticed that there is a considerable difference, in the amount of available plant food, between Nos. 8, 10, 12, and 13, on the one hand, and Nos. 7, 9, and 11, on the other. The former are all either wholly or very largely made up of the alluvial deposits which surround the river mouth; of the latter, Nos. 7 and 9 were taken from the all-prevailing sandstone formation, and No. 11 from the Enon deposits which flank the alluvium, and with which No. 13 is also probably to a certain extent diluted. The following are the averages of each of these two sets of soils:—

	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
Nos. 8, 10, 12, and 13.	·242	·221	·067	·069
Nos. 7, 9, and 11	·128	·054	·031	·024

The poverty in available plant food constituents, noticed with respect to the southern portion of the George Division, extends, with some reservations, however, into the adjoining Division of Knysna. Here we find on an average even less potash and phosphoric oxide, but the lime shows a slight increase. There is a sufficiency of nitrogen all through, but the inorganic requirements of the soil are lacking in the Zwart River and Gouwkamma Field-Cornetcies. Potash, in fact, may be said to be lacking throughout the Division, with the exception of a limited area round the mouth of the Keurbooms River. Near Plettenberg Bay there is an improvement visible on the farms Ganze Vallei and Witte Drift. Of the two samples collected on the latter farm it will be observed that No. 10 is noticeably the better. The richness of the forest soils near Millwood in nitrogenous material, and organic matter generally, is worth noting, and special attention has already been directed to the quality of the alluvial soil No. 12 from the farm Matjesfontein near the Keurbooms River mouth. There is no doubt that these alluvial, or, as they are locally termed, "vlei" soils, are better supplied with plant nutriment than the average soils of the Division.

KOMGHA.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	No. 3.	Prospect.	St. C. O. Sinclair.
2.	"	"	"
3.	"	Ferndale.	"
4.	"	"	"
5.	"	Reedfontein.	"
6.	"	"	"
7.	"	"	"
8.	"	Hopewell.	"
9.	"	Stainland.	"
10.	"	"	"
11.	"	"	"
12.	"	"	"
13.	"	Zuurvlakte.	"
14.	"	"	"
15.	No. 1.	A. D. Campbell.	"
16.	"	Residency.	"
17.	No. 2.	Ben Hall.	"
18.	No. 6.	Lilyvale.	"
19.	"	"	"
20.	"	Westbury.	"
21.	"	E. Sanson.	"
22.	"	Fort Warden.	"
23.	"	Beaconsfield.	"
24.	"	Badnoch.	"
25.	"	"	"
26.	"	Jessie.	"
27.	No. 5.	Sea View.	"

In taking samples in the Komgha Division, it became necessary, for the reasons mentioned in connection with the Cathcart Division, to place one's self largely in the hands of the local agriculturists in respect to the selection of localities from which to take samples. In a few cases samples were taken for special reasons: for instance, where experiments in fruit growing were being carried on, and where it was the intention of the occupier to use his land for specific crops, and it was consequently desirable to have the most reliable information as to the exact physical and chemical nature of the soil in use.

The soil of the Komgha Division is essentially derived from the peculiar "Lower Karroo" sandstone (Ecca beds, or, as the Geological Commission has now termed them, in that part of the Colony,* Umsikaba beds). Dolerite, occurring either in sheets, dykes, or loose boulders, is exceedingly plentiful, and one cannot go anywhere in the district without finding it in evidence in one or other of these forms.

The surface soil, on the whole, appears distinctly loamy, consisting of clay with a very fair proportion of fine sand. In some cases, however, the soil seemed more sandy. The subsoil is generally either a red gravel, or a rather stiff yellow pot clay, although, of course, variations between the two are not rare.

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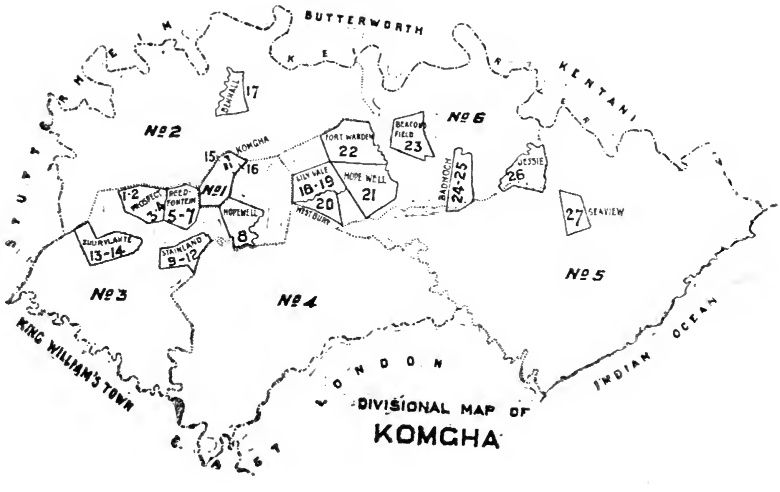
* Geological Commission Annual Report 1902, pp. 9 and 14.

In judging of the latent fertility of the soil of any portion, the prevailing physical conditions, such as the nature and divisibility of the surface and subsoil, the situation and slope of the land, the exposure to prevailing winds, thunderstorms, and rains, always important factors, should be even more largely taken into account in the case of this division than is usually done. From a chemical point of view, external evidence leads one to expect a soil rich, on the whole, in the essential mineral plant foods, lime, potash, and phosphoric oxide, the last named, perhaps, not quite so plentiful in proportion as the other two.

In some cases the clayey nature of the soil makes draining desirable. Where this has been done, excellent results have been reported. Very little manuring is carried on, due to the scarcity of manure. A start has, however, been made with artificial fertilisers. Fruit trees, such as pears and plums, especially Japanese plum and orange, seem to thrive, and near the coast bananas do well. Wheat does not grow satisfactorily, although at one time its cultivation was profitable. On the other hand, the lands



stand maize well. A very possible explanation of this may be the fact that wheat is sown on lands which have borne crops of this cereal for a considerable time in the past, and consequently have undergone great loss of phosphatic material.* But maize, taking out of the soil a larger amount of lime in proportion than wheat, is able to flourish where wheat does but poorly.

Sample No. 1 was collected on the farm Prospect; it represents a dark hillside soil, with a red gravelly subsoil. No. 2 was also collected on this farm. Fruit growing is very successfully carried on here. Nos. 3 and 4 are types of black soils from the adjoining farm Ferndale. Around the locality whence the samples were taken, doleritic boulders were noticed. Nos. 5, 6, and 7 were collected on the farm Reedfontein. Of these, No. 5, a soil of good depth, was stated to yield poor results when sown with oats. No. 6, on the other hand, which contains nearly double the proportion of phosphoric oxide, and three times the quantity of potash, gave good results with the same crop—another instance of practical experience bearing out the results of chemical analysis. No. 7, lying on a subsoil of yellow clay, was reported to be very poor. The subsoil, which comes to within a short distance of the surface, was noticed to be

* See remarks on this subject on pp. 45 and 47.

very damp at the time of sampling. This is, no doubt, one factor which may account for the poor productiveness of the surface soil. No. 8 represents the red soil of the farm Hopewell. The land represented was intended to be used as an orchard. Nos. 24 and 25 were taken at Badnoch, and No. 27 is a sample of black and somewhat sandy soil found on the farm Sea View. No. 26 was taken a short distance from the roadside at Jessie. No. 20 is from Westbury, taken from the top of one of the hillocks near the homestead. No. 21 was collected on the farm of Mr. E. Sanson.

Samples 9, 10, 11, and 12 were taken at Stainland, the farm of Mr. Coulter. No. 9 represents a valley soil from a patch which was at one time a swamp, but had, by draining, been turned into an area where oats do well. It is very similar to No. 10, which differs from it in being more sandy. No. 11 is a red soil taken in the vicinity of some doleritic boulders. No. 12 is a valley soil which should prove valuable.

Nos. 13 and 14 were collected from Mr. Van Rensburg's farm Zuurvlakte. No. 15 was taken from a plot owned by Mr. A. D. Campbell, adjoining the commonage, and would be typical of the soil of a large portion of the latter. No. 18, from the farm Lilyvale, was taken from a patch studded with mimosa trees. No. 19 is from the same farm, and was taken underneath a mimosa tree. No. 17 was collected on the farm of Mr. Ben Hall. It represents the soil of the hill side sloping towards the Kei River. The surrounding soil was very shallow.

The results obtained by analysis are tabulated below:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	97·5	3·95	12·53	·0230	·252	·222	·042	·056
2.	92·9	2·47	6·80	·0329	·196	·134	·016	·014
3.	98·4	5·05	14·79	·0463	·252	·310	·124	·028
4.	95·8	4·47	12·01	·0275	·280	·490	·026	·036
5.	94·4	3·24	8·62	·0240	·168	·122	·025	·019
6.	97·2	1·84	5·84	·0110	·154	·106	·076	·032
7.	98·9	1·87	5·72	·0190	·154	·068	·116	·020
8.	98·1	2·84	9·45	·0162	·189	·122	·146	·020
9.	98·8	2·94	6·56	·0311	·182	·322	·017	·0089
10.	98·5	1·44	3·43	·0113	·126	·092	·014	·0064
11.	97·7	3·83	11·08	·0445	·217	·042	·045	·051
12.	96·8	2·17	7·50	·0339	·224	·098	·235	·032
13.	98·2	1·60	4·78	·0204	·147	·070	·060	·032
14.	94·6	1·83	6·09	·0544	·175	·078	·154	·031
15.	87·6	1·33	4·36	·0148	·147	·100	·042	·036
16.	92·9	2·36	6·89	·0050	·175	·064	·050	·037
17.	99·3	1·05	3·63	·0106	·133	·044	·063	·023
18.	98·1	1·24	4·41	·0035	·147	·068	·035	·030
19.	95·2	2·13	7·43	·0099	·273	·162	·046	·050
20.	97·1	1·25	4·17	·0311	·091	·032	·030	·015
21.	99·2	1·27	4·11	·0057	·133	·050	·033	·019
22.	98·8	·69	2·34	·0042	·098	·012	·023	·012
23.	98·4	4·19	13·34	·0057	·273	·062	·095	·067
24.	98·9	·97	3·62	·0183	·112	·056	·030	·0064
25.	97·4	4·50	14·63	·0057	·231	·120	·048	·013
26.	99·8	6·30	15·18	·0120	·245	·294	·019	·029
27.	98·5	1·49	6·10	·0290	·147	·072	·044	·0064

The proportions of lime and potash in the soils of the Komgha Division are, taken all round, fairly satisfactory, but phosphates are decidedly lacking: in this respect there is a strong resemblance to the adjoining division of Cathcart.

Of the soils in the above list, the three taken from Field-cornetcies Nos. 1 and 2 are all deficient in lime and phosphoric oxide: samples 15 and 16 are likewise deficient in potash, while No. 17 is not much better in this respect. The samples from Field-cornetcies Nos. 5 and 6 average poor results all round. Speaking generally, Field-cornetcy No. 3 is the best off with regard to lime and potash, but here too phosphatic material is lacking. To come to details; Nos. 10, 24, and 27 are poor in all of the three inorganic fertilising constituents, and phosphoric oxide, in particular, is almost entirely absent. Nos. 13, 18, 20, 21 and 22, although containing a little more phosphoric oxide, are nevertheless poor all round. No. 9 is also characterised by an almost entire absence of phosphoric oxide.

To summarise, eight, out of the 27 Komgha soils, are deficient in all of the three principal classes of inorganic plant food; seven others lack both phosphoric oxide and potash, namely: Nos. 2, 4, 5, 9, 15, 25, and 26: Nos. 7, 12, 14, 16, and 17 are poor in phosphoric oxide and lime. Three samples, *i.e.*, Nos. 3, 6, and 8, are poor in phosphoric oxide only, No. 11 is greatly in need of both lime and potash, Nos. 1 and 19 require potash, and No. 23 lime. Thus it happens that there is not a single soil, of all those taken, regarding which it can be said that it is well—or even fairly—supplied with all plant food constituents in an available condition.

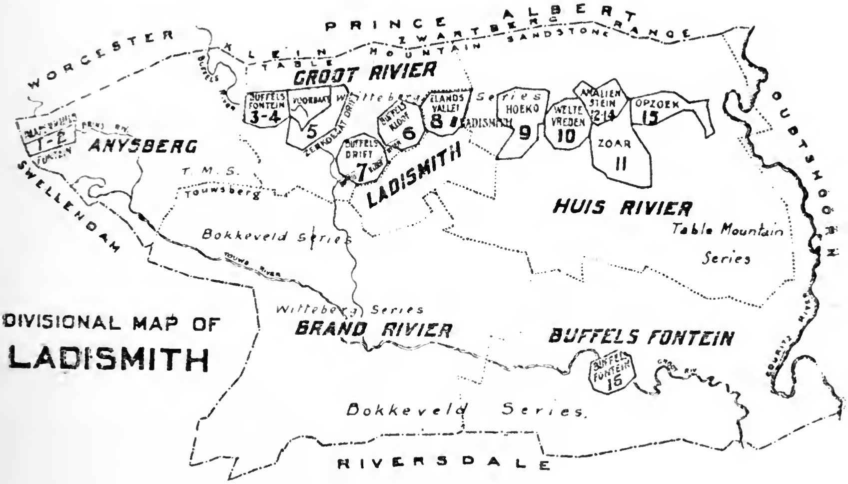
It will be noticed that these soils are all of a clayey nature, and they appear to contain, generally, a larger amount of chlorides than has been found by analysis in the Western Province soils.

LADISMITH.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Anysberg.	Papenkuilsfontein.	J. Muller.
2.	,,	,,	,,
3.	Groot River.	Buffelsfontein.	,,
4.	,,	,,	,,
5.	,,	Zeekoegatsdrift.	,,
6.	,,	Buffels Kloof.	,,
7.	,,	Buffels Drift.	,,
8.	Ladismith.	Elands Vallei.	,,
9.	Huis River.	Hoeko.	,,
10.	,,	Weltevreden.	,,
11.	,,	Zoar.	,,
12.	,,	Amalienstein.	,,
13.	,,	,,	,,
14.	,,	,,	,,
15.	,,	Opzoek.	,,
16.	Buffelsfontein.	Buffelsfontein.	,,

The first sample taken in this Division was No. 1, a rather poor, sandy soil, from lands on the slope of the hill south of De Erf, or Papenkuilsfontein. On the same farm No. 2 was taken, a dark alluvial soil, of greater productiveness than the previous one, and collected from the garden near the house. Both samples proved rather poor in phosphates, and No. 1 in lime as well: they also show signs of being brack, especially No. 2. A very barren belt of country stretches between the Prins and Buffels Rivers, and resembles the Gouph in every respect: flanked on the north by the Klein Zwartberg Range, and on the south by the Touwsberg Mountains, both of which ranges consist of Table Mountain sandstone, its barrenness is not to be wondered at. At Buffelsfontein the bed of the river widens out considerably, on entering a broad valley which is literally dotted with farms. Two samples were selected here:—No. 3, a sandy soil taken from a vineyard on the farm of Mr. J. J. van Zyl, and said to be very fertile, and richer than No. 4. The latter was a loose clay, taken from Mr. J. Wolfaardt's farm, and supposed to be as rich as the soil collected along the Touws River*; analysis, however, shows that there is not a superabundance of mineral plant food.



Passing through the farm Voorbaat, the river course was followed to the farm Zeekoegats Drift, and here sample No. 5 was selected from soil adjoining the vineyard. Good results have been obtained from sweet potatoes and other root corps on the particular soil represented by this sample: it is adequately furnished with potash and lime, a fact which will account for this. At Buffels Drift a loose, sandy clay, No. 7, was sampled, representing the bulk of the lands in the valley on either side of the Zwartbergs River. Then following the main road to Ladismith, these samples were collected: No. 6, taken from lands on the right bank of the Buffels Kloof River, on the farm Buffels Kloof. The soil here very closely resembles a red Karroo soil: although not equal to such a Karroo soil in fertility, it is said to yield much better results than No. 8. There are several large patches of this soil under cultivation. No. 8 represents a stiff clay, rather shallow, from the farm Elands Vallei. It is considered to be poorer than No. 6, and this supposition is borne out by chemical analysis. The amount of lime is extremely low.

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* See remarks later on, page 132, regarding the collection of sample from Zevenfontein, No. 1 from the Swellendam Division.

In the Field-Cornetcy of Huis River, No. 9, a rather loose, gravelly clay was taken from uncultivated parts in lucerne camps on the farm Hoeko, belonging to Mr. W. van der Merwe. Mr. Van der Merwe's cattle graze on the heights above the Touws River; manure, consequently, is rather difficult to procure on the farm, and costs too much to transport. The soil, however, is fairly rich in plant food. No. 10, a fine, sandy, alluvial soil, was taken, on the farm Weltevreden, from the gardens in the valley, and is locally considered poorer than No. 9, which was collected from camps along the hill slopes: the analysis certainly does bear out that opinion. No. 11, a red sandy soil, was taken from the garden plots of the Rev. Mr. Kretzen, at Zoar, the Mission Station.

At Amalienstein three samples were collected: No. 12, a rather sandy soil, was taken from lands near the main road, on the way from Zoar to Amalienstein. No. 13, a fairly stiff red clayey soil, was taken from the garden of the Rev. C. Prozesky. No. 14 represented a loose, somewhat sandy clay, from lands to the left of the road from Amalienstein to Calitzdorp. The crops, which were just being harvested, were exceptionally poor, the result principally of very servere drought and scarcity of kraal manure. At the farm Opzoek No. 15 was sampled—a rather stiff, clay soil, said to be very good from the farmer's standpoint. It contains a good quantity of lime and potash, and a fair supply of phosphates.

Buffelsfontein was the next place visited—more of a village than a farm—situated on the left bank of the Groot River, south-east of Ladismith. The soil along the river-bed is similar to that at Buffels Vallei, higher up on the Buffels River, and consequently no sample was taken here. On the heights above are several gardens, in a loose, sandy clay, of which No. 16 is a typical sample, collected from the garden of Mr. J. T. van Wyk. This soil is not considered to be as rich as that in the valley below.

The following table shows the results of the chemical analyses of the soils above described:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	60·5	·64	2·36	·0297	·043	·056	·136	·042
2	90·8	1·84	5·55	·1825	·112	·138	·110	·056
3.	65·0	·93	4·04	·0134	·126	·332	·166	·106
4.	71·4	·73	3·12	·0156	·070	·128	·052	·059
5.	97·5	·92	4·39	·0775	·098	·344	·187	·097
6.	56·3	1·54	7·08	·0134	·203	·102	·166	·104
7.	79·6	·95	3·72	·0255	·098	·102	·166	·077
8.	85·3	·93	4·08	·0095	·105	·036	·071	·068
9.	45·5	1·36	7·65	·0071	·203	·138	·196	·160
10.	81·0	·85	3·86	·0332	·126	·094	·133	·091
11.	67·1	1·04	4·49	·0318	·133	·256	·307	·147
12.	56·7	·61	4·06	·0042	·057	·088	·266	·099
13.	74·5	1·42	4·32	·0138	·084	·470	·260	·095
14.	77·3	1·07	3·52	·0966	·057	·148	·183	·052
15.	86·0	4·04	6·94	·0081	·161	·522	·314	·069
16.	86·8	1·66	4·97	·0219	·126	·150	·274	·073

Allusion has been made above to certain of the soils of this Division which resemble those of the vast stretch further inland, known as the Karroo. So great, in fact, is this resemblance, that a portion of this Division, and that of Oudtshoorn adjoining thereto, is often called the "Ladismith and Oudtshoorn Karroo." The soil of a great part of this area consists of the disintegrated Bokkeveld beds which overlie the sandstone formation referred to in connection with the soils of the George Division. These Bokkeveld beds consist not merely of sandstone, but also of siliceous clay slates, and thus, in decomposing, they give rise to a sandy loam, superior, for agricultural purposes, to the sands, for instance, of the George Division. This "Oudtshoorn and Ladismith Karroo" covers the stretch of country which extends eastwards between the Zwartberg and Langeberg Ranges and their continuations. This belt of country has a great reputation for fertility, especially in the Oudtshoorn Division, east of Ladismith; the cause of this is easily explained: there stretches throughout this belt a surface formation of calcareous marl, derived from a thin stratum of limestone called by local farmers "Kalkbank." Its fertilising effect is noticeable solely in the valleys, and further east, in the Oudtshoorn Division, it is one of the principal factors in the almost unexampled fertility of the Grobbelaars and Wynands River Valleys, the Cango district, and the region about Vlakte Plaats.

MACLEAR.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Wizard's Vale.	Thomson.	P. W. Leach.

A sample of soil was collected on the farm Thomson, at the junction of the Tsitsa and Mooi Rivers, from a spot where tobacco was being cultivated. The quality of the tobacco produced had been very highly commended by the Government Tobacco Expert. The soil is, taken all round, of good quality. Good tobacco had also been grown on the farms Gordon and Wizard's Vale, in the same district.

The following is the analysis of the above soil:—

(Method II.)

	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	1·75	9·18	·011	—	·87	·38	·19

MAFEKING.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	No. 1.	Hartebeestlaagte.	S. Minchin.
2.	No. 2.	West Hill.	M. W. B. Webb.

No. 1 was a sample of sandy soil, collected from the farm Hartebeestlaagte, which adjoins the railway line. It was intended to plant several hundreds of fruit and ornamental trees on this soil. The sample was taken about two feet below the surface, and was stated to overlie a granite formation. This formation is, in fact, exposed along the river beds of the Molopo and Maratsani.

No. 2 was taken, at a point 25 miles north-east of Maribogo Railway Station, from lands which it had been proposed to bring under irrigation and utilise for the growing of lucerne.

According to the following analytical figures, both the above soils are very poor in all plant food:—

(Method I.)

No.	Percent of Field Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1	75·2	1·78	4·53	·0007	·042	·036	·048	·056
2	78·5	·93	2·99	·0025	·056	·064	·056	·041

These poor soils may be considered as representative of the large area of surface sands and quartzites that stretches westwards from Mafeking for very many miles.

MALMESBURY.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Mossel Banks Rivier.	Kalabas Kraal Station.	J. C. Watermeyer.
2.	Middle Zwartland.	Twee Kuilen.	C. F. Juritz.
3.	,,	,,	,,
4.	,,	Vaderlandsche Rietkuil.	,,
5.	,,	Bloemendals Fontein.	J. C. Watermeyer.
6.	,,	Reeboksfontein.	,,
7.	,,	Michiel Heyns Kraal.	,,
8	,,	,,	,,
9.	Groene Kloof East.	Klipfontein.	,,
10.	,,	Karnemelksfontein.	,,
11.	,,	,,	,,
12.	,,	Alexanderfontein.	,,
13.	,,	Reeboksfontein.	,,
14.	,,	Platte Klip.	,,
15.	Honing Berg.	Geel Dam.	,,
16.	Zwartland.	Witkei.	C. F. Juritz.
17.	,,	,,	,,
18.	,,	,,	,,
19.	,,	Olifants Kuil.	,,
20.	,,	Geel Kuil.	,,
21.	,,	New Rush.	,,
22.	,,	,,	,,
23.	,,	,,	,,

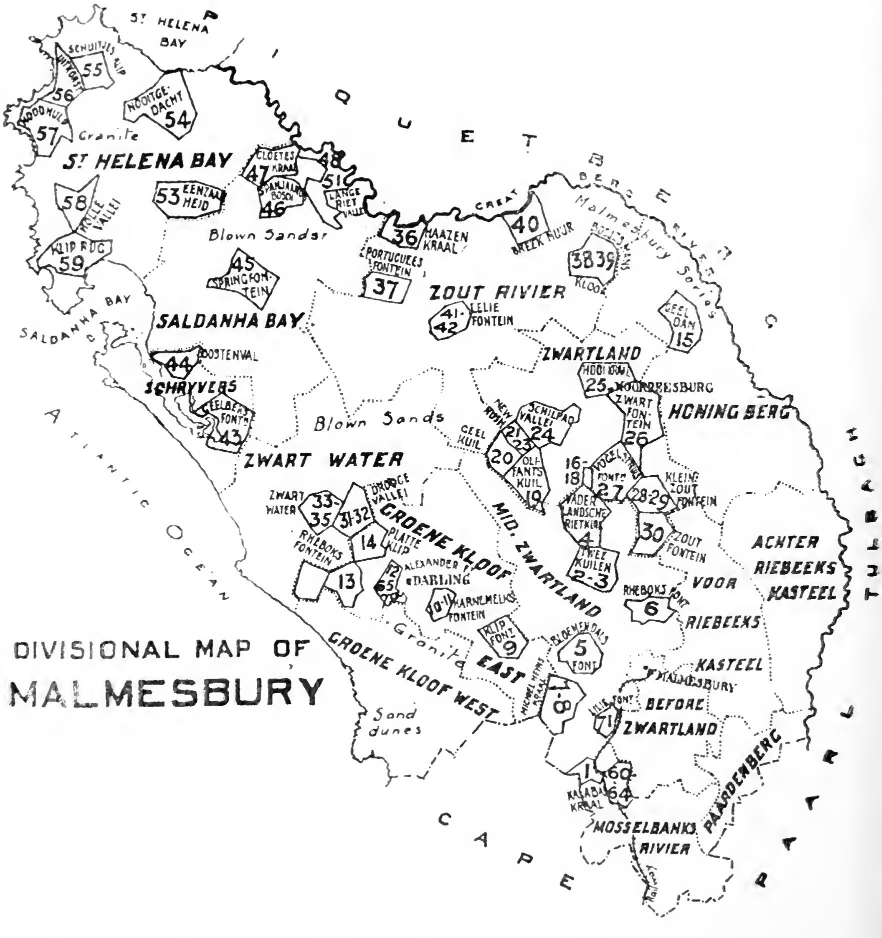
No.	Field Cornetcy.	Farm or place.	Collector.
24.	Zwartland.	Schildpad Vallei.	C. F. Juritz.
25.	"	Hooi Kraal.	"
26.	"	Zwartfontein.	"
27.	"	Vogelstruisfontein.	"
28.	"	Klein Zoutfontein.	"
29.	"	"	"
30.	"	Zoutfontein.	"
31.	Zwart Water.	Droge Vlei.	J. C. Watermeyer.
32.	"	"	"
33.	"	Zwart Water.	"
34.	"	"	"
35.	"	"	F. Blersch.
36.	Zout Rivier.	Hazen Kraal.	J. C. Watermeyer.
37.	"	Portugeeschfontein.	"
38.	"	Bosjesmans Kloof.	"
39.	"	"	"
40.	"	Breek Muur.	"
41.	"	Leliefontein.	"
42.	"	"	"
43.	Schryvers Hoek.	Geelbeksfontein.	"
44.	"	Oostenwal.	"
45.	Saldanha Bay.	Springfontein.	"
46.	"	Spanjaardsbosch.	"
47.	"	Cloetes Kraal.	"
48.	"	Lang Riet Vlei.	"
49.	"	"	"
50.	"	"	"
51.	"	"	"
52.	St. Helena Bay.	Muishondfontein.	"
53.	"	Eenzaamheid.	"
54.	"	Nooitgedacht.	"
55.	"	Schuitjes Klip.	"
56.	"	Uitkomst.	"
57.	"	Noodhulp.	"
58.	"	Holle Vallei.	"
59.	"	Klip Rug.	"

The Malmesbury Division gives its name to the geological formation which extends over practically the whole of its area, and consists of a hard clay slate that ultimately decomposes to a loamy clay soil. The strata wherein these clay slates occur constitute what is commonly termed the Malmesbury series, and, as a rule, do not yield a rich soil. A more or less similar condition obtains all along the south-western corner of the Colony, the Bokkeveld series replacing the older Malmesbury formation in the south, and these two formations stretch practically in succession from the Division of Piquetberg to that of Riversdale, both inclusive.

Intrusive in these Malmesbury clay slates are outcrops of granite, at such places as Saldanha Bay, Darling, Groene Kloof, Riebeeks Kasteel, Paardeberg, Groeneberg, Wellington, Paarl, Simonsberg, Stellenbosch, Somerset West, etc. The soils derived from this granite are very fertile when the rock whence they were produced has been thoroughly disintegrated and decomposed but not otherwise.

The two classes of soils above mentioned form the principal broad types of this division; they bear a general resemblance, therefore, to those of the Cape Division.

Proceeding from the village of Malmesbury, about ten miles in a north-easterly direction, two soils were collected from the farm Twee Kuilen. The occupant of the farm Vaderlandsche Rietkuil, where the next sample



DIVISIONAL MAP OF MALMESBURY

was taken, appeared to have progressed somewhat beyond the system of manuring by convenience noticed in some of the Cape Division farms:* he generally employed horse or sheep manure for fertilising his land, but declared that, according to his experience, the portion of the farm whence sample No. 4 was taken was sufficiently productive to need no other than horse manure. Two and three-quarter miles further to the north, from the comparatively small farm Witkei, situated $15\frac{3}{4}$ miles N.N.W. of Malmesbury and occupied by Mr. Gert Rust, three samples were collected.

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* See page 40.

Mr. Rust—who has spent his entire life on the farm, and has kept a continuous farm diary for over a quarter of a century—states that on one part of his farm the crops had never yet been seriously attacked by rust, that rust had, in fact, very seldom so much as appeared on this part of his lands, and that, during seasons when most of his crops had been completely ravaged, the cereal crops in this particular locality had enjoyed entire immunity from the pest. The existence of such patches of land—where rust seldom or never appears, and where the crops, if attacked, suffer no serious damage—has not yet been satisfactorily explained. In many of these cases, such as that under immediate discussion, the chlorides have been found to be rather high; in others, the soil has appeared to be of an all-round better quality than the average. Of the samples of soil collected on this farm, one—No. 16 on the above list—was taken from lands that had been attacked by rust season after season, and the crops destroyed; another sample—No. 17—was taken from the rust-proof locality above mentioned. In this case it was noticeable that the underlying formation was largely calcareous. Both these samples were procured from lands which had been treated with horse and sheep manure. The third sample taken from this farm, No. 18, represents a virgin soil corresponding in nature to No. 16.

Journeying about four miles in a westerly direction from Witkei, the farm Olifants Kuil was touched at, and sample No. 19 taken. On this farm, it was said, rust had for the previous six or seven years effected a considerable amount of damage. From a spot three miles north-west of this, on the farm Geel Kuil—the southern part of the farm formerly bearing that name—another sample was taken, and then the northern portion of the old farm, now called New Rush, was visited: here three samples were collected. No. 21 was a sample of virgin soil, but Nos. 22 and 23 were both taken from ground that had been under cultivation for twelve years: of these two, the former represents the top of a hill where rust has occasionally made its appearance, but has never done much harm to the crops, while the latter was taken from a low-lying valley, a situation evidently much more subject to damp than that of the previous sample. As a matter of fact the field whence the last soil was taken is frequently visited by rust, which at that spot does considerable harm to the crop; nor can this excite much wonder when the situation is borne in mind.

Turning now the north-east, a sample of soil was obtained at a distance of four miles from the last—nearly five miles W.S.W. of Moorreesburg village, and 21 miles N.N.W. of Malmesbury—on the farm Schildpad Vallei. Here, as in a few former instances, a visitation of rust rarely occurs, and, when it does take place, effects comparatively little harm. The next soil, No. 25, was collected on the farm Hooi Kraal, from a point rather less than two miles to the north of Moorreesburg.

On the way back to Malmesbury, a sample, No. 26, was collected from the farm Zwartfontein, about 2¼ miles south-east of Moorreesburg, another from the farm Vogelstruisfontein, otherwise known as Drie Heuvel, nearly 5¾ miles south of Moorreesburg, and 16 miles north of Malmesbury. Two samples were then collected on the farm Klein Zoutfontein, at distances respectively 3⅓ and 4⅔ miles south-east of the spot where the previous sample was procured. The last sample of this tour was taken on the farm Zoutfontein, nearly ten miles due north of Malmesbury.

On a subsequent journey the first farm visited after leaving Malmesbury was Bloemendalsfontein, about 6½ miles north-west of the village: there a sample of uncultivated soil, No. 5, a sandy clay, was obtained. At the farm Klipfontein, about 4¾ miles further west, No. 9, also an uncultivated soil, even more sandy than the previous one, was taken. Six miles north-west of this, on the farm Karnemelksfontein, two samples (Nos. 10 and 11) were secured from land which had lain uncultivated for six years, and was being prepared for the next season's sowing. At this spot the soil was clay of somewhat sandy nature. Mr. F. Duckitt, the owner of the farm, mentioned that here, on one and the same piece of land, the yield was apt to differ considerably; that of the low-lying portions being inferior to that of the higher ground; two samples were therefore taken, No. 10 from high ground, and No. 11 from a lower level, at spots within a few yards of each other, in order to ascertain whether any difference in chemical composition could be detected, or whether excessive moisture in the low-lying parts was the cause of the variation in the crop. Of the two soils, the former was found to possess a higher retentive capacity for moisture; it is also better supplied with lime, but in both cases potash and phosphoric oxide are very low. The hills about the village of Darling are, to a great extent, granitic, and, although the farm of Mr. C. Duckitt, The Towers, was visited, the granitic grain land was altogether omitted, nor was any sample of the clay soil taken here, as a sample (No. 12) of soil of the same type was procured four miles north-west of Karnemelksfontein, at Alexanderfontein, the farm of Mr. M. Duckitt, from land which was being prepared for the next season's use, after having been uncultivated for four years. On proceeding to the farm Reeboksfontein, 3¼ miles west of Alexanderfontein, and principally granitic soil, a sample, No. 13, of clay soil was obtained; this soil had been uncultivated for three years. On the farm Platteklip, 2½ miles north of Reeboksfontein, a sample of sandy clay soil, No. 14, was collected; this had not been cultivated for one year, but was being prepared for the next season. These last three soils are alluvial clays, No. 14 being evidently affected by the granite which underlies them all: this also manifests itself in the smaller percentage of lime and the higher proportion of potash that it contains. On the farm Drogevlei, two miles north-west of Platteklip, two samples, Nos. 31 and 32, about one hundred yards apart, were taken from land said to be extremely fertile, lying to the north of a saltpan. The first soil was a greyish-coloured stiff clay, which proved to be rich in lime and potash, and contained a fair quantity of phosphates; the second, a lighter, more or less sandy clay of a reddish colour, contained a moderate amount of lime and potash, but proved decidedly poor in phosphoric oxide. This soil is reputed to be rust-resistent, and is cultivated without manuring. On the farm Zwartwater, about a mile to the north-west, No. 33, a soil similar in appearance to No. 31, was taken for comparison; it was found to be chemically much the poorer. Why these soils should be superior to others as regards immunity from rust, does not appear from the chemical analyses. The position of this soil with respect to the adjoining saltpan is similar to that of No. 31. The next sample, No. 34, was taken from sandy soil, 1¼ mile further north-west, and not rust-resistent. This soil had not been cultivated for three years, and is never manured. Practical experience had found it poorer than the preceding sample, and chemical analysis confirms this, although the difference is not great. In this neighbourhood too farmers have frequently observed that, while the surrounding crops are affected by rust, certain patches of ground year after year escape visitation, or, when affected, do not suffer greatly. It was from such a patch that sample No. 35 was taken. The particular patch extends over about 40 or 50 acres; it had never been manured, and was used for the cultivation of wheat every alternate year, lying fallow in the intervening years. Proceeding from this farm, a sandy tract is entered upon, which stretches as far as the coast, about nine or ten miles. Underlying the stratum of sand, which is two feet or more in depth, is a bed of limestone. This limestone bed had already been noticed on the farm Klipfontein.

From the farm Geelbeksfontein, about 9½ miles north-west of Zwartwater, a sample, No. 43, was collected, consisting of hitherto uncultivated humus soil, which was to be sown upon, without manuring, the next season. The only other grain land in this vicinity is granitic. This humus soil as well as most of the sandy soils, and the limestone soils which will be mentioned presently, is simply ploughed and sown immediately, not being fallowed previously, as has been the practice with the clay soils: in this case, apparently, the opinion is that the productiveness of the soil renders fallowing needless. At Oostenwal, 7½ miles north-west of Geelbeksfontein, a sample of virgin soil, No. 44—a mixture of limestone with granitic soil—was taken. This soil is also cultivated without manuring. The soil of the adjacent farm, Meeuwklip, resembles that of Oostenwal; at Karnberg sandy soil is again met with, limestone being not far below: over Zoutkuil to Springfontein, about nine miles north-east of Oostenwal, where No. 45 was collected, the sand diminishes and the limestone increases. At Springfontein the limestone is exposed to such an extent that the surface of the otherwise hard material has become sufficiently friable to be easily cut up by the plough, and mixed with the inch or two of sand that covers it. This soil is sown without manuring, and farmers who were questioned on the subject, including the occupant of Springfontein, state that the limestone soil to a great extent withstands the rust, and that, at times, when the grain sown on the sandy soil is almost entirely destroyed by rust, that on the lime soil is only slightly affected.

Leaving Springfontein, and passing over Kersbosch and Klipfontein to Spanjaardsbosch, about six miles north of Springfontein, the soil becomes more sandy, and is here of about the same appearance as that of Zoutkuil and Karnberg further to the south-west. From Spanjaardsbosch a sample (No. 46) of uncultivated sandy soil, having somewhat of an admixture of lime, was collected. Thence the journey was directed to Cloete's Kraal, about 3¼ miles north of Spanjaardsbosch, where the soil loses its very sandy nature, and here also a sample (No. 47) of uncultivated soil was procured. The next farm is that of the Brothers Kotze, Lang Riet Vlei, at Berg River, about five miles east of Cloete's Kraal. Here, at the request of Messrs. Kotze, four samples were taken at spots pointed out by them, namely: No. 48, "Vaalbos" ground, where the Cape salt bush grows luxuriantly, a dark grey, somewhat stiff clay soil; No. 49 a looser and lighter clay, said to be the richest grain land on the farm; No. 50, a sandy soil, low-lying and yielding poor returns; and No. 51, a sandy soil, similar to the previous one, at a higher situation, and yielding better crops physically as well as chemically it proves to be the better soil of the two.

Between Lang Riet Vlei and Hazenkraal, about eight miles south-east of the former, alluvial vlei deposit stretches all the way along the Berg River, skirted by sand. The way from Hazenkraal to the village of Hopefield lies along the bed of the Zout River, and the elevated land, under cultivation on either side of the river bed from here to Hopefield, is a coarser sandstone formation than that previously passed over, no indications of the presence of limestone being noticed. A sample of this soil, No. 36, was taken from uncultivated land at Hazenkraal, and again, nearly four miles south of this, No. 37, at Portugeeschfontein. The former of these two samples contains a slight admixture of clay. These were the last samples taken on this tour, for on leaving Hopefield the Malmesbury clay beds are almost immediately entered upon. These soils afford a fair idea of the grain country from Darling to Saldanha Bay, and thence to Hopefield. The intermediate sandy country is mainly devoted to cattle and sheep farming.

Regarding the non-manuring of the lands, the impression conveyed is that manuring is dispensed with wherever possible, as much owing to the want of a sufficiency of stable and cattle manure, as on account of the reputed fertility of the soil; but the fact cannot be too strongly emphasised that the richest soil is bound to be impoverished in course of time, if cultivated without manuring, and it behoves agriculturists to guard their interests, and attend to the quality of their lands, and merchants to place within reach of the farmer artificial fertilisers at as reasonable rates as possible, so that the farmer may learn their value, and the whole agricultural community, as also the country at large, may profit by the experience.

The final trip of this series was undertaken with a view to obtain samples from the St. Helena Bay district, and, at the same time, to supply the omissions of previous journeys, and thus render the investigation more complete. St. Helena Bay, it need scarcely be said, is an important grain-growing district, and the land, according to the farmers, is so fertile that it can be cultivated continuously without manure, the chief obstacle to success being the low rainfall.

The samples collected on this journey are detailed below. A light clay soil, No. 6, was taken on the farm Reeboksfontein, about five miles north of Malmesbury. No further samples were collected in this neighbourhood, as, with those previously collected, the work had been practically completed as regards the Middle Zwartland farms. Proceeding northwards, a stiff clay soil, No. 15, was collected on the farm Geeldam, a portion of Holle Rivier, seven miles from Moorreesburg in a north-easterly direction. About nine miles north-west of this Nos. 38 and 39 were taken on Mr. M. Karsten's farm Bosjesmans Kloof; the former of these two is a light clay, the latter a very stony clay soil. In Mr. Karsten's experience No. 38 is the poorer. On the farm Breek Muur, which borders on the Berg River, and lies six miles north-west of Bosjesmans Kloof, sample No. 40 was taken. Here the soil is more sandy in character, being, in fact, a sandy loam. Eight miles south-west of this, on the farm Leliefontein, sample No. 41 was taken; this is a stiff white clay, somewhat stony, but said to be very fertile. The lime and nitrogen in this soil are satisfactory in amount, and the potash fair, but phosphates are deficient. On the same farm, about 2¼ miles further south-west, sample No. 42, a sandy loam, was collected. The farmers in this part use stable manure, and also guano and artificial fertilisers in small quantities.

Before reaching the St. Helena Bay area, the farm Eenzaamheid, about 16 or 17 miles north-west of Hopefield, was visited. Two samples, Nos. 52 and 53, were taken here; the former on the portion of the farm known as Muishondfontein, and the latter about two miles further west on Eenzaamheid proper. The soil here is sandy, resembling that of Spanjaardsbosch. The farm Eenzaamheid, and other farms forming the inland boundary of the Field-Cornetcy of St. Helena Bay, are situated on a low-lying, sandy flat, whilst, with the exception of a narrow strip of similar sandy flat along the coastline, the other farms lie at elevations of probably 500 to 700 feet, upon and around granitic hills, the highest of which may be 900 feet. The soils of this part are, therefore, mostly granitic. The first sample taken here, No. 54, was from the farm Nooitgedacht, portion of Patrysberg, about five miles north-east of Vredenburg; and seven miles north-west of this, on the farm Schuitjes Klip, sample No. 55 was taken. These two soils are of a rather sandy nature. On the farm Uitkomst, adjoining Schuitjes Klip, and about 2½ miles to the south-west, sample No. 56, a clay soil, in appearance resembling the clay soils about Malmesbury, was collected. Judging by its agricultural returns, this soil was expected to yield good analytical results, and it certainly does show, in addition to a fair proportion of nitrogen, more lime, potash, and phosphoric oxide than any other soil collected within the Field-Cornetcy. The three soils which complete the circuit in the neighbourhood are sandy loams, clay being more in evidence on the farms west of Uitkomst than on those east of it. No. 57 was taken on the farm Noodhulp, three miles south-west of Uitkomst, No. 58 on the farm Holle Vallei, about 6½ miles south-east of Noodhulp, and No. 59 on the farm Kliprug, about three miles south-east of Holle Vallei. The reputation of the soil is good; chemically it shows a normal proportion of nitrogen, and, although poor in phosphates, it contains fair amounts of lime and potash.

It remains to add that samples 7 and 8 were taken on the farm Michiel Heyns Kraal, eight miles south-west of Malmesbury: this is not a grain, but a dairy farm. No. 7 represents a loam and No. 8 a humus soil. No. 1, a sandy loam, was taken from Crown lands at Kalabas Kraal Station, seven miles north-east of the farm Lange Rug in the Cape Division; it represented the only uncultivated ground in the vicinity. All the samples collected on this journey represent virgin soils.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
60.	Mosselbanks Rivier.	Kalabas Kraal.	D. E. Hutchins.
61.	,,	,,	,,
62.	,,	,,	,,
63.	,,	,,	,,
64.	,,	,,	,,
65.	Groene Kloof East.	Alexanderfontein.	J. P. Cloete.
66.	,,	,,	,,
67.	,,	,,	,,
68.	,,	,,	,,
69.	,,	,,	,,
70.	,,	,,	,,
71.	Middle Zwartland.	Leliefontein.	C. Nelson.

From the Kalabas Kraal Outspan five samples were taken: No. 60 represents the subsoil from a hill top, and No. 61 the surface soil at the same place. No. 62 represents a light loam from the valley, and Nos. 63 and 64 are sands, the former being from sour veld and the latter mixed sand from the river bed.

While travelling through the Malmesbury Division in connection with the collection of the samples mentioned in the previous list, attention was frequently directed by the local farmers to numerous slight elevations, from one to four feet in height, and twenty or more yards in diameter; the soil of these hillocks—called "heuveltjes" by the farmers—was alleged to be extremely rich, and cereals of all kinds were said to grow on them with luxuriance; while on the lower ground, between the elevations, the soil would be poor and produce scanty crops. It is not customary—so it is asserted—ever to manure these hillocks, and some lands are alleged to have grown wheat for nearly a century without the hillocks either receiving any manure or becoming exhausted. Mr. J. P.

Cloete, of Alexandersfontein, through whose good offices specimens of hillock and other soils were procured for comparative analysis, stated that for the last four years he had been urging farmers to use lime largely on the poor cold soils between the hillocks, and he quoted instances of very poor lands having yielded heavy crops of wheat by the aid of a good dressing of lime.

In order to ascertain by chemical analysis what difference, if any, existed between the hillock soils and those of the lower levels, samples of each were specially collected and analysed. Those from hillocks are numbered 65, 66, and 67, and those from the level below 68, 69, and 70: all of these were taken from lands that had been cultivated. In every case the soils taken from the low-lying ground proved to be exceedingly poor in lime, and herein lies the great difference between the hillock soils and those below, curiously enough tending to verify Mr. Cloete's prognostications. Even the hillock soils Nos. 66 and 67 are rather deficient in lime, although considerably superior to the lower soils. No. 65 contains lime in fair amount. The potash present in the hillock soils is fair in quantity, but in this respect No. 69 is poor, while Nos. 68 and 70 show a moderate proportion, although in each case poorer than the corresponding samples from the hillocks. As far as phosphates go, there is a fair proportion in the hillock soils, but the other three are rather poor. These few analyses tend to confirm the popular idea; and yet the difference all round is not as striking as some of the statements made might possibly have led one to expect. To this last observation there is just the exception already noted—that of the lime. Physically as well as chemically, the hillock soils appear to be slightly superior: in water retentive capacity their average stands higher than that of the soils around, a point also noted in connection with the soils collected on the farm Karnemelksfontein (*vide* p. 82). There is, moreover, a better proportion of organic matter in the hillock soils than in the others, and the former are likewise the richer in nitrogen. Without unduly pressing the points of difference, the inferiority of the low-lying soils also comes out in the amounts of chlorine they contain, in as far as these amounts indicate tendency to become brack: all along the line, therefore, the hillock soils have points in their favour.

Reverting for a moment to the soils from Karnemelksfontein, it may be observed that there too the hillock soil was the better, not only in water retaining capacity, but likewise in organic matter and nitrogen, and there too the chief difference lay in the proportion of lime.

Another instance of comparative analyses of hillock and level soils will be briefly referred to in connection with the farm Groenberg in the Paarl Division.

Under all the circumstances it seems quite feasible that the process of levelling down the hillocks—said to have been attended with general improvement of the land in some instances—may have led to an all-round increase in fertility, notably where these hillocks have been numerous. It seems also reasonable to suppose, from what these results reveal, that an addition of lime would lead to an improvement. Speaking of carbonate of lime as a dominant factor in soil productiveness, Professor Hilgard observes: —*

"Its presence exerts a dominant and beneficial influence in many respects, as is readily apparent from the prompt change in vegetation whenever it is introduced into soils deficient in it."

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* Hilgard: "Soils; their formation, properties, composition and relations to climate and plant growth." 1906, pp. 353, 354.

In the Malmesbury Division there are several outcrops of carbonate of lime, for instance on the farms Drooge Vlei (Field-cornetcy Zwartwater), Geelbeksfontein (Field-cornetcy Schryvers Hoek), Springfontein and Lang Riet Vlei (Field-cornetcy Saldanha Bay). Even if levelling-down does not achieve the desired result, there should be abundance of lime near at hand on which to draw for a supply.

The existence of these hillocks in various parts of this Colony has been attributed to insects—ants, presumably. In this connection attention may be directed to the following:—

"The work of ants is in some regions on so large a scale as to attract the attention of the most casual observer. Especially is this the case in portions of the arid region, from Texas to Montana, where at times large areas are so thickly studded with hills from three to twelve feet in diameter, and one to two feet high, that it is difficult to pass without being attacked by the insects. The 'mounds' studding a large portion of the prairie country of Louisiana seem also to be due to the work of ants, although not inhabited at present."*

The last sentence seems to fit exactly the conditions of the Cape "heuveltjes."

The results of the analyses of the soils from the Malmesbury Division are tabulated below:—

(Method II.)

	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	·30	·85	·0006	·014	·059	·041	·016
60.	1·11	2·22	·0101	—	·064	·026	·041
61.	·22	·44	·0024	—	·037	·018	·052
62.	1·46	2·40	·0056	—	·097	·044	·038
63.	·34	·52	·0025	—	·046	·025	·034
64.	1·23	1·28	·0070	—	·060	·023	·023
2.	·49	1·90	·0003	·061	·056	·107	·051
3.	·68	2·47	·0003	·078	·092	·171	·071
4.	1·16	5·24	·0008	·095	·136	·128	·064
5.	·14	1·07	·0004	·050	·059	·038	·025
6.	·91	2·91	·0014	·091	·049	·031	·030
7.	·67	2·30	·0011	·070	·168	·039	·038
8.	7·16	15·36	·0056	·252	·369	·033	·080
9.	·17	·95	·0008	·067	·039	·042	·033
10.	1·03	4·44	·0014	·089	·147	·059	·041
11.	·29	2·16	·0006	·072	·062	·064	·022
12.	·49	3·12	·0010	·129	·081	·035	·045
13.	·80	4·16	·0032	·117	·095	·098	·048
14.	·56	2·24	·0012	·035	·046	·102	·050
15.	·94	2·50	·0009	·063	·064	·074	·032
16.	·98	3·60	·0022	·117	·160	·130	·056
17.	·80	1·86	·0347	·072	·056	·077	·044
18.	1·05	2·79	·0010	·095	·108	·101	·051
19.	·62	2·68	·0004	·056	·104	·062	·038
20.	1·23	4·02	·0007	·033	·036	·119	·035
21.	·60	2·99	·0012	·078	·028	·144	·071
22.	·58	2·61	·0010	·084	·082	·090	·064
23.	·59	2·53	·0081	·061	·098	·092	·051
24.	·46	2·04	·0002	·067	·060	·020	·074

* Hilgard: *op. cit.* p. 160.

(*Method II*)—continued.

No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
25.	·68	2·94	·0009	·084	·032	·033	·053
26.	·35	1·72	·0005	·072	·064	·042	·040
27.	·73	5·17	·0002	·100	·076	·090	·076
28.	·37	1·63	·0003	·056	·052	·042	·066
29.	1·68	3·17	·0005	·156	·068	·090	·063
30.	·31	1·76	·0002	·077	·036	·045	·086
31.	7·25	9·26	·0058	·140	1·991	·492	·063
32.	·93	2·14	·0057	·028	·156	·122	·028
33.	·78	1·81	·0025	·035	·125	·075	·033
34.	·48	2·04	·0017	·028	·108	·054	·039
35.	3·16	14·30	·018	—	12·07	·44	·17
36.	·24	1·06	·0050	·042	·024	·045	·124
37.	·17	·59	·0005	·021	·053	·018	·034
38.	·87	1·83	·0103	·091	·187	·066	·042
39.	1·08	7·90	·0042	·133	·010	·052	·058
40.	·70	1·55	·0020	·077	·046	·048	·042
41.	1·94	4·09	·0108	·126	·256	·075	·027
42.	·39	1·20	·0009	·035	·039	·026	·038
43.	1·85	16·26	·2258	·325	1·159	·443	·180
44.	·78	3·29	·0013	·042	·364	·124	·052
45.	·52	2·43	·0016	·035	4·715	·058	·025
46.	·42	·94	·0015	·049	·231	·037	·075
47.	1·17	2·59	·0006	·049	·220	·068	·055
48.	1·98	2·97	·0147	·070	1·826	·182	·053
49.	·58	1·31	·0022	·047	·073	·063	·027
50.	·20	·54	·0006	·028	·063	·046	·025
51.	·51	1·01	·0008	·028	·114	·061	·034
52.	·41	·68	·0006	·084	·084	·042	·048
53.	·35	·67	·0010	·056	·034	·035	·027
54.	·47	1·12	·0009	·049	·062	·046	·027
55.	1·01	2·53	·0093	·035	·015	·021	·050
56.	2·32	3·48	·0017	·091	·418	·105	·094
57.	1·86	2·55	·0011	·077	·165	·062	·046
58.	1·28	4·82	·0024	·084	·043	·039	·027
59.	1·94	4·30	·0016	·112	·139	·060	·045

(*Method I.*)

No.	Percent. of Field Sample. Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
		Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
65.	72·0	1·57	5·83	·0106	·175	·146	·121	·061
66.	73·8	1·15	3·18	·0078	·189	·072	·075	·072
67.	80·0	1·47	5·01	·0042	·126	·096	·095	·073
68.	72·2	1·01	4·33	·0261	·119	·014	·114	·049
69.	68·0	1·09	2·64	·0159	·112	·014	·045	·028
70.	76·0	1·28	4·30	·0078	·119	·014	·095	·055
71.	31·8	·28	1·95	·0071	·091	·032	·020	·017

In the Malmesbury grain soils, as in those of the Cape Division, the great lack is phosphatic material, and potash is almost as urgently needed; at the same time it must be said that, not only in proportion to the lime present, but also absolutely, the amount of phosphoric oxide is higher in the Malmesbury than in the Cape Division, and seems to continue increasing in amount as one travels northward from Tygerberg to Zwartland.

It is noteworthy that the surface soils which are more or less influenced by the underlying lime deposits—such as those at Drooge Vlei, Geelbeksfontein, Oostenwal, and Uitkomst—in addition to containing more lime than the other soils, are also richer in potash. The ultimate origin of the comparatively large amount of potash in the soils of this class is a point of some interest which it is worth while elucidating: it does not seem improbable that it is caused by the debris of granitic rocks being mixed with the compacted sand; from the blown sand itself the potash could certainly not have been derived.*

Out of 68 soils overlying the rocks of the Malmesbury series, collected in the Cape and Malmesbury Divisions, no less than 16 were deficient in all three inorganic plant food constituents in an available form; as many as 45 are poor in phosphoric oxide; and of these latter five also lack potash, and eight lime. Of the remaining 23 soils, eight were deficient in lime only, three in potash only, and five in both lime and potash. There were, therefore, only seven soils, of all those 68, that were not lacking in respect of one or other of the three mineral fertilising constituents, and even out of these seven, six were no better than fair all round.

MIDDELBURG.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Nauwpoort.	Carlton.	Dist. Railway Engineer.

Amongst the characteristic features of the Beaufort geological series, the occurrence of bands of dark purple mudstones and shales may be noticed by any traveller by rail in those parts of the country where the rocks of the Beaufort series appear at the surface, for instance, between Nauwpoort Junction and Ludlow on the Midland Railways. References to these mudstones and shales may be found, *inter alia*, on pages 33 and 174 of the Geological Commission's Report for 1903, on pages 78 and 81 of the Commission's Report for 1904, and on page 98 of that for 1905.

These purple shales are exposed in various parts of the railway cuttings on the west of the railway line south of Carlton, and especially so just at the 262nd milepost. They frequently appear to be of a calcareous nature, and to investigate this point, some of the weathered and finely disintegrated shale was procured for analysis. As the shale is found intermixed with limestone bands and layers of sandstone, no opportunity has been available of procuring any of this purple material in a sufficiently decomposed condition to form an actual soil by itself, but the above sample, taken from the cutting south of Carlton, represents the weathered shale in as finely divided a condition as it was possible

* A somewhat similar problem arises in connection with the soils of the farm Hoogekraal, Nos. 33 and 34 of the Cape Division soils (*vide* pages 40 and 43 of this volume). The point will be reverted to later when discussing the bearing which the geological relations of soils have upon the proportions of plant food which they contain : see Part V.

to procure it free from other rock material that could in any way modify the chemical composition of the sample.

In order to afford an idea of its state of sub-division, it may be mentioned that a mechanical analysis of the shale as collected gave the following results:—

Pebbles*	12·55
Coarse gravel	12·70
Fine gravel	36·55
Coarse sand	10·74
Fine earth (by difference)	26·75
Moisture	·71
Total	100·00

The chemical analysis of this sample yielded the following results:—

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide
1.	27·5	1·86	—	—	—	·476	·120	·126

It is obvious that the disintegration of these purple shales will produce a very fertile soil, and indeed it was the known fertility of soils into whose composition the shales had appeared to enter that led to the selection of this sample for analysis.

MOSSEL BAY.

(Officially collected.)

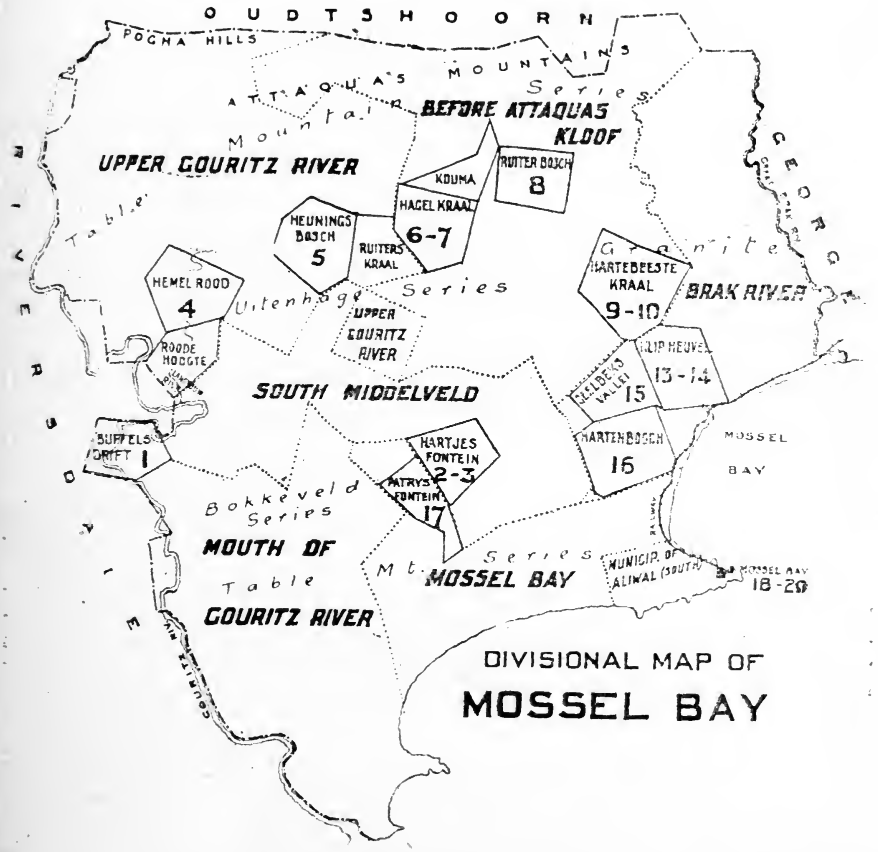
No.	Field Cornetcy.	Farm or place.	Collector.
1.	South Middelveld.	Buffels Drift.	J. Muller.
2.	,,	Hartjesfontein.	,,
3.	,,	,,	,,
4.	Upper Gouritz River.	Hemelrood.	,,
5.	,,	Heuningbosch.	,,
6.	Before Attaquas Kloof.	Hagel Kraal.	,,
7.	,,	,,	,,
8.	,,	Ruiter Bosch.	,,
9.	,,	Hartebeeste Kraal.	,,
10.	,,	,,	,,
11.	Brak River.	Great Brak River.	,,
12.	,,	,,	,,
13.	,,	Klipheuvel.	,,
14.	,,	,,	,,
15.	,,	Geelboks Vallei.	,,
16.	,,	Hartenbosch.	,,
17.	Mossel Bay.	Patrysfontein.	,,

Entering the Mossel Bay Division from Riversdale, at the farm Buffels Drift, which lies on the boundary of the two divisions, a typical sample of river soil was collected, No. 1 in the above list. The Gouritz

* The signification of each of these terms will be explained later, under the head of "Physical composition of soils."

River flows midway through the farm, and the river bed widens out considerably at that point; extensive and very deep deposits of silt are washed down and deposited anew all along the river course, serving as an excellent soil for gardening. No. 1 forms a representative sample of such a deposit of very rich and deep soil, which, on most of the farms lying along this river bed, is brought under irrigation by air-motors.

The silt thus deposited by the Gouritz River is identical with that to which the whole of the Oudtshoorn Division owes its great fertility, being brought down—ultimately from the Karroo—by the Olifants River and other tributaries of the Gouritz. It is hardly open to doubt that, if some scheme could be devised to intercept by means of retaining weirs



or otherwise, the rich Oudtshoorn silt which these rivers are constantly carrying into the sea, and to spread it over the adjacent farms of the Mossel Bay and Riversdale Divisions, great benefit to those areas would result.

Crossing the Gouritz River bridge, and leaving the main road, a course along the left bank of the river was taken, passing through Roode Hoogte, the very fertile farm of Messrs. Muller Bros., the soil of which is similar to that at Buffels Drift, lower down the river; then, proceeding up the left bank of the tributary Langtouw River, to the farm Hemelrood, better known as Herbert's Dale—quite a small village—

sample No. 4, a loose red sandy clay, was collected on the right of the road before entering this village. It represents the predominating soil all along the valley, which, like several others, is well cultivated, mostly for garden purposes, all sowing being done on the slopes of the surrounding hills, capped as they are with a fairly deep layer of rich "Karroo" soil.

On leaving the Langtouw River valley, a very hilly tract is traversed to Heuning Bosch, where No. 5, a sour soil, representing the upper and more mountainous parts, was taken from old lands adjoining those just under the plough. It was said to be a very poor soil, but yielded fairly satisfactory crops when manured with guano. The same type of soil is also to be found at Ruiters Kraal and Goedmoed. These poor soils are all derived from the sandstone formation to the north. Keeping along this ridge, a series of undulating plateaux is crossed over; they consist mostly of sour veld, with some occasional tracts of rich land, alternately "zwart turf" and natural red "Karroo" soil. Nos. 6 and 7, respectively typical of each, were secured at the farm Hagel Kraal. The "kweek" soil along the river is literally covered with the grass which obtains for it its vernacular appellation, and proves a great inconvenience and drawback to the growth of lucerne. At Roode Krans and Kouma a more or less similar soil is to be found, possibly somewhat more acid. At Ruiterbosch a sample of very acid soil, No. 8, was taken. Both at this farm and at Hagel Kraal, basic slag had been widely used as a fertiliser for cereals, but too sparingly, for it is a well-known fact that these acid soils, or "zuur veld" as they are locally termed, require principally lime and phosphates.

Between the last mentioned farm and Hartebeeste Kraal, there is not much sowing carried on; at the latter place, however, several varieties of soil were under cultivation, of which only two were selected, namely, No. 9, a "broken" red sour soil, not very fertile, and No. 10, a black sour soil, inferior to No. 9. These two soils were taken from above the mass of granite which commences north-west of Mossel Bay, and extends over a considerable portion of the George Division. The relatively large amount of potash in No. 9 is, not improbably, due to the felspar of the granite.*

From this point a course was laid for Great Brak River, the picturesque little hamlet situated on the river bearing that name, the boundary between the divisions of Mossel Bay and George; practically the whole of this hamlet is owned by Messrs. Searle Bros. In the valley on the right bank of the river, between the latter and the main road, there is a very level tract of an intermediate "broken vlei soil"; two samples were collected here, Nos. 11 and 12; the former of these is a loose, rather sandy clay, about nine inches deep, lying upon a bed of yellow clay; the other sample represents a loose sandy loam, which, after sowing for three successive years, becomes so "brack" or alkaline, that its owner is compelled, through poverty of the crops, to let the land lie fallow, for a year or two, until entirely covered with grass, when it is again ploughed over, well manured, and sown; fairly good results have thus been obtained.

At Klipheuvel there are several varieties of "broken vlei soil" under cultivation. Only Nos. 13 and 14, the former a rich dark loam, the latter a red sandy soil, were taken. Of these two soils, the latter has constantly been subject to visitations of rust; it is in every respect chemically the poorer soil of the two. Proceeding about three or four miles south-east of Klipheuvel, sample No. 15, a loose brack soil, was

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* A reference to this feature has already been made in connection with the Malmesbury soils. See page 89.

collected from the farm Geelbeks Vallei. The proportion of chlorine, it will be noticed from the following table, is higher than in any other of the Mossel Bay Division soils analysed. Sample No. 16, a light, yellow soil, with alkaline patches here and there, was taken from lands adjoining the roadside, on the farm Hartenbosch. Journeying almost due west from the last mentioned farm, over several varieties of "broken" soil, to Hartjesfontein, more commonly known as Matjes Drift, some very fertile varieties of alluvial clay soil were found. No. 2 is a good "Karroo" soil, while No. 3 is a dark loose clay, said to be very fertile. It is probable that this fertility is due to the lime present in the soil, the proportion being the maximum for the Mossel Bay Division. Nos. 2 and 3 represent the two classes of soil mostly under cultivation here. There is also a third variety, locally known as "vaal grond," but not equally extensively cultivated. The last sample taken in this division was No. 17, a loose gravelly clay soil, from the farm Patrysfontein. The range of hills south of this is composed of sandstone, and forms the natural boundary between the central belt of country, and the sand dunes which stretch along the coast. The comparative poverty of the Hartenbosch and Patrysfontein soils is evidently due to the influence of the sandstone.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
18.	Mossel Bay.	Mossel Bay.	C. W. Black.
19.	,,	,,	,,
20.	,,	,,	,,

These soils were taken from the Public Park at Mossel Bay, where the underlying geological formation is Table Mountain sandstone; they all represent poor sandy soils, No. 18 containing an admixture of a small proportion of clay.

The analyses of the soils enumerated in the foregoing lists are tabulated below:—

(Method III.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	97·0	2·52	6·29	·0062	·056	·43	·39	·13
2.	93·6	2·99	4·87	·037	·043	·23	·46	·070
3.	92·2	6·95	10·24	·035	·17	·59	·87	·12
4.	93·6	1·58	3·54	·011	·028	·10	·39	·074
5.	75·6	2·52	4·98	·016	·042	·16	·20	·054
6.	95·2	2·66	5·67	·011	·030	·15	·25	·11
7.	88·2	2·75	4·47	·040	·17	·13	·36	·059
8.	95·2	1·97	4·17	·012	·044	·15	·080	·064
9.	81·6	3·52	5·68	·032	·056	·15	·63	·074
10.	54·2	·92	2·47	·0071	·031	·13	·18	·061
11.	93·4	2·73	5·01	·0079	·046	·39	·58	·056
12.	95·2	1·97	6·29	·047	·044	·30	·34	·10
13.	79·0	2·12	4·41	·044	·057	·31	·56	·092
14.	94·0	1·05	2·13	·044	·029	·15	·26	·058
15.	92·6	2·21	5·71	·057	·056	·40	·76	·15
16.	79·4	·46	·89	·021	·045	·11	·14	·046
17.	82·6	·78	2·29	·026	·13	·10	·13	·033

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
18.	1·15	3·95	·0014	·123	·125	·076	·038
19.	·37	1·66	·0011	·016	·051	·026	·017
20.	·81	·66	·0026	·084	·055	·049	·019

It is to be expected that the method whereby most of the soils from this division have been analysed will yield higher proportions of lime and potash than in the case of soil-extraction by Method I.; to exemplify this the analytical results given in the above table for the poor sour soil at Heuning Bosch (No. 5) should be compared with the analyses of similar sandstone-derived soils extracted by Method I. The results obtained from the Hartenbosch and Patrysfontein soils (Nos. 16 and 17) should also be thus compared.

MOUNT CURRIE.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	No. 7.	Tiger Valley.	J. H. Corderoy.
2.	,,	,,	,,
3.	No. 5.	Poortje.	J. G. King.
4	,,	,,	,,

Two very poor gravelly soils were sampled at Tiger Valley; these are represented in the above list by samples 1 and 2. Nos. 3 and 4 were collected on the farm Poortje, near Kokstad. The soil, which is peaty, is about a foot deep, generally overlying red clay, although in some cases resting upon yellow shale. Some 200 acres had been ploughed up, but the agricultural capabilities of the land had proved disappointing.

The following results were obtained by analysis of the above four soils:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	56·3	1·16	3·56	·007	·028	·006	·031	·055
2.	63·7	1·74	4·56	·007	·125	·008	·020	·037

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
3.	6·22	20·40	·032	—	·075	·20	·074
4.	5·74	10·52	·038	—	·062	·20	·086

The disappointing character of the agricultural returns obtained from Nos. 3 and 4 exemplifies at the same time the value of chemical analysis as a means of judging of the fertility of some soils, and the law of the minimum* in respect of the need of all plant food in adequate proportion. Although in the soils referred to, potash is present in satisfactory amount, and phosphates in fair proportion, the percentage of lime is low, as indeed it is also in the other soil from this district; in such a case it is scarcely reasonable to hope for good returns, however satisfactory the soil may prove in other respects.

MOUNT FRERE.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Mount Frere.	Amanzamyama.	Distr. Forest Officer.
2.	”	”	”

The first of these two samples was a surface soil; the second was taken one foot below the surface: they were procured through the Conservator of Forests, Umtata, and had been collected in the Amanzamyana Plantation, about eight miles west of the village of Mount Frere, and adjoining Zibokwana's location. They are representative of extensive tracts of country in which the cereal crops usually grown do not thrive, whereas arboriculture is fairly satisfactory. It is not surprising that shallow rooted crops fail, for the soil is exceedingly deficient in both lime and potash; there is, however, a moderate store of phosphoric oxide available, according to the analyses, which resulted as shown below:—

(Method I.)

No.	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	99·2	7·13	7·20	·0049	·287	·012	·051	·091
2.	97·4	17·67	14·71	·0057	·168	·004	·019	·065

NAMAQUALAND.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Port Nolloth.	Port Nolloth.	A. G. Heywood.
2.	”	”	”
3.	”	”	”

These were three drift sands collected in the vicinity of Port Nolloth. The first two were surface soils, taken, respectively, from the south and from the north drift. The third was taken one foot below the surface. Lime, as may be expected in this case, is plentiful, but in respect of other mineral plant food the soils are poor.

The determinations made resulted as follows:—

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	—	—	—	—	·80	·063	·015
2.	—	—	—	—	2·07	·036	·100
3.	—	—	—	—	1·445	·029	·014

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* See page 17.

OUDTSHOORN.

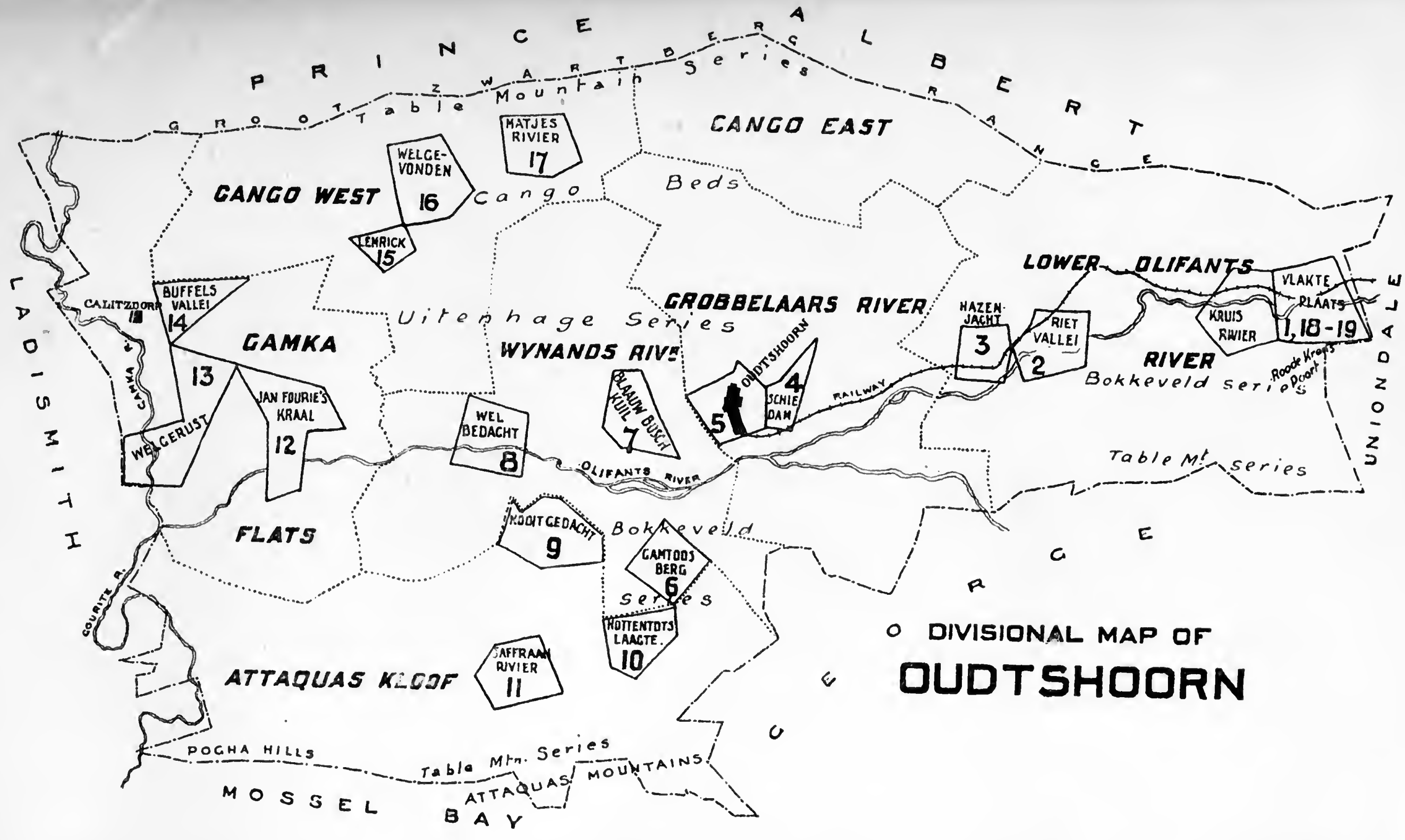
(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Lower Olifants River.	Vlakte Plaats.	C. F. Juritz.
2.	„	Riet Vallei.	„
3.	„	Hazenjacht.	„
4.	Grobbelaars River.	Schiedam.	„
5.	„	Oudtshoorn.	„
6.	Wynands River.	Gamtoos Berg.	„
7.	„	Blauwbosch Kuil.	„
8.	„	Welbedacht.	„
9.	Attaquas Kloof.	Nooitgedacht.	„
10.	„	Hottentots Laagte.	„
11.	„	Saffraan Rivier.	„
12.	Gamka Flats.	Jan Fouries Kraal.	„
13.	„	Welgerust.	„
14.	„	Adjoining Buffels Vlei.	„
15.	Cango West.	Lemrick.	„
16.	„	Welgevonden.	„
17.	„	Matjes Rivier.	„

As one passes from the Uniondale Division to that of Oudtshoorn, through Roode Krans Poort (an immediate change in the character of the soil becomes noticeable. A closer resemblance to the Karroo soil than on the eastern side of the "poort" begins to be traceable. The rhenoster bush, which is much in evidence in the north-western portion of the Uniondale Division, disappears completely, and the Ganna bush of the Karroo is frequently to be seen. It is generally believed that where the rhenoster bush flourishes lime is deficient in the soil, while the Ganna, on the other hand, indicates a lime soil: as will appear from the sequel, the analyses of the Uniondale and Oudtshoorn soils tend to give confirmation to this popular idea. Of such a soil, where the Ganna bush grows, a sample, No. 1 in the above list, was taken on the farm Vlakte Plaats. Further west, on the adjoining farm Kruis Rivier, a change in the character of the flora would seem to be indicative of a corresponding change in the nature of the soil; the ganna thins out, in fact dies away practically altogether, and the rhenoster bush reappears; but as one approaches the town of Oudtshoorn the soil again becomes more akin to that of the Karroo, and sandier than is the case further east. Of this last class of soil, two samples, Nos. 3 and 4, were taken at Hazenjacht, 13 miles from Oudtshoorn (this soil, by the way, proves chemically rather poor—for an Oudtshoorn soil), and Schiedam, two miles from Oudtshoorn, respectively, while one collected at Riet Vallei, No. 2 (14½ miles W.S.W. of Vlakte Plaats, and 4 miles north-east of Hazenjacht), was more of the nature of an alluvial or "vlei" soil.

Underlying the surface soil throughout the Olifants River valley, at times appearing on the surface, but generally within from four to eighteen inches thereof, is a very stiff red clay, here and there showing bands of limestone. This clay has the local reputation of being the cause of the great fertility of the Division,* and a sample of it was taken (No. 5) from Mr. E. T. L. Edmeades' property, just outside the town of Oudtshoorn. From the level tract of country south-west of Oudtshoorn, sample No. 7,

* It is, of course, river alluvium, originally brought down from the Karoo.



PRINCE ALBERT
GROOT ZWARTBERG RANGE
Table Mountain Series
CANGO EAST
CANGO WEST
Cango
Beds
MATJES RIVIER 17
WELGE-VONDEN 16
LEMRICK 15
LOWER OLIFANTS RIVER
VLAKTE PLAATS 1,18-19
KRUIS RIVIER
Roode Krans Poort
Bokkeveld series
Table Mt. series
GROBBELAARS RIVER
HAZEN-JACHT 3
RIET VALLEI 2
RAILWAY
OUDTSHOORN
SCHIEDAM 4
5
Uitenhage Series
WYNANDS RIVER
BLAAUW BUSCH KUIL 7
WEL BEDACHT 8
OLIFANTS RIVER
BUFFELS VALLEI 14
CALITZDORP 18
GAMKA
GAMKA R.
13
JAN FOURIE'S KRAAL 12
WELGERUST
FLATS
KOOIT GEDACHT 9
Bokkeveld Series
GAMTOOS BERG 6
HOTTENTOTS LAAGTE 10
SAFFRAAN RIVIER 11
ATTAQUAS KLOOF
GOURITS R.
POGHA HILLS
Table Mtn. Series
ATTAQUAS MOUNTAINS
MOSSEL BAY
GEORGE
UNIONDALE
LADISMITH
DIVISIONAL MAP OF
OUDTSHOORN

a fine loose clay soil, was taken on the farm Blauwboschkuil, at a distance of five miles from the town. About $6\frac{3}{4}$ miles further on in the same direction, on the farm Nooitgedacht, a similar sample, No. 9, was collected; that taken at Saffraan River, No. 11, 10 miles from Nooitgedacht, was sandier,—being largely derived from the sandstone of the Attaqua Mountains,—and, as one may expect under such circumstances, a rather poor soil. There are abundant evidences of limestone all over the extent of country traversed between Oudtshoorn and Saffraan River: No. 10, taken six miles E.N.E. of Saffraan River, on the way back to Oudtshoorn, is a very shallow, fine, clay soil, similar in character to those just alluded to; No. 6 being another similar soil of greater depth, collected at a distance of about 11 miles south of Oudtshoorn. These two soils, Nos. 6 and 10, were taken from hill sides. From the extent of country stretching northwards from the town of Oudtshoorn to Cango no samples were taken. The river bed is here practically the only cultivated portion, and every available part of that is under actual cultivation, so that virgin soil was unobtainable; as for the "veld," employing the term in a sense inclusive of hill slopes,—except close to the town, in the vicinity of which samples had already been secured, it is very stony, and covered with prickly pear, while farther north the hills are so steep and rocky as to debar cultivation, except along the river side.

Along the Olifants River, west of Oudtshoorn, two samples were taken, Nos. 8 and 12, light sandy clays, the former from the farm Welbedacht, $11\frac{3}{4}$ miles from Oudtshoorn, the latter at Jan Fouries Kraal, 21 miles from Oudtshoorn, and $11\frac{1}{2}$ miles south-east of Calitzdorp. Sample 13, taken from the farm Welgerust, is representative of the area known as the Gamka Flats, which extend south of the village of Calitzdorp; the predominating feature in the vegetation of this area is what is generally known to Karro· farmers as the Kouwgoed *(Augea capensis).* On the higher level, north of this region, and subjacent to the low mountain range which extends eastwards to the north of Calitzdorp, the spekboom *(Portulacaria afra)* grows luxuriantly over a space stretching about four miles east. Just beyond this area sample No. 14 was collected. A red sand soil, No. 15, was taken in Coetzee's Poort, at the base of the conglomerate hills flanking the southern portion of that pass. Further north the Karroo bushes disappear completely, and the rhenoster covers the entire veld; the loose limestone too, so abundantly scattered about the ground near Calitzdorp, is no longer to be seen, but instead there are numerous fragments of quartz: naturally a corresponding alteration in the character of the soil, both physically and chemically, is to be expected. Of the new type of soil, a sample, No. 16, was taken on the farm Welgevonden, near the top of a small hill north-east of the homestead. Further east, on the farms Voorbedacht and Matjes River, the limestone reappears in abundance, and to the change in the nature of the soil which this involves is doubtless due the reputed suitability of the latter for tobacco culture. A sample of this soil, No. 17, was taken from a gently sloping hillside, south of, and overlooking, the cultivated lands on that farm.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
18.	Lower Olifants River.	Vlakte Plaats.	J. W. Louw.
19.	,,	,,	,,

On the farm Vlakte Plaats, already mentioned as the place where sample No. 1 had been collected, two additional samples, Nos. 18 and 19, were procured through the agency of Mr. J. W. Louw. No. 18 was taken from the valleys amongst the mountains, and it is therefore probable that disintegrated Table Mountain sandstone enters largely into its composition: as a virgin soil it is declared to be very rich, and capable of producing magnificent tubers, but after some years of cultivation there is a marked decrease in its productiveness. No. 19 is a virgin Karroo type of soil, very good for most crops excepting potatoes.

The analyses of the above nineteen soils will be found tabulated below:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	89·5	2·06	6·25	·0035	·168	1·170	·299	·150
18.	77·5	·97	2·27	·0071	·084	·104	·080	·037
19.	96·1	2·26	7·82	·0170	·252	·828	·211	·101
2.	56·0	·65	1·85	·0035	·084	·154	·100	·074
3.	65·0	·33	·85	·0134	·070	·056	·071	·054
4.	83·7	1·10	2·65	·0035	·098	·170	·096	·049
5.	69·9	3·73	4·33	·0113	·070	·100	·149	·058
6.	78·7	1·21	4·34	·0612	·140	·098	·165	·123
7.	91·5	1·97	4·31	·0272	·112	·530	·211	·134
8.	91·0	·87	2·50	·0191	·084	·606	·144	·124
9.	93·2	1·88	4·53	·3919	·098	·958	·141	·139
10.	68·6	2·39	6·41	·0413	·182	·206	·201	·119
11.	76·3	·40	1·89	·0212	·112	·074	·035	·040
12.	95·9	·84	2·36	·0081	·112	·172	·161	·063
13.	91·1	1·57	2·65	·0026	·077	·170	·170	·063
14.	81·9	·44	1·64	·0216	·091	·046	·098	·049
15.	58·6	1·11	3·68	·0046	·126	·068	·194	·123
16.	76·0	1·90	5·10	·0035	·182	·084	·144	·067
17.	61·6	3·15	17·14*	·0092	·350	7·460	·087	·166

One cause of the superiority of the Oudtshoorn soils to those of the surrounding Divisions stands revealed immediately upon comparison of the chemical results: in the former, lime, potash, and phosphoric oxide are all present in much larger quantities than in the soils of other areas. The fertility of the soil does not terminate with the boundaries of the Oudtshoorn Division, but is also clearly traceable in the soils of the Buffels Klip Field-cornetcy, in the neighbouring division of Uniondale. The transition, nevertheless, becomes very striking when passing from the latter division, the moment that the Oudtshoorn boundary is crossed.

It is, of course, lime that is chiefly abundant in the Oudtshoorn area, and gives their distinctive character to the alluvial calcareous loams of this division and the adjacent division of Ladismith, but the fertility is not to be ascribed to the lime alone, for both potash and phosphoric oxide are present in satisfactory amount. This is due to the fact that the soils of the Oudtshoorn basin are largely the result of ages of deposition of river silts brought down from the Karroo by the Gamka and Olifants Rivers, and are therefore made up of the finely divided products of decomposition of the rocks of the Karroo system: thus they are, both physically and chemically, excellently adapted for the agricultural purposes that they are known to serve so well. Strange as it may appear, nitrogenous material is rather less prominent in this fruitful district than, for instance, in the

* This includes carbon dioxide combined as calcium carbonate.

neighbouring divisions of George, Knysna, and Uniondale,—a clear evidence that the soil can do with less nitrogen than, say, the Knysna soils provide, if only the deficiencies in other respects be made up. A remark of Prof. Hilgard may here be quoted as bearing directly on this point; he says:* (and the italics are in the original):—"In general, we find that *lower percentages of potash, phosphoric acid, and nitrogen are adequate, when a large proportion of lime carbonate is present.*"

The stiff red clay about the town of Oudtshoorn has potash as its distinguishing characteristic: possibly the virtue of this clay lies herein, that on mixture with surface soils already containing lime, and perhaps phosphates, in adequate amount the addition of potash fulfils the one need. Samples 7 and 9, which contain good proportions of all the elements of fertility, exemplify the causes of productiveness in the soils of this division.

The soils taken in the north-western part of the division are apparently less fertile, lying, as they do, under the shadow of the great sandstone range of the Zwartbergs, and in respect of both lime and phosphoric oxide they show a diminution; but on approaching the Zwartberg Pass, near which, it must be remembered, the limestone caves of the Cango district are situated, the amount of lime in the soil naturally increases enormously.

On the whole it may be said that the soils of the Oudtshoorn Division show good quantities of lime and nitrogen, and are also satisfactory as regards potash and phosphates.

PAARL.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	French Hoek.	Keerweder.	St. C. O. Sinclair.
2.	"	"	"
3.	"	La Dauphine.	"
4.	"	Cabriere.	"
5.	"	La terre de Luque.	"
6.	"	"	"
7.	"	Zand Drift.	"
8.	Groot Drakenstein.	Le Plaisir Merle.	"
9.	"	Bossen Dal.	"
10.	"	Babylons Toren.	"
11.	Achter de Paarl.	Matjes Kuil.	"
12.	"	Groenfontein.	"
13.	"	Kuilenberg.	"
14.	"	"	"
15.	"	Brandenburg.	"
16.	Paardeberg.	Lange Rug.	"
17.	"	Knolle Vallei.	"
18.	"	"	"
19	North Paarl.	Vrede Hof.	"
20.	Wellington.	Blauwvallei.	"
21.	"	"	"
22.	"	Welbedacht.	"
23.	"	"	"
24.	"	"	"
25.	Wagenmakers Vallei.	Hexenberg.	"

* Hilgard: "Soils: their formation, properties, composition, and relations to climate and plant growth." p. 354.

No.	Field Cornetcy.	Farm or place.	Collector.
26.	Wagenmakers Vallei.	Hexenberg.	St. C. O. Sinclair.
27.	,,	Drie Fonteinen.	,,
28.	,,	Vruchtbaar.	C. F. Juritz.
29.	,,	,,	,,
30.	,,	Groenberg.	,,
31.	,,	,,	,,
32.	,,	,,	,,
33.	,,	,,	,,
34.	,,	Openhorst.	,,
35.	,,	Groenfontein.	,,
36.	Groene Berg.	Burgers Drift.	St. C. O. Sinclair.
37.	,,	Dryvers Vallei.	,,
38.	,,	Lang Hoogte.	,,

Seven samples were collected in the French Hoek Field-cornetcy. The soil of this region falls into two classes—the first is what is locally known as the "grauw grond," from the hillsides,—a yellow soil, consistting of clay with quartz pebbles and stones; and, secondly, a black alluvial soil from the lowest parts of the valley. It had been expected that the composition of the soils would be found to vary fairly considerably, owing to the diverse nature of the rocks occurring in this district; generally, however, the soil may be regarded as the product of rocks of the Malmesbury series, Table Mountain sandstone, and granite. The Field-cornetcy is practically encircled by sandstone mountains, a condition which one finds reflected in the poor proportions of plant food in its soils.*

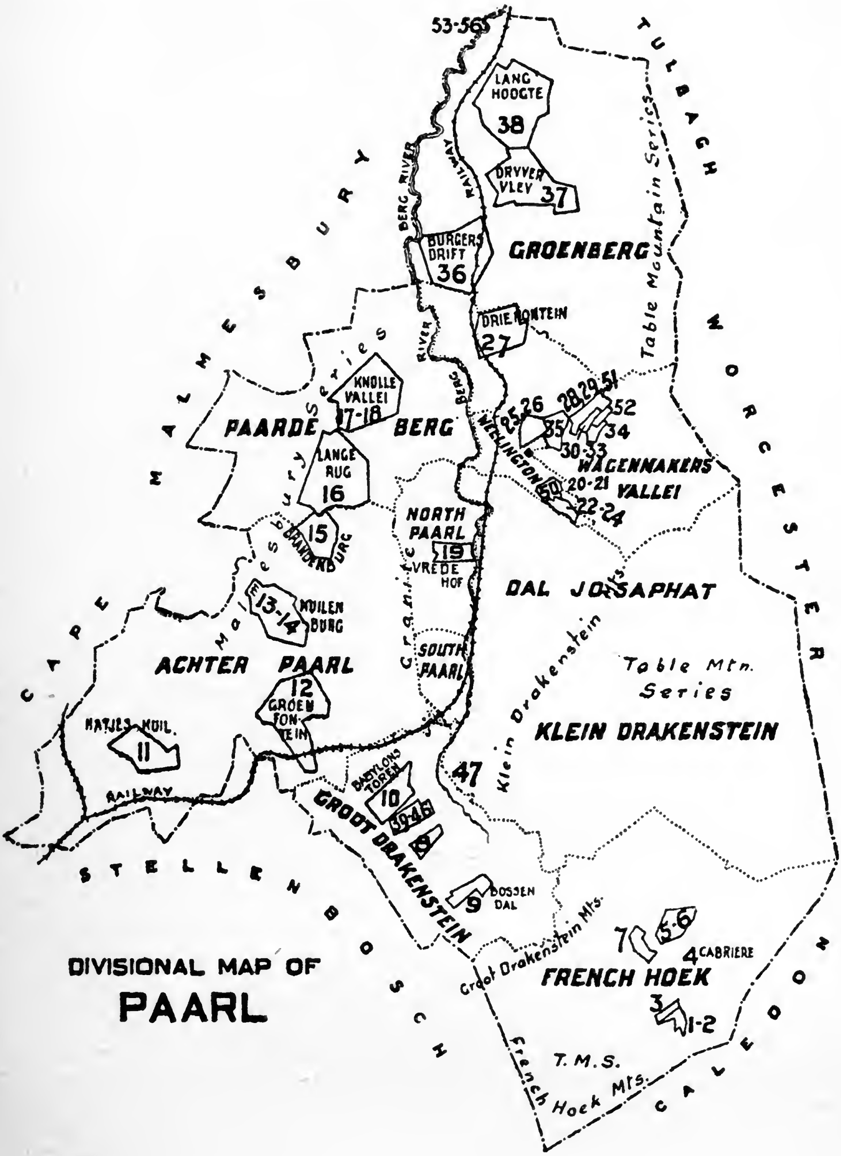
Nos. 1 and 6 are hillside soils; Nos. 2, 3, 4, 5, and 7 are alluvial soils from the valley. No. 1 was taken from Mr. G. Kriel's farm adjoining Keerweder: the soil, which is very poor, is gravelly in texture. No. 2 represents a black alluvial soil taken from the same farm. The land typified by the sample is planted with vines. No. 3, a similar soil, is representative of that of the farm La Dauphine. Sample No. 4, taken on the farm Cabriere, is similar in character to Nos. 2 and 3, but the effect of the decomposed granite is seen in the larger proportion of potash.† No. 5 was a black soil overlying potclay on the farm La Terre de Luque. No. 6 represents a mixture of surface and subsoil—such as is obtained when the ground is put under cultivation—on La Terre de Luque. The subsoil is a yellow gravel containing much clay and pebbles. Below the depth to which the sample was taken potclay is found. The surface soil in this part is a clay. The soil appears to have a good water capacity, and the vegetation thereon is reported to withstand the effects of drought to a greater extent than is the case with the "grauw grond," which is the ordinary hillside soil. Of this "grauw grond" No. 1, as already stated, may be taken as representative. No. 7 represents a black soil lying close to the river on the farm Zand Drift, and may be regarded as typical of the lands along the river.

The remarks made in connection with the origin of the soil in the French Hoek Field-cornetcy apply also largely to the Field-cornetcy of Groot Drakenstein: sandstone, however, does not predominate to the same extent, its place being taken by granite. No. 8 represents a black valley soil from the farm Le Plaisir Merle. The soils along the Dwars River are represented by No. 9 from the farm Bossen Dal. No. 10 represents a hill side soil, which was collected on the farm Babylons Toren.

*It will be remembered that in connection with the Caledon Division soils a similar condition was observed to exist. (See p. 38).

† Compare also No. 9 of the Mossel Bay soils, page 93.

In the Achter de Paarl Field-cornetcy five samples were taken. No. 11, from Matjes Kuil, is a sandy soil containing a little clay, and overlying a gravel. When manured with stable and kraal manure, wheat, rye, and oats appear to thrive well. On going westwards the soil becomes



more and more sandy. Nos. 13 and 14 furnish examples respectively of the "hillock" and low-lying soils already mentioned in connection with the Malmesbury Division. The occurrence of these little hillocks—"heuveltjes," as they are vernacularly termed—has been remarked, not only in the Malmesbury and Paarl Divisions, but also in other parts of the South-Western Districts of the Colony. The soil of such hillocks has usually been found to be richer than the soil round about. Whilst the rhenosterbosch, a bush more or less typical of rather poor soils of the Cape Peninsula,* is found all *around* these hillocks, *on* the hillocks themselves we find the "distel doorn," which generally seeks the richer soil. No. 15, from Brandenburg, represents the soil north of Kuilenberg. When properly treated it appears, from all accounts, to yield very satisfactory results. "Lamziekte" is unknown on the farm, and on the pasturage goats thrive well. This, it was thought, would seem to be evidence of the presence of lime or phosphates in the soil in sufficient quantity, and, curiously enough, the proportion of phosphates found—higher than in almost any of the other soils from this division—confirmed anticipations in this respect. The geological formation of this area is that of the Malmesbury series.

In the area represented by the Paardeberg Field Cornetcy, a similar geological formation prevails. Three samples were taken as typical of the soils of this portion of the Paarl Division; of these, Nos. 17 and 18 represent the hillock and lower soil respectively at Knolle Vallei. It has been found that barley grown on these hillocks withstands the attacks of rust to a much greater extent than the barley on the surrounding soil. No. 18 is somewhat more sandy, and appears generally poorer than No. 17.

In the Field Cornetcy North Paarl, sample No. 19, taken on the farm Vrede Hof, is a type of the soil at the foot of the Paarl Mountain. Here the intrusive granite, which constitutes the Paarl Mountain, will, if sufficiently decomposed, bring about a change in the composition of the soil.

No. 20 is a type of hillside soil from the farm of Mr. Stucki, part of Reebok Kloof at Blauwvallei, in the Wellington Field Cornetcy, No. 21, taken from underneath the oaks on the farm, resembles in colour the black soil known in the district as "turf." It is, however, a coarser soil, and contains more lime than any other of the samples taken in the same district. This soil was designated by Mr. Stucki as "vet heuvel grond." No. 22 represents what is known locally as "turf" or "zwart grond"; the sample was taken from the side of a poplar plantation on the farm Welbedacht, belonging to Mr. W. P. van der Merwe. It was somewhat mixed with sand. No. 23 was a sample of what is called "doode turf" from the vineyard adjoining the homestead on the same farm. This "doode turf," which exists in patches about the vineyard, appears to be less fertile than the soil around it. This must evidently be ascribed to physical causes, rather than to difference of chemical composition. The soil is stiff and compact, and more clayey than that represented by the previous sample. It would naturally, therefore, hold more water, and so become cold in spite of its warm black colour. It will be noticed that the sample contained more than three times as much water as No. 22. There would seem to be some similarity here to the cause of the trouble in the vineyards of the Graaff-Reinet Division, already alluded to.† No. 24 was a sample of stiff black soil from the edge of a plot of ground which, with suitable manipulation (such as an admixture of gravel from the hill-sides, etc.) and manure, had borne sweet potatoes for upwards of forty years. It was found to overlie a subsoil of gravel. The soil represented by this sample is locally known as "Blauw pot clay."

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* See pages 56, 68, and 96.

† See page 61.

No. 25 was a sample of clayey soil, taken from the farm Hexenberg, in the Wagenmakers Vallei Field Cornetcy; a small portion of the surrounding land was at the time being used as a brickfield, but it was the intention to put it all under cultivation. The sample was stated to be similar to soil found on the contiguous portion of the adjoining farm of Mr. G. J. Hugo. No. 26 represents a stiff black soil a short distance in front of the homestead on the same farm.

Going northwards from Wellington, No. 27 was taken from the farm Drie Fontein. This soil, which is described as a cool soil, overlies a clay subsoil. Vines do well on it, and do not appear to languish as when grown on black "turf" (alluvial) soil. No. 28 was a sample of hillside soil, planted with an apricot orchard of 2,000 trees, on the farm Vruchtbaar, owned by Mr. C. P. Cillie. This sample was reported to be typical of the soil in the N.N.E. portion of the Wagenmakers Vallei Field Cornetcy. No. 29 was taken from the edge of the orchard near the homestead of Vruchtbaar. It consists of the fine clay washed out of the soil represented by No. 31. From a *chemical* point of view, it is, on the whole, the best of the soils collected in this district. It consists almost entirely of clay, the organic matter present being due to incidental dropping of leaves, etc. As a set off against the chemical qualities of this soil, it must be mentioned that, owing to its clayey nature, it is apt to retain large quantities of water, which tend to render the soil cold; and the light colour will have a similar tendency.

No. 30 was a sample of soil prevailing on the farm Groenberg, also belonging to Mr. Cillie; the sample was taken from the side of a watercourse on the hill slope. No. 31 was taken from the bottom of the same water course. The soil represented, when treated with stable manure, was said to answer for vines, but not for fruit trees. This fact is probably accounted for by the deficiency of lime, shown by the chemical analysis, not being corrected by the manure applied. Soil similar to the sample was said to occur in fairly large quantities throughout the district. No. 32, also a sample of the soil found on the farm Groenberg, was taken from the vineyard some distance above the spot where the preceding sample was collected. No. 33 was taken from one of the little hillocks locally called "heuveltjes," occurring in the same vineyard as No. 32. These hillocks, of which many are to be found in the Wellington district, have, as has already been stated, the local reputation of being more fertile than the surrounding ground. On comparing the results of the analyses of these two samples, it will be seen that No. 33 is considerably the richer in lime and potash, whilst the amount of phosphoric oxide is practically the same in both cases. The amount of nitrogen and of organic matter in No. 33 is also greater than in No. 32. The texture of the two samples. as far as shown by the mechanical analyses, is, for all practical purposes, the same, No. 33 being *very slightly* coarser.

Proceeding from the Kromme Rivier towards Blauwvallei, the soil is said to become more and more clayey; this is borne out by the mechanical analyses.

No. 34 was a sample from a part of the farm Openhorst that had been last sown with oats. No. 35 represents a somewhat similar soil on the farm Groenfontein; in this case too the portion of the farm whence the sample was taken had been sown with oats.

The soil of Burgers Drift in the Groene Berg Field Cornetcy was sampled in No. 36, taken from a portion of the farm occupied by Mr. Malan. In dry seasons the plants on this soil are parched. No. 37 was taken from Mr. J. Cillie's farm Dryvers Vallei, and represents his corn lands. No. 38 was a sample of what is locally known as "klippertjes grond," taken on the farm Lang Hoogte. The sample is a type of the poorest lands on the farm. The oats grown in the districts, from which samples 20 to 38 were collected, had suffered severely from rust. Wheat had not yet been appreciably affected, although signs were not wanting to show that the disease had made its appearance. Barley had not been attacked.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
39.	Groot Drakenstein.	Donkerhoek.	R. D. Koch.
40.	,,	,,	,,
41.	,,	,,	,,
42.	,,	,,	,,
43.	,,	,,	,,
44.	,,	,,	,,
45.	,,	,,	,,
46.	,,	,,	,,
47.	Klein Drakenstein.	—	D. G. Cillie.
48.	,,	—	C. Mayer.
49.	,,	—	,,
50.	Wellington.	Reeboks Kloof.	,,
51.	Wagenmakers Vallei.	Vruchtbaar.	,,
52.	,,	Twyfeling.	,,
53.	Groeneberg.	Kilkerran.	J. W. Mason.
54.	,,	,,	,,
55.	,,	,,	,,
56.	,,	,,	,,

Eight samples of soil were collected on the farm Donkerhoek from the orchards of the Donkerhoek Fruit Syndicate. Of these, Nos. 39, 40 and 41 were collected previous to the orchard being manured. Nos. 39 and 40 were clayey soils, and No. 41 a sand. Nos. 42, 43, and 44 represent the same soils after manuring and five years of cultivation. Nos. 45 and 46 were respectively a surface soil and a subsoil, also collected on the farm Donkerhoek, and taken to a depth of thirty inches; these two are typical of the veld soil which constitutes two-thirds of the district. They both represent cool gravelly sands, with a substratum of ironstone. The local opinion was that they were decidedly poor; in fact, farmers in former years used to consider this type of soil quite unfit for cultivation; since then, however, vines have been planted there. It may be said that agriculturists find the best soils of the district to lie along the river, and in the mountain kloofs; these soils are of limited extent.

On the eastern bank of the Berg River, in the Klein Drakenstein Field Cornetcy, opposite Simondium, a mixed sample of sandy soil, No. 47, was collected. This sample was taken from the surface to a depth of 10 to 15 inches, at four different spots, and a mixture made. The soil in the vicinity is composed of river drift sand to a depth of four feet; below this lies a good black loamy subsoil. The surface soil is naturally poor, but does not represent all the soil in the neighbourhood—least of all Simondium, where, according to local opinion, the soil is as good as any in the Western Province for vines and fruit trees.

Nos. 48 to 52 were samples of vineyard soil. Of these No. 51 had not been manured for four years; the lands whence Nos. 50 and 52 were taken had both received "kraal manure" a year before the collection of the samples.

Four samples—Nos. 53 to 56—were taken at Kilkerran farm, Hermon. No. 53 was a dark soil from a "heuvel" or hillock, on land adjacent to the Berg River, 20 to 30 feet above the river bed, and about three miles north of Hermon; Mr. Mason's experience was that these hillocks, which consist of dark rich looking soil, are exceedingly fertile. No. 54 was a shade lighter in colour, and was collected from the level ground in the immediate vicinity of the preceding sample. No. 55 represents a red subsoil from the same locality, and No. 56 was taken from the grain lands, at some distance from the river. The soil by the riverside is a clayey loam, with a red subsoil of great depth; the rhenoster bush grows luxuriantly on this land if left to itself; it ploughs freely, when sufficiently moist, but the surface sets hard after rain, from the amount of silt and clay present. Both this soil, as well as the grain soil from which No. 56 was collected, vary considerably within short distance in regard to their mechanical condition; the latter is very shallow in parts, with a subsoil ranging from shale to yellow clay. Mr. Mason declared that these soils were all found to require manuring in order to ensure productiveness, and in this respect his experience quite confirms the results of the chemical analyses.

The analytical results are shown in the following tables:—

(Method I.)

No.	Percent of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	77·9	2·16	7·57	·0092	·146	·010	·039	·042
2.	70·4	1·40	4·27	·0102	·116	·042	·087	·042
3.	57·8	·81	2·55	·0081	·088	·008	·013	·038
4.	84·5	1·89	4·80	·0265	·116	·016	·124	·037
5.	65·1	·97	2·78	·0067	·081	·008	·013	·022
6.	56·9	1·56	4·77	·0106	·088	·006	·015	·017
7.	86·3	1·41	3·85	·0127	·116	·058	·019	·038
8.	68·4	·99	3·45	·0035	·116	·020	·021	·073
9.	95·1	3·79	9·96	·0184	·174	·008	·033	·098
10.	59·8	·31	1·17	·0092	·029	·040	·014	·020
42.	70·3	2·19	6·32	·0057	·102	·096	·026	·082
43.	80·3	2·22	6·01	·0240	·059	·048	·019	·036
44.	36·9	·61	2·52	·0046	·088	·184	·040	·064
45.	59·1	—	—	—	—	·020	·023	·019
46.	63·9	—	—	—	—	·010	·017	·047
47.	69·3	·41	2·06	·005	·070	·060	·013	·115
11.	51·0	·29	1·29	·0071	·038	·024	·010	·017
12.	81·2	·67	2·65	·0212	·095	·012	·029	·027
13.	53·6	1·13	5·23	·0127	·116	·072	·045	·061
14.	55·1	1·72	6·41	·0212	·160	·100	·073	·055
15.	81·7	1·30	6·59	·0081	·116	·014	·091	·115
16.	65·3	1·11	5·22	·0109	·088	·034	·041	·046
17.	79·6	1·72	7·39	·0170	·153	·098	·044	·056
18.	68·7	·32	1·77	·0149	·052	·012	·013	·010
19.	61·5	·87	3·69	·0060	·066	·034	·014	·055
20.	37·0	·41	4·02	·0049	·294	·063	·072	·059

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
21.	57·2	1·24	7·33	·0059	·025	·380	·056	·097
22.	69·0	·60	4·23	·006	·017	·053	·056	·008
23.	88·6	2·20	12·29	·0064	·003	·024	·064	·159
24.	99·3	1·79	12·15	·0106	·011	·138	·075	·072
25.	77·8	1·16	5·93	·0141	·011	·027	·064	·102
26.	70·2	·58	3·69	·0081	·045	·099	·056	·077
50.	77·0	1·80	5·77	·0049	·108	·016	·043	·051
27.	50·6	·52	1·23	·0216	·073	·022	·048	·019
28.	46·8	·51	3·52	·0085	·025	·026	·032	·051
29.	95·0	·83	8·46	·0078	·003	·096	·194	·082
51.	90·4	1·92	5·22	·0049	·115	·138	·152	·070
52.	45·3	2·92	7·49	·0049	·101	·038	·446	·107
30.	47·6	·46	5·07	·0085	·006	·036	·354	·036
31.	21·0	·36	4·17	·0103	·009	·020	·203	·095
32.	66·2	·76	5·11	·006	·003	·037	·084	·077
33.	65·6	·76	5·57	·0255	·006	·064	·171	·074
34.	8·6	·39	3·93	·0042	·011	·028	·042	·125
35.	19·5	·28	2·41	·0049	·006	·103	·059	·067
36.	60·3	1·20	4·07	·1620	·073	·026	·075	·054
37.	51·8	1·48	4·87	·0088	·139	·014	·039	·055
38.	55·8	·63	2·33	·0071	·059	·010	·042	·027
53.	92·4	·79	2·73	·0106	·059	·020	·035	·029
54.	91·6	·57	2·11	·0120	·043	·016	·033	·027
55.	90·3	·44	1·68	·0145	·036	·010	·026	·038
56.	41·3	1·12	3·65	·0106	·087	·018	·047	·038

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
39.	1·61	5·03	·0031	·168	·201	·032	·041
40.	1·56	4·16	·0032	·140	·108	·023	·010
41.	·49	1·48	·0012	·028	·059	·0095	·009
48.	·52	2·96	·014	—	·143	·182	·006
49.	·17	1·01	—	—	·17	trace	trace

On the whole it may be said that the Paarl soils turn out rather poor in lime, potash, and phosphoric oxide, while the average amount of nitrogen that they contain is about normal. In respect of potash, some parts of the Wagenmakers Vallei Field Cornetcy show up best, and, next to that, part of the district lying to the north-west, especially the Achter de Paarl and Paardeberg Field Cornetcies; at French Hoek, however, the proportions of potash in the soil are very meagre. The largest percentages of nitrogen are contained in the soils of South-western Paarl, that is to say, in the Field Cornetcies of French Hoek, Groot Drakenstein, and Achter de Paarl; in the rest of the division nitrogen is present in the soil in moderate amount.

PIQUETBERG.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Piquetberg.	De Tuin.	G. H. Dunn.
2.	„	Moutons Vlei.	Dr. Simon.

A sample of soil where vines and fruit trees flourish was collected on the farm De Tuin, once part of the farm Rietfontein, now commonly known as De Hoek, and adjoining Wittewater. The soil in this neighbourhood varies considerably, but the sample under notice is typical of the slopes immediately below the mountain; it is of considerable depth, in fact sluits nearly twenty feet deep show no change all the way down. This soil differs from that on the lower levels, such as the Piquetberg Karroo, which, however, outwardly resembles it, but differs from it in being somewhat gravelly, containing ironstone pebbles.

No. 2 is a type of the soil used for the cultivation of tobacco on the farm Moutons Vlei, one of the tobacco farms of the north-western districts.

The analyses of these two soils are given below:—

(Method I.)

No.	Percent. of Field Sample.	Percentage of Soil sifted through through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide
1.	72·4	1·47	3·80	·008	·140	·064	·103	·068

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
2.	·72	7·49	·014	—	·40	·11	·061

PORT ST. JOHN'S.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	——	Isinuka.	H. H. Davison.

A sample of alluvial soil—excluding that upon the immediate surface—was collected upon the banks of the St. John's River; the soil at this spot had been used for mealies, and it was intended to apply it to the cultivation of tobacco.

The analysis of this sample resulted as shown below:—*

(Method I.)

No.	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	97·2	2·73	16·5	·015	·24	·52	·171	·137

* Results of a partial mechanical analysis of this soil will be found under the head of "Physical composition of soils."

This soil apparently contains a good quantity of lime and a satisfactory proportion of potash and phosphates.

PRIESKA.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Stuurman.	Zeekoebaard.	J. G. Rose.
2.	,,	Stofkraal.	,,
3.	,,	Keuken Draai.	,,
4.	,,	,,	,,

No. 1 was a sample of the silt carried down by the Orange River while in flood, and deposited by the river when receding within normal limits after overflowing its banks. The sample was collected from the river bed, near the Buchuberg Irrigation works, at the western boundary of the Government farm Zeekoebaard. The river was very low at the time, and the silt was only slightly moist. It subsequently dried as hard as a brick, without being exposed either to solar or artificial heat. Wherever the flow of the river is sufficiently slow, this mud is deposited, sometimes to the depth of many feet. Local farmers consider it to be extremely fertile, but, owing to its hard compact condition when dry, it is capable of employment for agricultural purposes only when mixed with sand or loose soil. If a water-furrow be made of stones closely packed, and the interstices of the latter be filled with this silt, the furrow is said to become perfectly water-tight, so that the adhesive properties of the silt are considerable.

Large tracts of country are covered by the blown sands of the Kalahari, and along the river banks a continual intermingling of the alternating blown sands and river silts is in progress. Of these mixtures Nos. 2, 3, and 4 are samples; they were taken from the centre of each of the large tracts of irrigable land, No. 2 from the farm Stofkraal, 11¼ miles down the river from the irrigation works, Nos. 3 and 4 from the farm Keuken Draai, at distances respectively 14 and 16 miles from the works.

The results of the chemical analyses* of these samples are as follows:

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	100	5·99	14·81	·004	·099	1·444	·473	·221
2.	99·8	2·83	1·89	·0057	·056	1·055	·056	·081
3.	99·9	4·62	5·05	·0042	·196	1·344	·164	·141
4.	90·3	3·94	2·85	·0071	·168	1·224	·115	·076

* Mechanical analyses of these and other samples from the same localities will be dealt with under the head of "Physical composition of soils."

The specific gravity of the silt represented by No. 1 is 2·03 on the basis of the dry specimen as above described, so that a cubic foot would weigh about 127 pounds. One acre of land, covered with the silt to a depth of half an inch, and thus receiving a deposit of 1,815 cubic feet, or 115 Cape tons, of the silt, would therefore be enriched to the extent of:

3,314 pounds of lime,
1,086 pounds of potash,
507 pounds of phosphoric oxide.

In round figures, each such acre would receive about one ton and a half of lime, half a ton of potash, and a quarter of a ton of phosphoric oxide. The commercial value of the fertilising constituents, in an available form, added to each acre of land upon which the silt is deposited to half an inch in depth is at least £30; the pecuniary value of these silt deposits, therefore, bears comparison, and very favourable comparison, with the cost of manuring in the ordinary way.

Many other instances may be quoted of lands having acquired fertility by the accretion of similar river-borne silts. It is, for example, largely due to the fact, already commented on,* that its soil has been built up of old alluvial deposits that the Oudtshoorn Division is so fertile; the rich silts and clays brought down from the Karroo by the Olifants and Gamka Rivers have, in great part, contributed to this. It is also common knowledge that these rivers occasionally overflow their banks on their seaward course through the Mossel Bay and Riversdale Divisions, and thus contribute greatly to the fertility of the adjacent farm lands. Furthermore, on certain farms in the Division of Britstown, traversed by a tributary of the Brak River, the practice, when the river comes down in flood, of constructing checks or weirs to control the passage of the water and retain the silt, so as to ensure the deposition of the transported silt on the lands, is said to have resulted in such a continual enrichment of the latter as to render any other mode of fertilising needless. This is scarcely to be wondered at, and so valuable an accretion to the land surely deserves the expenditure of time and trouble in retaining it.

It is, of course, well known—not to confine our examples to South Africa—that this system of silting has been practised in the Nile Valley from ancient times, and sandy soils, comparatively worthless before, have become rich fields, and have remained productive for thousands of years. Another case in point is that of the Rio Grande, the application of 24 inches of water from which adds nearly one quarter of an inch of soil to the field, in the form of river sediment, and supplies every acre with 1,821 pounds of potassium sulphate, 116 pounds of phosphoric oxide, and 107 pounds of nitrogen. With regard to this, King observes:—†

"Four years of irrigation at this rate would add an inch of soil to the field, and 24 years would cover it six inches deep with a sediment containing three times the amount of potash found in the average clay soil, and the same percentage of phosphoric acid, and a high percentage of nitrogen."

QUEENSTOWN.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Gwatyu.	J. Fronemann, junr.	St. C. O. Sinclair.
2.	"	"	"
3.	"	"	"
4.	"	"	"

* See pages 91 and 93.

† "Irrigation and Drainage," 2nd ed., 1902, p. 259.

This division was visited only incidentally, and samples were taken from not more than a single farm, that of Mr. J. Fronemann, junr., lying just across the Kei River, in the Gwatyu Field Cornetcy. The subsoil below the place where No. 1 was taken is of a clayey character. No. 2 represents a dark, loamy, alluvial soil, on a pot-clay subsoil, lying east of the homestead. The land represented is reported to be fertile, oats especially doing well upon it. No. 3 is a similar soil to No. 2, and was collected in the same direction. No. 4 was taken from a dark clayey soil, also lying east of the homestead, but nearer the river bank than either Nos. 2 or 3.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
5.	Whittlesea.	Poplar Grove.	F. Walsh.
6.	,,	,,	,,

Two samples of the soil occurring on the farm Poplar Grove were collected, No. 5 being a red, and No. 6 a black soil.

The following are the results of the analyses of these soils:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	85·0	2·36	4·82	·0060	·098	·346	·191	·041
2.	94·6	1·40	3·26	·0050	·091	·248	·127	·027
3.	96·5	1·80	4·65	·0064	·084	·170	·158	·013
4.	98·9	2·46	6·57	·0067	·126	·354	·209	·051
5.	99·2	1·34	2·68	·0831	·046	·150	·203	·052
6.	98·5	4·41	7·45	·0078	·119	1·762	·215	·084

In this division, as in the adjoining division of Wodehouse, a distinct tendency towards alkalinity is exhibited by certain soils, of which No. 5 in the above list is an instance—note its proportion of chlorine. Practically all the Queenstown soils examined were deficient in phosphates: potash and lime are, generally speaking, present in ample quantities.

RICHMOND.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	East Uitvlugt.	Toonbothasfontein.	C. T. Ackermann.
2.	,,	,,	,,

These two samples were taken from lands which were being used for the cultivation of cereals. On the soil represented by No. 1, wheat was grown, and although the straw produced was satisfactory, the grain was less so, the ears being rather short. The soil from which No. 2 was taken had been found to give much trouble, owing to its tendency to form lumps after ploughing, and when water had been put on to the land once or twice, it became compact and impermeable, and hence difficult to work.

The results of the analyses* are as follows:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide
1.	86·3	1·63	5·12	·0021	·245	1·744	·242	·106
2.	91·1	1·73	4·48	·0190	·231	1·574	·269	·092

The soils represented by both these samples are rich in lime, and are also well supplied with nitrogen and potash; phosphoric oxide is present in fair quantity, so that the defects above referred to have their origin apparently solely in the physical condition of the soil.

RIVERSDALE.

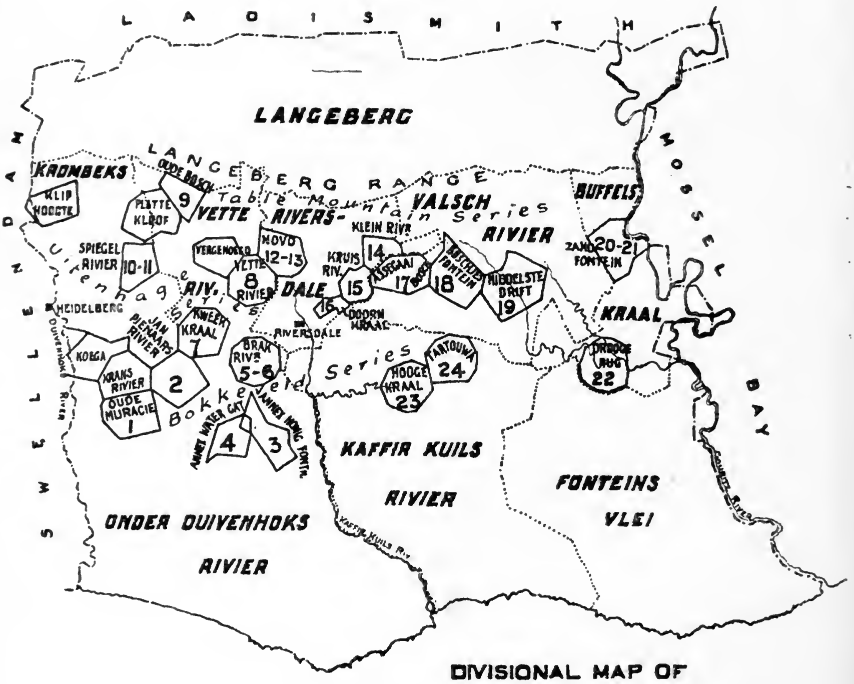
(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Onder Duivenhoks River.	Oude Muragie.	J. Muller.
2.	„	Jan Pienaar's Rivier.	„
3.	„	Honigfontein.	„
4.	„	Water Gat.	„
5.	Vette River.	Brak Rivier.	„
6.	„	„	„
7.	„	Kweek Kraal.	„
8.	„	Vette Rivier.	„
9.	„	Oude Bosch.	„
10.	Krombeks Rivier.	Spiegel Rivier.	„
11.	„	„	„
12.	Riversdale.	Novo.	„
13.	„	„	„
14.	„	Klein Rivier.	„
15.	„	Kruis Rivier.	„
16.	„	Doorn Kraal.	„
17.	Valsch Rivier.	Assegaai Bosch.	„
18.	„	Bosjesfontein.	„
19.	„	Middelste Drift.	„
20.	Buffels Kraal.	Zandfontein.	„
21.	„	„	„
22.	„	Droge Rug.	„
23.	Kaffir Kuils Rivier.	Hooge Kraal.	„
24.	„	Tartouwa.	„

Broadly speaking, this division comprises three distinct belts of country,† clearly recognisable by the agricultural community; they run from east to west, and each possesses a different type of soil. First of all

* For mechanical analyses of these soils see under "Physical composition of soils" (Part VII.). † See page 29.

there is the area generally known as the Berg or Zuurveld, lying to the north of the village of Riversdale, and parallel to the Langeberg Mountains. Little sowing is done, but the soil, derived as it is from the sandstone of the Langeberg Range, needs a good deal of manure, a usual feature with soils of such origin. Secondly, the stretch of country termed the Ruggens; it is the intermediate belt which runs along south of the Zuurveld, and is situated chiefly on the geological formation known as the Bokkeveld series. Within this belt most of the sowing is carried on, and it is here that the best results are obtained. Lastly, to the south of the Ruggens are the sand dunes all along the coast; these dunes are hardly used, if indeed at all, for sowing purposes.



DIVISIONAL MAP OF
RIVERSDALE

Proceeding in a south-easterly direction from the village of Heidelberg, the farm Oude Muragie was first visited, and a loose clay soil, No. 1, was sampled, somewhat similar to the soil of the Ruggens in the Caledon Division. Soil of this nature is also found at Koega and at Krans Rivier. South of this farm are the sand dunes, extensive loose sandy tracts, stretching for miles along the coast line, past the mouth of the Gouritz River, on to Mossel Bay and Brak River, and serving as a splendid pasturage, principally for cattle. As already observed, very little or no sowing is carried on here.

About four miles to the north-east, sample No. 2, a loose clay soil, was taken from the farm Jan Pienaar's Rivier. From this point the nature of the soil varies very much until the farm Brak River is reached, where two samples were selected, No. 5 from the side of a kloof destitute of aloes (which seem to flourish better in the red Karroo soil than in the ordinary Caledon Ruggens or clay soil, and hardly thrive at all on sour veld). The other sample, No. 6, was a dark soil, collected from lands on the opposite side of the homestead, and nearer the main road. From the farm Kweek Kraal sample No. 7 was taken, typical of the poorest lands under cultivation on that farm. Keeping along the right bank of the Kaffir Kuils River, No. 3, a red sandy clay, was taken from the plateau to the south-west of the farm Honigfontein, and a little further west sample No. 4 was taken—a soil very similar in appearance to the one just preceding—from the farm Water Gat, or Zwart Heuvel.

Before crossing the high watershed between Spiegel Rivier and Platte Kloof, two samples were taken from the former place—No. 10, a black loamy garden soil, and No. 11, a loose yellowish clay, which is said to be an excellent soil for sweet potatoes. No. 9, from Oude Bosch, is a soil similar to No. 10, more or less typical of the soil at Kliphoogte, Remhoogte, Vergenoegd, on to Novo, where, however, the veld is not quite so sour. On all four farms tobacco grows fairly well.

From Vette Rivier a loose sandy soil, No. 8, was taken, as well as Nos. 12 and 13 from lands in the valley on the farm Novo. Both of the latter are rather dark sandy soils, differing in shade and fertility, the latter being, it was said, somewhat less productive. Continuing along the right bank of the Kaffir Kuils River, northward towards the mountains, one passes over some very fine farms, and several varieties of soil; typical samples, Nos. 14, 15, and 16, taken from the farms Klein River and Kruis River, and from lands on the hill slopes north of the village of Riversdale, respectively, were selected. No. 17, a loose clay from the farm Assegaai Bosch, taken north-east of the house, resembled the soil from the Caledon Ruggens. This resemblance is also noticeable in the case of the area between the last-mentioned farm and Bosjesfontein, where No. 18, a rather poor soil, was selected. Perhaps one of the largest grain farms in the district is Middelste Drift; No. 19, a rich red Karroo soil, is typical of the lands under cultivation on this farm; no manure whatever is used. The amount of potash yielded by this soil, it may here be remarked, was, with one exception, higher than that of any other soil in the Division. Quite as good a soil, if not more fertile, is sample No. 21, taken from lands on the hills above the level of the Gouritz River bed, while No. 20 is typical of that below in the basin of the river; both these samples were obtained on the farm Zandfontein. No. 20 is apparently largely influenced by the fertile silt carried down from Oudtshoorn and the Karroo by the Gamka and Olifants Rivers, and subsequently by the Gouritz, as noted in connection with the Mossel Bay soils.* At Onverwacht and all farms similarly situated on either side of the river, soil more or less of the nature of No. 21 is found. This almost dark red Karroo soil is extremely productive, and does very well without manure, but, being a very warm soil, crops shrivel up very soon in seasons of drought. There being so much of this good soil available, bright prospects may be awaiting this district as a whole, and more particularly this section thereof, if only the water question, which indeed is the great difficulty, could be solved, either by dam making, or by more extensive irrigation by means of water raised from the Gouritz River on to the fertile plains above. Before the advent of the railway, farmers in this vicinity, having no market within easy reach, nor any means sufficiently remunerative of disposing of their crops, were reluctant to venture on any extensive irrigation schemes. Under such circumstances, more extensive sowing was carried on during dry years all along the less productive slopes of the Langeberg Range, where

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* See page 91.

water was plentiful, even though the comparative poverty of the soil involved the application of much manure in order to secure good results.

Beyond the farm Droge Rug, where sample No. 22 was selected, the country becomes very hilly and rugged; certainly not suited for sowing, it is more adapted for pastoral purposes, especially for goats and sheep. Keeping along the main road to Riversdale, several good farms were passed over—the soil bearing great resemblance to that at Droge Rug—until Hooge Kraal was reached, where No. 23, a very good red "Karroo" soil was collected; a portion of the land represented by this sample was at the time well under cultivation with cereals. At Tartouwa No. 24 was sampled, a very poor soil from old lands lying waste and declared to be unfit for further cultivation. The sample is quite typical of many of the surrounding farms; physically the soil may be defective owing to its coarseness of texture, but chemically its phosphoric oxide is certainly very low, and it yields less nitrogen than any other soil collected within this division.

The results of the analyses of the Riversdale soils are given in the following table:—

(Method III.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	55·2	2·10	5·20	·014	·028	·013	·36	·090
2.	58·8	1·79	4·85	·017	·056	·11	·21	·058
3.	52·4	1·49	2·23	·004	·059	·44	·074	·098
4.	59·6	·82	2·47	·003	·030	·19	·25	·082
5.	65·2	1·73	4·20	·010	·15	·12	·13	·058
6.	69·6	1·14	4·81	·012	·056	·12	·32	·081
7.	59·6	2·66	6·59	·040	·11	·16	·22	·13
8.	87·6	·91	1·66	·0088	·056	·093	·22	·13
9.	83·6	1·66	3·78	·010	·056	·19	·14	·087
10.	82·4	4·27	4·71	·020	·056	·075	·27	·065
11.	77·2	4·35	5·95	·019	·084	·025	·26	·099
12.	88·8	3·32	4·98	·012	·028	·15	·11	·078
13.	77·6	2·05	4·01	·012	·15	·18	·24	·099
14.	84·0	3·63	5·71	·013	·028	·13	·24	·15
15.	77·6	1·13	2·99	·013	·028	·13	·24	·11
16.	72·8	2·08	3·85	·054	·028	·18	·28	·061
17.	68·0	1·88	3·57	·013	·030	·23	·082	·061
18.	75·6	2·69	4·50	·062	·070	·14	·19	·069
19.	85·6	4·05	4·87	·012	·11	·13	·34	·056
20.	82·8	4·27	5·45	·014	·14	·93	·29	·22
21.	93·0	2·58	2·85	·0062	·028	·11	·15	·044
22.	77·2	·96	2·13	·0053	·028	·14	·26	·069
23.	77·8	2·38	4·68	·011	·029	·10	·29	·089
24.	48·4	1·61	4·32	·025	·027	·13	·24	·044

The soils of a large portion of this division,—especially the Field-cornetcies of Onder Duivenhoks River, Valsch Rivier, and Kaffir Kuils River, are for the most part, to judge from the above figures, rather low in phosphates, particularly if used for the cultivation of wheat. In this respect they exhibit the one great want of the clay slate and shale soils, which constitute so extensive an area of the Western Province grain districts.

ROBERTSON.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Achter Cogmans Kloof.	Donkerkloof.	J. Muller.
2.	„	„	„
3.	„	Concordia.	„
4.	„	„	„
5.	„	Harmonie I.	„
6.	„	„	„
7.	„	Harmonie II.	„
8.	„	Het Kruis.	„
9.	„	„	„
10.	„	Baden.	„
11.	„	„	„
12.	Montagu.	Montagu.	„
13.	„	„	„
14.	„	„	„
15.	„	Riet Vallei.	„
16.	„	Het Kruis Pad.	„
17.	„	„	„
18.	Tradouw.	Brakkefontein.	„
19.	Voor Cogmans Kloof.	Riet Vallei.	S. B. Morgenrood.
20.	„	„	„
21.	Robertson.	Government Experiment Station.	E. A. Nobbs.
22.	„	„	„
23.	„	„	„
24.	„	„	„
25.	„	Keur Kloof.	S. B. Morgenrood.
26.	„	Hex River.	„
27.	„	„	„
28.	Middle Bosjesveld.	Vrolykheid.	„
29.	„	Riet Vallei.	„
30.	„	Bosjesmans River.	„
31.	„	„	„

The Robertson Division is more of a viticultural than a grain-producing district. Geologically, the nature of the country is most comprehensive: the chemically poor Table Mountain sandstone is much less in evidence than in the more southerly and westerly divisions of the Colony; on the other hand, especially as one approaches the village of Robertson, not only do granite and Malmesbury slates contribute to the formation of the soil, but the latter is enriched by the cretaceous Enon formation, and diversified by beds of the Ecca, Dwyka, Witteberg, and Bokkeveld series. Naturally then, as one may expect, the soil is frequently very rich, and, with the Breede River and its tributaries not far distant, it is more available for irrigation than is the case in the Swellendam Division, and can therefore the more easily be made to yield good crops.

To commence with the description of the soils collected within the Field Cornetcy of Robertson, four soils, Nos. 21, 22, 23, and 24, were collected by Dr. Nobbs from the Government Experiment Station, which occupies about 61 acres of the Robertson Municipal Commonage. The lands consist of alluvial valley soil, and comprise three somewhat different types. These three types are represented respectively by Nos. 21, 22, and 23. No. 22 is a red-coloured light sandy loam, resting upon a denser, and more clayey subsoil, over twenty feet in depth: this soil has a tendency towards alkalinity in parts, and No. 24, in fact, represents an alkaline patch in the area covered by the soil whereof No. 22 is a type. No. 21 is another red sandy loam of considerable depth, overlying a subsoil similar to that of No. 22. The third type of soil at the station is that whereof No. 23 is a sample. It is a grey calcareous loam, with a subsoil of almost white appearance. In this soil brak water is met with a short distance below the surface. Various parts of the district around possess a "Karroo" type of soil, which inclines to become alkaline, whilst in the direction of the mountains, and along the bānks of the larger rivers, the soil is naturally more "broken." No. 25 represents an intermediate, or transition, "broken" alluvial soil from the farm Keur Kloof, off Lange Vallei, on the mountain side of Robertson. At the time the sample was taken the wheat in this valley was quite six feet high, with full ears. Proceeding up the Vink River valley, No. 26, a sample of "vlei turf" soil, was obtained at the junction of the Norree and Vink Rivers, on the Norree side of the same, and another, No. 27, representing the area of the Upper Vink River. The latter was taken close to the river bed, and could not be expected to be as fertile as the other "Karroo" soil, such as No. 19, for instance. Both No. 26 and No. 27 were procured on the farm Hex River.

No. 19 represents a good "Karroo" soil from the farm Riet Vallei, on the Klaasvoogds River, and No. 20 is what is termed a "doorn" soil from the same area.

Crossing the Breede River towards Lady Grey, one comes upon two similar valleys: the Konings and Keizers River valleys. No. 28 was taken from the latter, on the farm Vrolykheid, while No. 29 is a sour soil from Riet Vallei, representing the upper mountainous regions: its lime content shows a diminution upon those of the other soils of this vicinity. Returning eastwards, No. 31 is a type of alluvial soil from the valley of the Bosjesmans River, where there are a number of small farms, and No. 30 is a primary hill soil, representing the "Ruggens" on the right bank of the Breede River, and to eastward of the Bosjesmans River.

The best cultivated section of the Robertson Division is the southern portion of the Field Cornetcy of Achter Cogmans Kloof, and more especially those areas known as The Coo and The Keisie. In the Coo, from the farm Donkerkloof, two samples were taken: No. 1 from lands on the right bank of the Laats River, and No. 2 not far from the homestead. The "veld" here, as well as at the neighbouring farms Concordia and Keerom,—all of which are situated along the Coos River—is sour, as is frequently the case with a sandstone derived soil. No. 3 was a virgin soil of loose sandy clay, typical of most of the cultivated lands about Concordia, and said to be very suitable for potatoes: chemically it proves to be decidedly poor all round: for potatoes it may possibly be suited on account of its physical, that is to say, its sandy nature, but much manuring, especially with potash, would be needed to maintain potato crops. No. 4, taken from the rise nearer the homestead, is somewhat more clayey, but is at the same time a more gravelly, and, in local opinion, a poorer soil than No. 3. Judging, however, from the analytical results, both are deficient in plant food, and would require to be well manured with a good all-round fertiliser. The last four samples are typical of the Coo, which, notwithstanding external resemblances, differs inherently from the Keisie, a belt of country running along the Keisies River towards Montagu, and bounded on the north by the Riethoek Mountains and on the south by the Langeberg Range. The line of demarcation between the Coo and the Keisie is the high watershed of the Coos Berg, the Coo being several hundred feet higher than the Keisie, and also drier and more

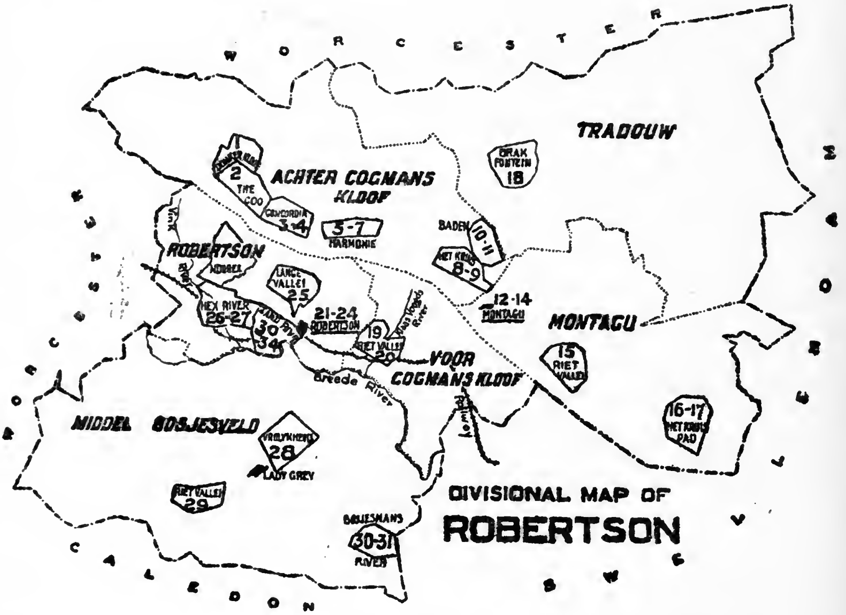
Karroo-like in character. There is more sowing in the Coo than in the Keisie; but, on the other hand, the latter is very picturesque with its many orchards and vineyards on either side of the river. From the results of the chemical analyses it appears that the soils of the Keisie have a richer store of plant food than those of the Coo, especially the more eastern Keisie soils, *i.e.*, towards Baden. The presence of abundance of available lime seems in a great measure to be accountable for the superiority of the Keisie for fruit culture, and it is not improbable that the latter valley has been enriched by alluvium carried down from the higher levels of the Coo. The first farm visited on entering the Keisie was Mr. J. D. Conradie's Harmonie. Here two distinct varieties of soil were sampled; No. 5, a virgin sandy clay, somewhat like a Karroo soil in appearance, commonly known as "gebroken grond" (*i.e.*, broken Karroo) representing the soil of the lands on the slopes, and No. 6, taken from lands on the right bank of the river, rather further from the homestead, and all round a better soil than No. 5, although rather alkaline. It represents a fairly good alluvial soil, not very clayey, but retentive of moisture. It is obvious from the analysis why, of these two soils, No. 6 succeeds better than No. 5; it contains eight times the quantity of lime, and fifty per cent. more phosphoric oxide.

Following the course of the river, the farm of Mr. E. J. van Zyl, Harmonie, was visited, and No. 7, an alluvial soil, was taken close to the river bed: it is said to be richer than the two former, but slightly more brackish: it contains nearly five times as much lime as No. 6, and forty times more than No. 5, and herein it illustrates the adage that "a lime country is a rich country." At the farm Het Kruis No. 8, a sample of "vlei" (*i.e.*, alluvial) soil, was taken near to a vineyard. The owner of the farm, Mr. B. B. Burger, stated that by continued cultivation and irrigation it is rendered alkaline,—a characteristic of many Karroo soils, for by irrigation the surfaces of such clayey soils become quite hard, and, evaporation proceeding very rapidly during warm weather, the water from lower depths raises the alkaline salts—or "brak" as they are locally termed—and deposits them at the soil surface. Hence the necessity in such cases, for efficient drainage and for keeping the surface soil loose. Mr. Burger gives it as his experience that guano is of practically no use to his soil. No. 9, a very finely grained clay soil ,was collected next to vineyards situated at the junction of the Keisies and Keizers Rivers: it was declared to be richer than No. 8, and the explanation may be found in the fact that it contains very much more lime: that it does not become brack on irrigation is most probably due to the fact that the conditions for rapid surface evaporation are less favourable than in the case of No. 8. In that case, the vines being mostly young, and their foliage having been destroyed by frost, protection for the surface of the soil from the rays of the sun is lacking, so that a speedy caking of the surface ensues, and evaporation goes on much more rapidly: as a result, the alkaline salts collect sooner than in a well-drained vineyard where the surface is constantly loosened, and evaporation reduced to a minimum.

From the farm Baden two samples were taken: No. 10, a virgin sample of vineyard soil, and No. 11, a rich clay "turf" of very fine texture, said to be an excellent potato soil. The chemical analysis of this soil certainly confirms the farm-owner's opinion regarding its fertility.

The village of Montagu being known for its luxuriant vines and healthy fruit, typical samples of the soils predominating in and about that village were selected: No. 12, an average sample of a sandy clay soil, was taken from the vineyard of Mr. D. S. du Toit. No. 13, a rather more clayey soil, was taken from Mr. J. F. Burger's garden. In his opinion basic slag gives good results for French grapes in a sandy soil, but not in stiff clay. No. 14 was taken from fallow lands close to the road, on the way to Baden: this was a loose sandy soil, rather poor and requiring good general manuring. No. 15 represents an alluvial soil taken on the farm Riet Vallei. The surrounding "veld" is very sour, and the soil appears to have been thoroughly worked out. All three constituents of mineral plant food—lime, potash, and phosphoric oxide—are very badly needed. At Kruis Pad two samples were taken: No. 16, a loose clay soil, said to give good results with cereals when manured with bird guano, and No. 17, a somewhat similar soil, but found to be more productive, and an excellent soil for potatoes. These views, it may be noted, are not borne out by the analyses.*

From the village of Montagu a north-easterly course was taken: the character of the soil passed over, up to the Wagenbooms Bergen, is very similar to previous samples of "Karroo" soil. On crossing this high



ridge, a distinct change is at once manifest, the "veld" becomes sour, and the soil very much poorer in appearance. A typical sample of this soil is No. 18, collected from the farm Brakkefontein, where very little sowing is done; cattle farming is principally carried on, so that there is an abundance of manure. As the soil in this vicinity is primary sandstone soil, from the Wagenbooms Mountains, it is probable that most samples taken from this locality would show less lime and potash than No. 18, which may possibly have become affected by manuring, a point regarding which there is occasionally much uncertainty.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
32.	Robertson.	Zand Rivier.	Forest Officer.
33.	"	"	"
34.	"	"	"

* Except in so far that No. 17 is rather coarse-grained and therefore more suited for potato culture than fine-grained soils usually are.

These three samples of soil were collected on the Government Forest Plantation, about a mile and a half from Robertson village, and located between the Worcester Road and the Breede River.

The analytical results are recorded in the following tables:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chloiine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	90·1	1·08	6·18	·0212	·175	·064	·126	·061
2.	80·9	·65	4·33	·0057	·098	·032	·180	·068
3.	66·4	·81	3·25	·0035	·084	·030	·027	·036
4.	62·4	·59	2·95	·0057	·084	·013	·060	·045
5.	70·2	·98	4·52	·0028	·112	·016	·147	·050
6.	80·5	1·23	5·41	·0230	·154	·122	·153	·079
7.	83·9	1·07	3·92	·0251	·112	·564	·095	·047
8.	80·8	1·13	4·64	·0095	·098	·114	·250	·120
9.	95·2	1·49	5·71	·0138	·196	·742	·202	·193
10.	49·3	1·93	5·28	·0092	·098	·808	·331	·148
11.	94·7	1·28	6·07	·0085	·168	·600	·247	·139
12.	91·1	·96	4·17	·0170	·098	·260	·242	·096
13.	88·1	1·21	5·47	·0156	·217	·120	·218	·132
14.	70·9	·28	1·54	·0067	·070	·064	·070	·037
15.	60·3	·21	1·21	·0046	·028	·010	·036	·010
16.	71·1	1·20	6·45	·0078	·168	·038	·125	·079
17.	64·7	·90	3·63	·0092	·084	·050	·078	·074
18.	65·0	·38	1·91	·0057	·070	·116	·111	·055
21.	90·4	·97	2·59	·0184	·084	·207	·095	·036
22.	90·0	·95	2·98	·0099	·070	·276	·091	·033
23.	89·2	1·97	4·72	·0248	·154	·461	·179	·042
24.	75·0	2·85	3·35	·5489	·056	·078	·129	·040

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
19.	1·54	2·45	·0071	·077	2·65	·15	·017
20.	1·26	3·64	·014	·11	·89	·070	·0037
25.	1·11	4·51	·014	·11	·72	·14	·011
26.	2·09	7·60	·095	·098	1·20	·12	·083
27.	·38	1·53	·0053	·13	·34	·066	·036
32.	·50	1·15	·0118	·112	·025	·035	·041
33.	1·84	3·16	·0982	·119	·143	·100	·054
34.	2·40	5·27	·1598	·140	1·311	·147	·092
28.	·34	1·94	·023	·077	1·08	·070	·060
29.	1·35	5·01	·014	·14	·13	·10	·021
30.	2·09	6·30	·0088	·16	·79	·32	·051
31.	1·48	4·96	·035	·056	·29	·22	·068

In regard to Nos. 21, 22, 23, and 24, additional extractions of the soil were made, for the purpose of comparing the results, by methods IV. and V., and by pure distilled water: in the soil-extracts obtained by method V. determinations of lime, potash, and phosphoric oxide were made, in those obtained by method IV. lime and potash were determined, and in the aqueous extract determinations of lime alone were performed: the results thus arrived at are appended:—

(Method IV.)

No.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.
21.	·200	·492
22.	·312	·447
23.	·510	·677
24.	·072	·833

(Method V.)

No.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
21.	·213	·025	·0028
22.	·310	·032	·0045
23.	·396	·040	·0069
24.	·072	·021	·0007

(By extraction with water.)

No.	Percentage of Soil sifted through 3 mm. Sieve. Lime.
24.	·0444

The soils of the Robertson Division show an improvement upon those of Caledon, Bredasdorp, and Swellendam in respect of the proportion of phosphatic material contained. The three divisions just mentioned have in their soils an exceedingly meagre reserve of available phosphates: it is, therefore, by no means surprising that farmers in some portions of the Robertson Division complain that they have purchased and applied superphosphates with no marked results; for, in the areas referred to potash was quite as essentially needed, especially in the cultivation of root crops, and this need was in no way supplied by superphosphates alone—an illustration of the applicability of the law of the minimum.

On the basis of the chemical analyses, the western part of the Achter Cogmans Kloof Field-cornetcy is distinctly inferior to that further east, as may easily be verified by comparing the analytical figures of Nos. 1 to 5 with those of Nos. 6 to 11. Nos. 1 to 5 are all poor in lime, Nos. 3 and 4 being also lacking in phosphates; in fact, No. 3 is deficient all round. In the remaining soils of the Field Cornetcy a more satisfactory state of affairs prevails: true, No. 8 is low in its proportion of lime, but this is quite a solitary instance in that part of the district. In the Montagu Field Cornetcy the results of the analyses are lower; Nos. 14, 15, 16, and 17 are all lacking in respect of lime, and No. 14 in phosphates as well, while No. 15 is poor in lime, potash, phosphates, and nitrogen. It is a matter of interest worth noting that, beginning with the western part of Ladismith Division, and travelling eastwards towards Oudtshoorn, there is a manifest upward tendency in the potash content of the soil. Many of the soils of this area would, nevertheless, be the better for a larger proportion of available phosphates, and some, notably Nos. 8, 10, and 12 of the Ladismith soils, are really poor with respect to lime.

ST. MARK'S.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Cofimvaba.	Government Plantation.	St. C. O. Sinclair.
2.	,,	,,	,,
3.	,,	,,	,,
4.	,,	,,	,,

Of these samples, collected from the Government Plantation at Cofimvaba, the first, a black valley soil, was taken from No. III. compartment, Block A. It rests on a reddish subsoil, inclined to be gravelly, and containing a small quantity of ironstone pebbles. The second sample also represents a black valley soil which lies on the same level as the preceding sample, and was taken from Compartment II. of the same block. No. 3, representing the subsoil of No. 2, consists largely of potclay with a small amount of ironstone pebbles. No. 4 is a red soil from Compartment VI., Block B, resting on red micaceous sandstone. The soils of this area are apparently derived from the Burghersdorp beds (Beaufort series) of the Karroo system, and may possibly be influenced as to their composition by the presence of dolerite in some localities: the soils represented by the above samples, however, are not as well supplied with plant food as those, for instance, of the Albert Division.

The analyses resulted as follows:—

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	90·1	1·52	3·08	·0276	·056	·020	·070	·022
2.	87·9	1·61	2·91	·0361	·119	·060	·051	·022
3.	90·1	5·38	4·95	·0439	·119	·141	·155	·033
4.	57·9	1·39	2·69	·0248	·091	·032	·061	·020

The greatest need of these soils seems to be phosphatic material. The three surface soils are likewise deficient in lime, nor are they particularly well supplied with potash. From a chemical point of view the soil represented by sample No. 2 would be considerably improved by bringing its subsoil (of which No. 3 is a specimen) to the surface, and no doubt such a course may be found profitable in many other localities, but to indicate such spots chemical investigation is needed.

SOMERSET EAST.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Somerset.	Sterkwater.	E. A. Nobbs.
2.	,,	,,	,,
3.	Vogel Rivier.	Cranmere.	A. C. MacDonald.

Nos. 1 and 2 were collected on the Cape Government Railway farm Sterkwater: one was taken from newly broken land in the cultivated area, and the second from a very characteristic stretch of "rooi gras" veld. The former of these two had been very frequently cropped, and the result is seen in the chemical analysis which shows it to be somewhat inferior to the other. In both cases the soil lacks lime, and, although in lesser degree, phosphates: nitrogen and potash, however, are present in good quantity.

Sample No. 3 was taken on Mr. G. Palmer's farm Cranmere or Galgenbosch.

The following figures were obtained by analysis:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 m.m Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	99·5	4·34	13·54	·006	·293	·026	·146	·087
2.	99·1	4·21	14·09	·006	·321	·034	·124	·093

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
3	2·81	5·65	·011	—	·68	·31	·01

STELLENBOSCH.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Klapmuts.	Elsenburg.	A. Simons.
2.	,,	,,	,,
3.	,,	,,	A. C. MacDonald.
4.	,,	,,	,,
5.	,,	,,	,,
6.	,,	,,	,,
7.	,,	,,	,,
8.	,,	,,	,,
9.	,,	,,	,,
10.	,,	,,	,,
11.	,,	,,	,,
12.	,,	,,	,,
13.	,,	,,	,,
14.	,,	,,	,,
15.	,,	,,	,,
16.	,,	,,	,,
17.	,,	,,	,,
18.	,,	,,	,,
19.	,,	,,	,,
20.	,,	Nooitgedacht.	C. F. Juritz.
21.	,,	,,	,,
22.	,,	,,	,,
23.	,,	,,	,,
24.	,,	,,	,,

Nineteen samples of surface soils and subsoils were collected on the Government Farm Elsenburg; these soils were taken from different parts of the farm, the surface soils to a depth of eight inches, and the subsoils, represented by Nos. 4, 6, 8, 10, 12, and 14, from eight inches to a depth of two feet in each case. Nearly all of these soils were fairly coarse-grained. The farm lies on rocks of the Malmesbury series, but quartzite is very prominent, and potash, as well as phosphoric oxide, are accordingly present in only small amount; the proportion of lime is, generally speaking, more satisfactory. Results bearing close resemblance to those obtained from the Elsenburg soils, were yielded by the analyses of many of the soils collected in the Cape Division near Durban, from the farms Bloemhof and Phesante Kraal, for instance, and also in the Malmesbury Division.

DIVISIONAL MAP OF STELLENBOSCH

Five soils were taken on the farm Nooitgedacht, in the same Field Cornetcy; the farm lies on rocks of the Malmesbury series. Nos. 20 and 21, which represented clay soils, were taken respectively from the side of a hill west of the homestead, and from low-lying marshy ground north of the homestead. No. 22 was collected near the centre of the farm, while Nos. 23 and 24 were taken from vineyards, the former near the house, and the latter from a hillside east of the homestead. All these were taken from the portion of the farm lying between the highway and the railroad. There is not much difference between these soils and those from Elsenburg, already alluded to; the Elsenburg soils, like these, lie on Malmesbury slates.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
25.	Klapmuts.	Nooitgedacht.	C. P. Lounsbury.
26.	,,	,,	,,
27.	Stellenbosch.	Zand Drift.	C. Mayer.
28.	,,	Thelma.	,,
29.	Eerste River.	Neethlingshof.	,,
30.	,,	Eerste River Station.	A. H. Mathew.
31.	,,	Govt. Forest Plantation.	D. E. Hutchins.
32.	,,	,,	,,
33.	,,	,,	,,
34.	,,	,,	,,
35.	,,	,,	,,
36.	,,	,,	,,
37.	,,	Saxenburg.	J. C. de Waal.
38.	,,	,,	,,
39.	Helderberg.	Kuiken Vallei.	J.W. L. Hofmeyr.
40.	Hottentot's Holland.	Fair View.	J. Cairncross.

Nos. 25 and 26 were two red clayey soils from Nooitgedacht, rather different from the others taken on the same farm; they were taken from a vineyard on the hillside to the left of the main road from Stellenbosch, where probably they would be largely influenced by the disintegration of the granite from the Bottelary Berg. These two samples did not represent the whole of the vineyard soil, but only patches of reddish soil, termed in the vernacular "red dead ground"—where vines had never flourished, and were showing signs of dying out. No. 25 was taken from a depth of from six to nine inches. No. 26 was a clay from three feet deep. Here, unlike the case of the Graaff-Reinet soils and that of No. 23 of the Paarl soils, it appeared to be the chemical condition of the soil that was at fault, and not the physical alone, if indeed at all. The fact seemed to be that the nutrition of the vines was defective, if the poverty of the soil is any criterion, both samples being deficient in all plant food; they closely resembled in this respect some primary granitic soils analysed by Dr. Hahn several years ago, in which the granite had not been completely decomposed. The results of some of these analysis are here given:—

Locality.	Lime.	Potash.	Phosphoric oxide.
Groot Constantia	·025	·011	·009
,, ...	·008	·020	·019
High Constantia	·002	·013	·019
,, ...	·081	·043	·075
Hout Bay	·016	·002	·002
,, ...	·026	·012	·011
Eerste River (Vlaggeberg)	·018	·010	·011
,, ,, ...	·181	·017	·011
,, ,, ...	·063	·004	·007
Stellenbosch	·014	·019	·002
Somerset West	·034	·029	trace.
,, ...	·080	·025	trace.

Two samples of vineyard soils—Nos. 27 and 28—of which No. 28 had been manured with basic slag, were taken on the farms Zand Drift and Thelma, in the immediate vicinity of the town of Stellenbosch, and from granite soil at Neethlingshof in the Eerste River Field Cornetcy, near Vlottenberg, a sample was taken representing a soil that had been unmanured for six years. At Saxenburg, in the same Field Cornetcy, where No. 37 was collected, the effect of the lime from the blown sea-sand begins to be perceptible; it is also to be noticed in at least one of the three Vlaggeberg soils from the same vicinity, analysed by Dr. Hahn. No. 30 was collected at a spot about 200 yards off the main road, near Eerste River Station. The surface soil at this point is the usual white sand of the Cape Flats and Downs, with a darker soil below. The locality where this particular sample was taken lies about 14 miles distant, almost due west, from the part of the Wynberg Flats where Nos. 55 and 56 of the Cape Division soils were obtained, the former representing the western and the latter the eastern margin of the Cape Flats.

In the direction of Somerset West two soils were taken for analysis; one of these was taken on the hill near Somerset West, from part of the farm De Hoop, now known as Fair View; the other was a granitic soil from the farm Kuiken Vallei, where the subsoil consists of pot clay. These two soils are represented by Nos. 39 and 40.

The analytical results obtained from the soils of this Division are tabulated below:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
		Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	80·2	·95	2·07	·0085	·056	·065	·024	·024*
2.	57·7	·63	2·25	·0106	·056	·044	·024	·050
3.	85·4	—	—	—	—	·144	·024	·036
4.	88·3	—	—	—	—	·156	·022	·014
5.	85·2	—	—	—	—	·137	·018	·015
6.	85·4	—	—	—	—	·132	·017	·018
7.	81·1	—	—	—	—	·219	·027	·044
8.	83·5	—	—	—	—	·160	·018	·046
9.	70·7	—	—	—	—	·036	·017	·034
10.	76·6	—	—	—	—	·034	·016	·050
11.	62·0	—	—	—	—	·136	·036	·042
12.	63·2	—	—	—	—	·088	·029	·062
13.	80·3	—	—	—	—	·210	·061	·064
14.	79·8	—	—	—	—	·172	·051	·054
15.	84·3	—	—	—	—	·165	·038	·034
16.	90·2	—	—	—	—	·365	·070	·067
17.	74·3	—	—	—	—	·118	·037	·038
18.	82·2	—	—	—	—	·062	·033	·019
19.	85·0	—	—	—	—	·037	·030	·026
25.	92·2	·81	4·26	·005	·014	·008	·039	·046
26.	93·6	1·03	4·90	·006	·014	·006	·039	·045
27.	74·0	1·25	3·66	·0035	·144	·078	·068	·061
28.	92·2	2·49	7·25	·0152	·101	·026	·021	·073
29.	69·1	1·26	4·05	·0053	·057	·024	·023	·018
30.	98·1	—	—	—	—	·066	·010	·003
40.	79·1	1·20	4·15	·0113	·059	·016	·015	·027

* In the case of this soil extractions by Method V and by water were also made; see next page.

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide
20.	—	—	—	—	·14	·15	·029
21.	—	—	—	—	·33	·082	·048
22.	—	—	—	—	·19	·077	·068
23.	—	—	—	—	·13	·16	·035
24.	—	—	—	—	·076	·052	·018
31.	1·28	—	·14	—	18·66	·28	·01
32.	·44	—	·014	—	15·57	·16	·01
33.	·58	—	·007	—	11·56	·20	·04
34.	·36	—	·016	—	16·27	·26	·07
35.	·40	—	·002	—	18·50	·12	·04
36.	·38	—	·11	—	15·98	·24	·09
37.	·10	1·27	·008	—	·60	·04	trace.
38.	·11	·19	·008	—	trace.	·04	trace.

(Method V.)

No.	Potash.	Phosphoric oxide.
1.	·017	·0036

Sample No. 1, upon extraction by water, yielded ·0013 per cent. of phosphoric oxide, or slightly over one twentieth the amount extracted by the standard hydrochloric acid method.

(Extraction by boiling with Hydrochloric acid.)

No.	Water.	Organic matter.	Chlorine.	Lime.	Potash.	Phosphoric oxide.
39.	·31	2·72	·019	·14	·44	·018

STEYNSBURG.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Brak River.	Klerks Kraal.	E. A. Nobbs.
2.	,,	Middel Water.	,,
3.	,,	Zout Kuil.	,,
4.	,,	,,	,,
5.	,,	,,	C. F. Juritz.
6.	,,	,,	,,
7.	,,	,,	,,
8.	,,	,,	,,
9.	,,	Van Vuuren's Kraal.	,,

The above soils were all taken from lands below the dam which it was proposed to construct in connection with the Thebus Irrigation project. No. 1 represents a typical Karroo soil, and No. 2 a Karroo soil of somewhat lighter character. No. 3 was taken from the side of a water course after removal of the surface soil, and No. 4 from lands which had been long under irrigation. Nos. 4 to 9 all represent surface soils, and, like the preceding four samples, differed considerably in some respects, especially in regard to the proportions of lime and potash contained from Nos. 10 to 19 (see below).

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
10.	Brak River.	Thebus.	Engineer, Public Works Department.
11.	,,	,,	,,
12.	,,	,,	,,
13.	,,	,,	,,
14.	,,	,,	,,
15.	,,	,,	,,
16.	,,	,,	,,
17.	,,	,,	,,
18.	,,	,,	,,
19.	,,	,,	,,
20.	,,	,,	,,

Nos. 10 to 19 were also collected within the irrigable area above referred to, at Thebus. No. 20 is representative of the silt brought down by the river at Thebus.

The results obtained by chemical analysis from the soils taken from this locality are set forth in the following tables:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	98·4	4·33	4·09	·0106	·071	·238	·196	·013
2.	98·8	4·27	3·79	·0276	·071	·130	·192	·037
3.	94·8	6·19	3·34	·0630	·043	·042	·195	·031
4.	92·9	2·89	3·23	·0149	·071	·448	·152	·038
5.	97·8	5·65	4·81	·114	·070	·062	·181	·089
6.	97·5	4·28	4·25	·049	·028	·062	·213	·121
7.	91·1	4·00	4·26	·132	·084	·044	·189	·097
8.	98·0	5·58	5·09	·141	·098	·066	·257	·093
9.	98·0	3·99	3·99	·024	·084	·188	·161	·080

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
*10.	4·70	6·16	·046	·028	6·775	·764	·053
11.	2·86	2·46	·016	·031	2·192	1·038	·151
12.	6·52	4·33	·337	·025	3·617	1·206	·055
13.	6·35	5·00	·044	·021	8·570	1·218	·110
14.	4·17	3·07	·177	·028	3·430	·566	·076
15.	3·20	2·47	·085	·084	2·075	·452	·089
16.	5·95	5·00	·319	·035	6·675	1·314	·051
17.	5·08	3·92	·087	·038	2·535	·038	·076
18.	3·25	2·29	·062	·028	1·445	1·010	·091
19.	4·21	4·42	·057	·077	12·022	·978	·258
20.	—	12·99	—	—	·580	·248	·139

* In connection with these results see also remarks on the soils of this Division under the head of "Alkalinity of Soils" (Part VI).

There is apparently a general resemblance, both chemical and physical, between the soils of this division and those of the adjoining divisions of Albert on the west, and Colesberg on the east: they are all fairly fine grained soils, not inadequately furnished with lime in the condition of plant food, and moderately supplied with phosphates. The Karroo rocks of the Stormberg series, wherein lime strata are specially prominent, are apparently responsible for these features. Between the Steynsburg and the Colesberg soils particularly, the similarity in respect of plant food is very strong, as may be seen from the following comparative figures:—

Division.	No. of Samples.	Fine Earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
Colesberg.	6	94·7	3·06	4·24	·006	·088	·174	·171	·078
Steynsburg.	9	96·4	4·58	4·09	·064	·069	·142	·193	·067

The samples available for comparison were these from Oorlogspoort (numbered 1 to 6) in the Colesberg Division, and the nine from Steynsburg analysed according to the same method. The latter differ materially from the former in one respect only, namely, in regard to the amounts of chlorides they contain: this point will be dealt with again in connection with the subject of alkaline soils.

STOCKENSTROM.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Mancazana.	Ebenezer West.	H. H. Davison.
2.	,,	,,	,,
3.	,,	,,	,,
4.	,,	,,	,,
5.	Balfour.	Upsher.	J. Berwinger.

A large portion of this division is devoted to the cultivation of tobacco, and four soils were taken for analysis from the Government Tobacco Farm at Ebenezer West: they would appear to be, for general purposes, fairly well furnished with lime, and also, except in the case of No. 3, with potash. All four, however, stand in need of phosphoric oxide.

No. 5 represents a soil which is used for tobacco culture at Upsher.

The results of the analysis of these soils are as follows:—

(Method II.)

	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	1·75	3·12	·0036	·088	·32	·16	·049
2.	2·22	3·81	·0034	·10	·44	·17	·048
3.	2·86	5·07	·0023	·10	·22	·097	·031
4.	4·34	7·39	·0022	·20	·60	·15	·045
5.	1·84	5·50	·014	—	·84	·32	13

SWELLENDAM.

(Officially collected.)

No.	Field-cornetcy.	Farm or place.	Collector.
1.	Tradouw.	Zevenfontein.	J. Muller.
2.	,,	Poortfontein.	,,
3.	,,	Uitvlugt.	,,
4.	,,	Het Goed Geloof.	,,
5.	,,	Barrydale.	,,
6.	,,	Tradouws Hoek.	,,
7.	,,	Doorn Rivers Vallei.	,,
8.	,,	,,	,,
9.	,,	Lemoens Hoek.	,,
10.	Rivier Zonder End	Appelskraal.	,,
11.	,,	,,	,,
12.	,,	,,	,,
13.	,,	,,	,,
14.	,,	Stormsvlei.	,,
15.	,,	Verdwaal Kloof.	,,
16.	,,	Klipfontein	,,
17.	Kluitjes Kraal.	Vryheid.	,,
18.	,,	Kluitjes Kraal.	,,
19.	Swellendam.	Klippe River.	,,
20.	,,	Appelbosch.	S. B. Morgenrood.
21.	,,	Distelsfontein.	,,
22.	,,	Oude Post.	,,
23.	,,	Bonteboks Kloof.	,,
24.	,,	Kinko.	,,
25.	Breede River.	Uitvlugt.	,,
26.	,,	Zwartklip.	,,
27.	,,	Kadies Vallei.	,,
28.	,,	Rhenosterfontein.	,,
29.	Heidelberg.	Klein Duine Rug.	,,
30.	,,	Wagen Drift.	,,
31.	,,	Asch Kraal.	,,
32.	,,	Duivenhoks River.	,,
33.	Karnemelk River.	Hooi Kraal.	,,
34.	,,	Honig Klip.	,,
35.	,,	Karnemelk River.	,,
36.	Zuurbrak.	Melkhoutboom.	,,
37.	,,	,,	,,
38.	Klip River.	Bosjesmans Pad.	,,

The Langeberg Range, which runs midway across the Swellendam Division, divides it into two areas widely differing in their characteristics. The southern portion resembles the adjacent division of Riversdale, although the coastal belt of downs is less prominent; the northern part—or Tradouw—is of similar type to the Ladismith Division, and the portion of Robertson which lies north of the aforementioned range. The soils of this entire area to the north of the Langeberg Range, between 20° 0′ E. and 21° 45′ E., appear to possess a better average of plant food than the soils south of the mountains; and, as far as analyses have shown hitherto, North Swellendam seems, in this respect, to be more advantageously situated than either Ladismith on the east, or North Robertson on the west.

Commencing with the consideration of the southern portion of the Swellendam Division, the first farm to be visited was Appelskraal, on the right bank of the River Zonder End. Here three samples of alluvial soils were taken from lands on the opposite side of the river; No. 10, a light sandy soil; No. 11, a black drift sand or sandy loam; and No. 12, a sandy clay. A sample of loose yellow clay, No. 13, was also taken, from lands about a mile east of the farmhouse, in the direction of the Ruggens. The general poverty, and especially the low lime-content of the soils will become evident on contrasting them with the results yielded by the other soils of this part of the division. The locality from which they were taken lies just on the verge of the mass of sandstone that forms the River Zonder End Range, and they are apparently influenced thereby. The poverty in lime of the Caledon soils* is ascribable to a similar cause.

No. 14, a sample of alluvial soil, was taken from the farm Stormsvlei, about an hour's drive further along the river; this represents a stiff clay soil mixed with organic matter. Proceeding thence about three miles south of Appelskraal, a loose clay, No. 15, was collected from the farm Verdwaal Kloof, and afterwards No. 16, also a loose clay, from the farm Klipfontein, about eight miles south-east of the point where the preceding soil was sampled.

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* See page 38.

At Vryheid, about $11\frac{1}{2}$ miles south-west of the village of Swellendam, a stiff clay soil, No. 17, was obtained, from lands to the right of the main road. Directing a course thence towards Swellendam, the farm Kluitjes Kraal, on the right of the Breede River, was touched at. From this farm a stiff clay, No. 18, similar to that from Vryheid, was procured. The last farm visited on this tour was Klippe River, just at the entrance to the village, along the main road. Here a sandy loam, No. 19, was taken from ground adjoining an area under tobacco culture.

On a subsequent journey, taking the tract of country between Swellendam and Zuurbrak, and between the Langeberg Mountains and the Breede River, one primary soil, No. 21, was collected at Distelsfontein; it was a fair, slightly warm soil, somewhat resembling the soil of Caledon, and moderately retentive of moisture. One "doorn" soil, No. 23, was taken at Bonteboks Kloof, and two alluvial soils, Nos. 20 and 22, from Appelsbosch and Oude Post respectively.

Proceeding in a south-easterly direction, along the Port Beaufort road, a diversion was made at Kinko. Here, on the small watershed, was found the most fertile type of soil met with between this and Caledon. This class of soil extends over Koerannie, Kinko, Uitvlugt, Hartebeeste River, and other farms eastward towards the Upper Slang River. The formation is not such denuded slate as is generally to be seen, the overlying sedimentary beds forming undulating hills capped by flat sandstone and iron "kopjes." On the higher ridges above Karnemelk River there are a number of deposits of clay. The soil is pebbly in the best lands, with substratum of lime, and very retentive of moisture, although not clayey. The samples from Kinko (No. 24), Uitvlugt (No. 25), and Karnemelks River (No. 35), sufficiently represent this area. Southwest of this, along the Breede River as far as Paarden Kloof, is a stretch of "geil-grond"—a fairly good but stony and warm soil, in which, except during a season of abundant rainfall, the crops shrivel up. During the drought that had continued for three years, the yield had been insignificant, and supplies had to be transported from the Caledon Division, a long day's journey. The formation is bare vertical shale, with outcrops of limestone; in the northern and southern portions there is some ironstone; the valleys are precipitous. One sample typical of this area was taken on the farm Zwartklip, near to Michiels Kraal. The gravels on this farm, and at Rhenosterberg, mentioned below, bear some resemblance to that already noticed at Klippe Drift, Bredasdorp Division. The fertility, both here and at Uitvlugt, seems to be chiefly owing to the presence of available lime in comparatively large amount.

Keeping along the ridge, a series of undulating plateaus are crossed, with extensive tracts of fertile land, alternately "zwart turf," and red gravel, with a subsoil of limestone. On the west bank of the Slang River the soil becomes entirely a red deep gravel, with little limestone, until, on ascending the other side, one comes to gravelly flats with occasional "turf." This continues throughout Zandfontein and Jakhalsfontein to Duine Rug, where the soil becomes more sandy. Towards Melkhout Kraal, along the Duivenhoks River, the soil is very sandy. A sample of "zwart turf," No. 27, was secured at Waterkloof, adjoining Kadies Vallei, another of gravelly soil, No. 28, at Rhenosterfontein, and one of "broken" soil, No. 29, at Duine Rug.

Between this area and Heidelberg the farms were very much subdivided, and several varieties of soil were under cultivation. No. 30 represents a "broken" gravel from Goedemans Kraal, on the border of Wagendrift; No. 31 is what is locally known as "Karroo" soil, from Asch Kraal. No. 33 is a hill soil from Hooi Kraal, and No. 32 a river soil from the farm Duivenhoks River, outside Heidelberg.

Crossing the high watershed, No. 34, a sample of Upper Ruggens soil was taken from Honigklip, where the land under cultivation lies at an exceedingly steep angle, and two samples from the farm Melkhoutboom were taken, representing the valleys between these hills and the Langeberg Range, namely, No. 36, a sample of "vlei" (alluvial) soil, and No. 37, a hill soil.

North-west of Swellendam, bounded by the Langeberg Mountains and the Breede River, is a long stretch of decomposed shale and sandstone in alternate hills and well-watered valleys. Nearly the whole of this picturesque section, dotted with orchards, vineyards, and grain lands, belongs to the Van Eeden family. Being favourably situated as regards rainfall, etc., this area admits of being extensively cultivated, the low-lying lands, with a potash dressing being particularly suited to the growth of potatoes, and possibly tobacco. Sample No. 38 from the farm Nooitgedacht (Bosjesman's Pad), together with a varient of the same previously obtained at Klippe River, sufficiently typifies these valleys.

A considerable portion of the Swellendam Division is really pastoral; the scant water supply and the difficulties of transport previous to the advent of the railway having rendered extension of the cultivated area too risky, even although good soil may have been available. The water question remains a great difficulty, and the ways and means of conserving more water have more than once been seriously discussed. Owing to a bend in the high Langeberg Range, the moisture laden clouds, whether from the north-west or south, precipitate their showers round and about Swellendam village, and northward thereof; a smaller portion condenses about the Potteberg mountains and Port Beaufort, while rain clouds pass over the intermediate area without shedding any of their moisture.

On a final visit to this division the northern portion, already referred to, was dealt with, and samples were collected from the Tradouw, the high plateau which extends right across that part of the Swellendam Division, and embraces a considerable part of the adjoining division of Robertson, stretching from the Touws River in the north and east, to the Langeberg Range in the south, and the Wagenbooms Bergen in the south-west. Sowing is carried on successfully only along the Touws River, which widens out very considerably in some parts. No. 1 was taken at Zevenfontein, and is a very typical sample of this fine red "Karroo" soil, known as "doorn grond." From the eastern portion of the Tradouw two samples were selected. Very little, if any, cultivation is carried on between the Groot River, south-east of the village of Ladismith, and the farm Uitvlugt, or Warmbad, situated at the eastern end of the Warmwater Bad Mountain. No. 2 represents a loose, unmanured, sandy soil, taken from the garden in front of the homestead on the latter farm. No. 3, a loose clay soil, was collected as being typical of the ground in the valley; it had a very good local reputation, and its quality is excellent according to the chemical analysis. In the neighbourhood of Barrydale, No. 9 was chosen as being more representative of the richer "broken" soil in the valley than the sour and poorer variety near the mountains. Beyond Doorn River the farm Doorn Rivers Vallei was touched at, and two samples of soil collected. The first of these, No. 7, was a "broken" Karroo soil. No. 8 was a loose clay, of the class usually known locally as "broken" soil, of a rather acid character. The soil becomes more sour on approaching the sandstone of the Langeberg Mountains. No. 5, a very loose clay soil, taken from the garden of Mr. G. du Toit, forms a representative sample of the nature of the soil in the village of Barrydale.

On the way from Barrydale to Montagu, No. 6, a somewhat sandy soil, said to be rather poor, though fairly well suited for potatoes when well manured, was taken at Tradouws Hoek. Here again chemical analysis confirms practical experience, for, on analysis, this soil was found to be far the poorest of all the Tradouw soils examined. No. 4, a virgin soil, was collected from the farm Het Goed Geloof, where the soil is rather more sour than at Tradouws Hoek.

In the following tables will be found the results obtained by analysis from the several soils enumerated above:

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	97·2	·64	3·59	·0078	·064	·220	·146	·082
2.	62·7	·31	1·32	·0120	·021	·046	·176	·036
3.	81·0	2·04	6·92	·1180	·126	2·518	·416	·234
4.	62·5	2·00	11·03	·0092	·392	·074	·210	·201
5.	83·4	1·16	6·12	·0120	·168	·040	·250	·096
6.	76·8	·77	4·15	·0134	·112	·024	·033	·023
7.	72·8	1·21	5·76	·0057	·189	·042	·262	·134
8.	80·3	1·18	5·95	·0099	·154	·106	·272	·151
9.	89·0	1·21	5·69	·0460	·168	·170	·197	·122

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
10.	·09	·77	·0056	·11	·084	·034	·0048
11.	1·05	5·41	·025	·18	·060	·035	·011
12.	·57	3·36	·013	·16	·044	·049	·015
13.	·75	3·85	·0085	·14	·058	·10	·014
14.	·68	3·59	·093	·15	·14	·078	·016
15.	·95	6·90	·018	·16	·25	·084	·013
16.	1·44	7·20	·028	·14	·16	·13	·012
17.	·51	3·73	·011	·16	·080	·055	·017
18.	·80	4·78	·086	·15	·084	·14	·022
19.	·86	6·26	·018	·16	·29	·12	·040
20.	1·50	4·64	·0028	·028	·096	·015	·036
21.	·65	4·30	·0019	·042	·16	·074	·052
22.	1·58	5·91	·0025	·065	·15	·053	·041
23.	1·81	6·76	·019	·098	·63	·23	·044
24.	1·08	4·14	·019	·098	·33	·062	·023
25.	1·76	5·65	·010	·098	1·18	·43	·009
26.	1·35	5·38	·0068	·077	·45	·23	·018
27.	3·16	9·30	·013	·070	7·57	·35	·038
28.	·59	1·87	·0073	·056	·16	·099	·010
29.	·84	2·98	·011	·042	·32	·018	·014
30.	·91	4·25	·019	·056	·37	·087	·019
31.	2·68	7·53	·086	·035	2·73	·29	·041
32.	·21	2·16	·0057	·063	·64	·033	·011
33.	1·64	4·97	·053	·15	·51	·11	·015
34.	1·70	9·26	·015	·12	·40	·045	·008
35.	4·82	4·07	·048	·077	·37	·11	·031
36.	2·86	9·07	·016	·084	·23	·060	·019
37.	2·07	4·67	·015	·084	·083	·099	·036
38.	1·43	5·80	·015	·084	·46	·10	·010

The proportion of lime in the soil appears to diminish as one passes from Heidelberg and Breede River, through the Swellendam and Zuurbrak Field Cornetcies in the direction of Robertson, but rises as soon as the latter division is reached. Phosphoric oxide is very deficient throughout. The soils of Northern Swellendam, it will be observed, are almost uniformly well supplied with potash.

TULBAGH.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Koopmans River.	Doornboom.	J. Muller.
2.	,,	,,	,,
3.	,,	,,	,,

Three samples of rather gravelly soil were collected on Mr. F. Baker's farm Doornboom, adjoining Porterville Road Railway Station. No. 1 was taken from stubble land, which was just being ploughed, between the cottage and the railway line; No. 2 was collected from land already ploughed, and nearer the cottage; No. 3 was from new lands beyond the cottage on the mountain side.

Geologically the Division of Tulbagh may be said to comprise four parallel strips, alternately of Malmesbury clay slate beds and sandstone ridges, running almost due north and south.* The three samples above mentioned were taken from the slope of the western sandstone mountains, just on the border of the Malmesbury formation; they conform, in chemical composition, to the usual poverty of the sandstone soils, and, as the proportions of fine earth show, are very coarse-grained in texture.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
4.	Koopmans River.	Porterville Road.	——
5.	,,	,,	——
6.	Breede River.	Kluitjes Kraal.	Forest Officer.
7.	,,	,,	,,
8.	,,	,,	,,
9.	,,	,,	,,
10.	,,	,,	,,
11.	Waterfalls.	Knolle Vallei.	,,
12.	,,	,,	,,
13.	Winterhoek.	Misgund.	J. F. Theron.

Two samples of soil were taken from the farm of the Imperial Cold Storage Company at Porterville Road. In practically all respects they resemble the neighbouring soils from the farm Doornboom.

All the remaining samples collected within this division were taken from the tongue of slates between the two sandstone ranges, but the surface soil is, generally speaking, influenced by the latter, and this—added to the fact that the soils, even if undiluted in this way, and formed solely by the disintegration of the Malmesbury beds, would probably show results no better than those noticed in the Malmesbury and Cape Divisions—leads one to expect all-round poor soils; an expectation which is fully realised by the results of the chemical analysis.

* See Map on page 160.

At Kluitjes Kraal, near Ceres Road Railway Station, is a Government Forest Plantation, whence, from different spots around the old homestead, four samples of sandy loam garden soil and adjacent old garden soil were collected: these four soils are represented in the tables by Nos. 7, 8, 9, and 10. No. 6 represents a black soil taken from the river bed on the same farm. This soil is, as may be surmised, much finer grained than the sandstone soils, and is fairly well supplied with organic matter and nitrogen, but the mineral components of plant food, although less scanty than in the sandier soils, are far from satisfactory for crops, although probably sufficient for the tardier requirements of arboriculture.

At Knolle Vallei, a farm adjacent to Kluitjes Kraal, and purchased by the Government for the purpose of a railway sleeper plantation, two samples were procured through the Conservator of Forests. Of these, No. 11 was a dark, and No. 12 a fine-grained light-coloured clay: they were taken from a hill about a mile east of the homestead. The surface soil in the vicinity had the appearance of a very rich clayey loam, about fifteen inches deep, the subsoil being a stiff reddish clay.

In the Winterhoek Field Cornetcy a sample was collected on the farm Misgund. The locality forms the very tip of the tongue of clay slate which runs up north between the sandstone of the Witzenberg Range on the east, and that of the Roode Zand Mountains on the west, and is cut off by the Winterhoek Mountains on the north. The soil is therefore naturally very poor in all plant food constituents, for the locality is a *cul-de-sac* of clay slate, surrounded on three sides by sandstone mountains. The soil had been used for the cultivation of tobacco, and had been manured. The sample was collected from a hillside, and consisted of a somewhat gravelly clay, the subsoil being a fine yellow clay. The local agriculturists declare that, unless manured, this soil proves almost worthless, and herein is again exemplified the confirmation by practical experience of the opinions based upon the chemical analysis of the soil.

The chemical analyses* of the Tulbagh soils resulted in the figures tabulated below:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	49·3	·49	2·84	·0067	·087	·014	·042	·027
2.	38·9	1·00	5·16	·0071	·130	·036	·063	·045
3.	24·4	·27	1·61	·0042	·043	·008	·020	·019
4.	34·7	1·12	3·22	·0850	·063	·032	·079	·063
5.	31·3	1·27	4·17	·0720	·105	·026	·084	·069
6.	94·8	2·92	11·78	·0375	·308	·070	·095	·070
11.	61·4	1·49	3·64	·0212	·095	·068	·038	·047
12.	98·7	5·75	10·09	·0127	·088	·008	·030	·033
13.	73·4	·95	3·51	·0064	·088	·044	·032	·023

*** Partial mechanical analyses of Nos. 1, 2, 3, and 6 will be found under the heading of "Physical composition of soils" (Part VII).**

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
7.	—	—	—	—	·060	·033	·052
8.	—	—	—	—	·083	·031	·075
9.	—	—	—	—	·102	·036	·052
10.	—	—	—	—	·050	·058	·089

All of these soils, with hardly an exception in any particular, are lacking in the several mineral constituents of plant food.

UITENHAGE.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Sundays River.	Upper Landdrost.	R. E. Wright.
2.	,,	,,	,,
3.	,,	Gouvernements Belooning.	,,
4.	,,	,,	,,
5.	,,	Klaas Kraal.	,,
6.	,,	,,	,,
7.	,,	,,	,,
8.	,,	Malmaison.	,,
9.	,,	,,	,,
10.	,,	Small Kloof.	,,
11.	Uitenhage.	Stoneleigh.	H. Griffiths.

The first ten samples in the above list were all collected on the Sundays River Estates, from lands intended to be placed under irrigation. No. 11 was taken from the residential plot Stoneleigh at the town of Uitenhage, where it was intended to plant some 50,000 tobacco plants: it proved to be poor in phosphoric oxide.

The results obtained by the analyses of these eleven soils* are given in the tables below:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic. matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	99·5	2·70	4·72	·0085	·126	·182	·292	·073
2.	98·9	·79	2·56	·0057	·091	·156	·197	·068
3.	99·1	1·92	5·62	·0028	·140	·718	·333	·143
4.	98·3	1·07	3·30	·0028	·084	·078	·108	·075
5.	93·2	·94	3·64	·0021	·105	·392	·239	·116
6.	98·4	·90	2·90	·0021	·084	·066	·178	·068
7.	99·6	1·02	2·54	·0042	·070	·182	·185	·092
8.	95·8	1·22	3·48	·0021	·098	·278	·276	·087
9.	99·2	1·18	3·73	·0028	·168	·338	·278	·132
10.	100	1·35	3·63	·0085	·140	·592	·226	·086

* For the results of partial mechanical analyses of the first ten soils, see under "Physical composition of soils" (Part VII).

(Method II.)

No.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through 3 mm. Sieve. Lime.	Potash.	Phosphoric oxide.
11.	3·13	6·46	·0034	·173	1·776	·206	·036

The analytical results show that the Sundays River Estates soils are, taken all round, satisfactorily furnished with Nitrogen, Lime, and Potash, and have a fair proportion of phosphates. It frequently happens that soils containing abundance of lime, as these do, are not inadequately provided with potash. The lime, in the present case, undoubtedly owes its presence in the soil to the numerous bands of limestone which form an integral part of the Sundays River beds in the Uitenhage geological series. To these limestone bands must evidently be ascribed the great difference that exists between the soils of the Sundays River Valley and those of the adjacent Humansdorp Division.

UMTATA.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Umtata.	Kambu Plantation.	Forest Officer.
2.	"	"	"

These two samples of soil were collected from the Kambu Forest Plantation, distant about fifteen miles west of Umtata: No. 1 represents the surface soil and No. 2 the subsoil. They were taken from a steep ridge which runs down about a thousand yards from the Kambu Forest to the Umtata River, at a point about half-way between the two. The surface soil in the vicinity is typical of the red sour veld, which abounds in the mountainous parts of the district, while the subsoil is somewhat clayey, and bright red in colour.

The analyses of the samples collected are as follows, and it will be observed that the soils are, like most sour veld soils, deficient in practically all inorganic plant food:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	99·0	3·39	16·06	·0075	·238	·024	·040	·093
2.	98·6	4·12	14·18	·016	·147	·010	·018	·065

UMZIMKULU.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Zuurberg.	Nieshoutfontein.	— Robinson.
2.	"	"	"
3.	Lower Ibisi.	Kippendavie.	H. C. C. Kippen.

Two samples of soil, No. 1 a surface soil, and No. 2 the sub-soil below it, from the farm Nieshoutfontein, or Sneezewood, were collected from a plantation of young cluster pines in the vicinity of Mr. James Cole's private forest. Attempts had been made in the neighbourhood, both by the Government Forest Department and by private persons, to grow Cluster Pine, but the results had not been satisfactory—at least not until the young trees had attained to some years of growth. The soil, which was taken from a gentle slope, is of a clayey nature, with some five or six inches surface deposit of decayed vegetable growth. Underlying the surface soil, at varying depths, is a yellow shale.

Soil No. 3 was taken from the farm Kippendavie, part of the farm Hopewell (A.4) and lying on the Umzimkulu River, about four miles from Umzimkulu village in a southerly direction. The soil represents lands whereon tobacco was being cultivated; the tobacco which it produced was said to be altogether too strong for smoking purposes. The piece of land whence the sample was taken is situated in a valley, and the soil is deep and sweet.

Below are the results of analysis:—

(Method I.)

	Percent. of Field Sample.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
No.	Fine earth.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	99·2	7·51	17·19	·0106	·350	·010	·037	·087
2.	99·0	7·41	12·18	·0502	·203	·010	·041	·042

(Method II.)

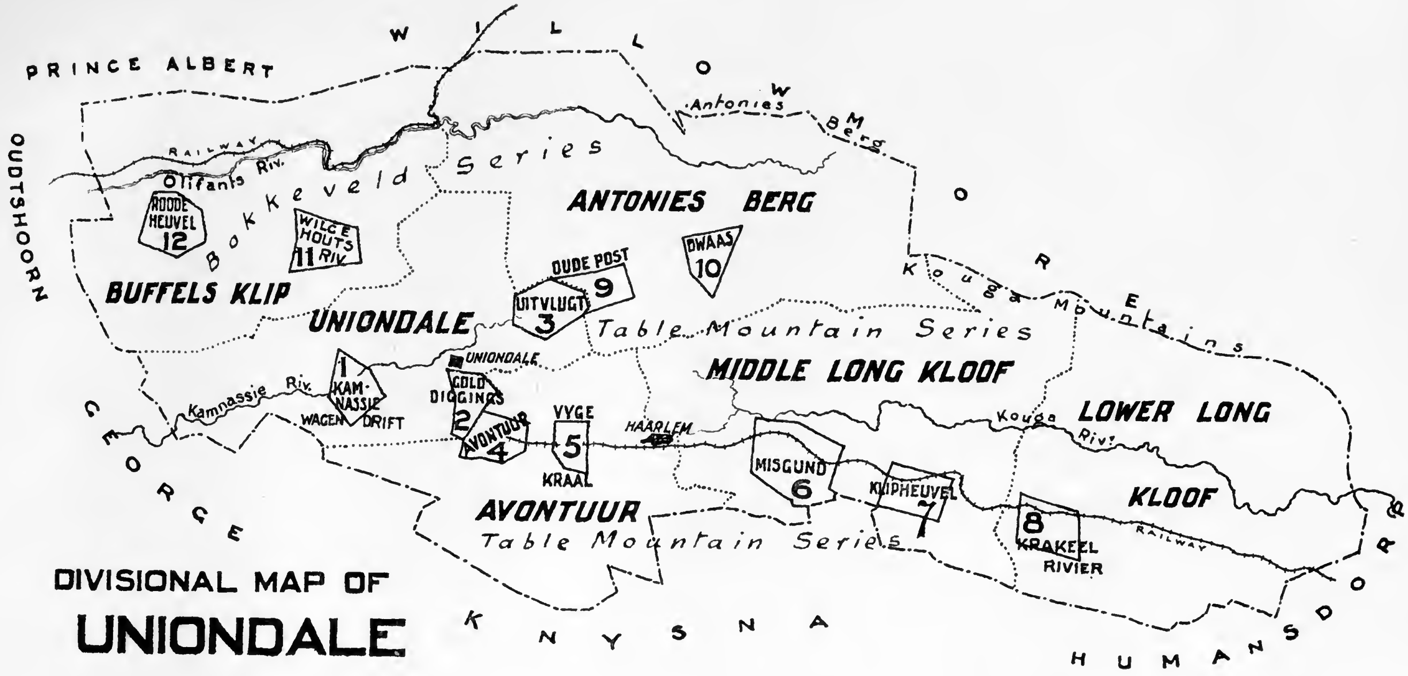
	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
3.	7·71	11·42	·0007	·084	·697	·052	·017

Of these soils, Nos. 1 and 2 show very poor results in all mineral plant food. No. 3 is deficient in every respect except as regards lime.

UNIONDALE.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Uniondale.	Kamnassie Wagen Drift.	C. F. Juritz.
2.	,,	Gold Diggings.	,,
3.	,,	Uitvlugt.	,,
4.	Avontuur.	Avontuur.	,,
5.	,,	Vyge Kraal.	,,
6.	Middle Long Kloof.	Misgund.	,,
7.	,,	Klipheuvel.	,,
8.	Lower Long Kloof.	Krakoel River.	,,
9.	Antonies Berg.	Oude Post.	,,
10.	,,	Dwaas.	,,
11.	Buffels Klip.	Wilgehouts Rivier.	,,
12.	,,	Roode Heuvel.	,,



DIVISIONAL MAP OF
UNIONDALE
PRINCE ALBERT
WILLOWMORE
OUDTSHOORN
GEORGE
KNYSNA
HUMANSDORP
Antonies Berg
Kouga Mountains
RAILWAY
Olifants Riv.
Bokkeveld Series
ANTONIES BERG
RODDE HEUVEL 12
WILGE HOUTS 11 RIV.
BUFFELS KLIP
UNIONDALE
OUDE POST 9
UITVLUGT 3
DWAAS 10
Table Mountain Series
MIDDLE LONG KLOOF
UNIONDALE
1 KAM-NASSIE
Kamnassie Riv.
WAGEN DRIFT
GOLD DIGGINGS 2
AVONTUUR 4
VYGE 5 KRAAL
HAARLEM
MISGUND 6
KLIPHEUVEL 7
8 KRAKEEL RIVIER
LOWER LONG KLOOF
Kouga Riv.
AVONTUUR
Table Mountain Series

The greater part of the Uniondale Division consists of valleys of Bokkeveld shales, and hills of Table Mountain sandstone. It resembles, therefore, many of the other divisions of the Colony in which rocks of the Table Mountain and Bokkeveld series occupy the most prominent part. Hence it may be anticipated that the Uniondale soils will exhibit similar characteristics to those of, for instance, the Caledon Division, and a large extent of the Bredasdorp and Swellendam Divisions. And, on the whole, where no modifying influences are exerted, we find this to be the case. Into this area of shales and sandstones there protrudes, from the Oudtshoorn Division, along the Olifants River banks, a wedge of the Uitenhage series, and this gives a proportion of lime to the soils in the vicinity, that serves as a preliminary indication to the traveller from Uniondale or Willowmore, that the Oudtshoorn boundary is being approached. It is not, however, until that boundary is actually crossed that the radical change becomes fully perceptible. Reference was made to this when dealing with the soils of Oudtshoorn.*

Entering the Uniondale Division from George, sample No. 1 was procured on the farm Kamnassie Wagen Drift, about 5¾ miles W.S.W. of Uniondale. This soil does not properly belong to the Long Kloof class,† nor does No. 2, taken from the farm Gold Diggings, 5¼ miles in a southwesterly direction from Uniondale. Of these two soils the former lies on the Bokkeveld formation, and the latter on the sandstone: the difference in chemical composition, to the disadvantage of the sandstone soil, is clearly seen from the table of analyses.

Very broadly speaking, the Uniondale soils may be classified into two groups, namely, the Long Kloof soils, derived from rocks of the Table Mountain series, and the soils of the Bokkeveld series, which more resemble the soil that characterises the Karroo. The Long Kloof, it is true, itself presents two varieties of soil, for "sour veld" is met with along the southern side of the kloof; but, as this class of soil had already been represented by samples collected in the George and Knysna Divisions, only sweet Long Kloof soils were taken for analysis, namely Nos. 4, 5, 6, 7, and 8. On all these soils the rhenoster bush abounds. North of the Long Kloof, and parellel to it, is another kloof, known as the Kouga, the soils of which are practically similar to those of the Long Kloof. For this reason samples of Kouga soils were not taken for special analysis.

Travelling in a north-easterly direction from Uniondale, and passing from the sandstones to the Bokkeveld series, the character of the soil changes, and approximates to that of the Karroo. Nowhere, however, does it assimilate closely to the *true* Karroo soil, judging from the flora; rhenoster bush continues to thrive, though less abundantly than in the Long Kloof, whereas the Ganna (*Salsola aphylla*) so distinctive a mark of Karroo soil, is entirely absent. These facts are easily understood, when the small proportions of lime in these Uniondale soils are taken into account. The absence of the rhenoster bush and the luxuriance of the Ganna are generally—as remarked in connection with the soils of Oudtshoorn*—indications that lime is present in good proportion. From this area No. 3 was collected on the farm Uitvlugt, about four miles northeast of Uniondale. At Oude Post, six miles further on in the same direction, another sample, No. 9, was taken, and on the farm Dwaas, 17 miles from Uniondale, No. 10 was procured. These samples—which contain rather more potash than the purely sandstone soils—were all taken from a band of Bokkeveld which extends—between the sandstone—over these three farms. The soils are rather coarse in texture, and both the above

* See page 96. † See page 57.

geological formations have evidently contributed to their composition. The Bokkeveld formation extends westwards over the farms Wilgehouts Rivier, Buffels Klip, and Roode Heuvel, but in this part of the division it is less under the influence of the sandstone; the soil is therefore finer in grain, and better in chemical composition. At Wilgehouts Rivier No. 11 was collected, about 16 miles north-west of Uniondale, No. 12 being taken from the farm Roode Heuvel, six miles further west. The five soils just mentioned, Nos, 3, 9, 10, 11, and 12, which are all rather loose brown clays, typify the soil of the entire northern part of the Uniondale division, and form the second of the two classes of soil previously mentioned.

The results of the chemical examination of the Uniondale soils are here tabulated:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted thorough 1mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	57·9	1·54	7·10	·0541	·175	·102	·182	·095
2.	57·1	1·78	4·72	·0099	·161	·054	·050	·077
3.	57·3	·90	3·04	·0244	·098	·052	·074	·044
4.	83·4	·71	2·92	·0495	·140	·058	·030	·036
5.	66·8	1·58	4·62	·0202	·161	·088	·026	·049
6.	35·8	·76	3·30	·0340	·098	·050	·062	·052
7.	94·2	·74	2·97	·0240	·126	·030	·038	·026
8.	92·4	1·07	3·20	·0226	·154	·040	·054	·044
9.	57·2	·65	2·44	·0095	·140	·036	·094	·049
10.	54·1	·76	2·72	·0109	·098	·028	·105	·067
11.	93·2	1·09	4·96	·0078	·154	·048	·212	·104
12.	81·7	·87	3·34	·0265	·112	·098	·255	·122

Taking the Uniondale soils all round, there is a general lack of lime, but a moderate supply of potash and phosphates, together with a good percentage of nitrogen. The two samples taken within the Field Cornetcy of Buffels Klip, representing the portion of the division bordering on the fertile district of Oudtshoorn, show a marked chemical superiority over the rest, for the reason already stated. No. 1, taken at Kamnassie Wagen Drift, is also a fairly good soil, and differs distinctly, both in physical and in chemical qualities, from the soils of the Long Kloof class. While not exactly deficient in any one constituent, it would be greatly improved by the addition of lime and phosphates.

The quasi-Karroo soils of this division have already been referred to, and five samples were specially mentioned as typifying this area, namely: Nos. 3, 9, 10, 11, and 12. The first three of these were collected in a north-easterly direction from the village of Uniondale. They are less fine-grained than the soils further south, are also less retentive of moisture, and contain a smaller proportion of nitrogenous material. Their supply of lime continues small—in fact, changes for the worse, but a slight improvement is noticeable in regard to phosphoric oxide, and a more distinct bettering with respect to potash. Turning further west, the area from which Nos. 11 and 12—already commented upon—is entered. Including with these five soils No. 1, we may perhaps venture to say that the northern part of the Uniondale Division is markedly superior to the kloofs in the south with respect to the inorganic plant food constituents of the soil.

VICTORIA EAST.

(Privately collected.)

No.	Field Cornetcy.	Farm or Place.	Collector.
1.	Tyumie.	Hogsback.	C. L. Harvey.

A sample of fine-grained soil, on which it was proposed to plant potatoes, was collected from the Hogsback Plateau, near Alice. The farm lies at an altitude of about 4,400 feet above sea-level. The surface soil at the locality where the sample was collected is red and loamy; the subsoil is also red, but more clayey. The farm has a local reputation on account of its good forage and potato crops, but, in order to produce these, a plentiful supply of manure is invariably found requisite: farmyard manure is practically the sole fertiliser employed in the district.

The analysis of this soil resulted as follows:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	99·6	5·87	10·72	·007	·182	·028	·038	·055

This analysis clearly shows the reason why thorough manuring is so necessary; lime and potash are both deficient, while phosphates are just above the border line of poverty.

VRYBURG.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	No. 7.	Salisbury.	E. A. Nobbs.
2.	,,	Luxmore.	,,
3.	,,	Middle Park.	,,
4.	,,	,,	,,
5.	,,	Mogogong.	,,
6.	,,	,,	,,
7.	,,	,,	,,
8.	,,	,,	,,
9.	,,	Banksdrift.	,,

The Taungs District, which is represented by the above samples, is situated at the northern extremity of the Campbell Rand, and therefore near the region of the crystalline and siliceous limestones which characterise that formation. One may accordingly expect to find a good proportion of lime in these soils, but such an anticipation is not borne out by actual results. The lime formation extends only over the Great Kaap Plateau, and practically terminates at its edge, with the Rand, below which, to the south-east, along the Harts River banks, are comparatively poor Dwyka shales—the grey and olive shales of Stow. The Taungs area extends across the Campbell Rand to the westward, and takes in part of the plateau above, but the samples of soil examined were collected only from the region of the shales, and on the bank of the river opposite to that flanked by the Campbell Rand. Even here, however, the influence of the lime formation may be noticed in certain localities (for instance in the Ganzepan and H.V.67 soils of the Barkly West Division), but for the most part the soil is poor.

The samples were collected by Dr. E. A. Nobbs, from grounds intended to be irrigated by means of a system of furrows from a canal leading the water of the Harts River. The description of the soils collected is compiled from the observations made by Dr. Nobbs on his tour. Entering the Taungs district from Barkly West, and leaving the long stretch of poor sandy ground through which the railway passes, sample No. 2, a fine and even dark grey loam, was collected on the farm Luxmore, on the slopes of the Phokwani Hills. This soil, owing to the dry season, was intensely hard, due to its fine compact texture, but not tough, and hence probably friable when wet. No. 3 represents a similar soil, although of somewhat looser texture, and was taken about 100 yards west of the 718th railway mile post, on the farm Middle Park. It is a deep, very fine-grained, and hence firm, sandy soil, of a whitish yellow colour on the surface. The veld is Karroo-like in character, and the Ganna bush is noticeable, but the entire area is not large, and appears to narrow down towards the Harts River. Here and nowhere else a tendency towards brackishness or alkalinity was observed. Three miles further north, however, the soil changes to a fine-grained deep-yellow sand over forty feet deep (as seen at the well at Railway Cottage 146). Of this soil—on which the Mimosa grows—No. 4 is a type. Chemical analysis shows it to be very poor. No. 9, taken about five miles to the north-west, at Banksdrift, is quite different in appearance, being a deep-red loamy sand of even consistency, and free from stones, friable and easily worked, but of varying depth, and lying upon shales and white sandstone; there is a very wide plain, apparently of this character throughout. For irrigation purposes, the lie of the land is ideal from this point, and over the farm Hartington; the chemical results, however, show insufficient proportions of plant food.

The farms to the south of Hartington, along the river, are generally unsuitable for irrigation purposes. A shallow sandy soil, limestone shales, sandstones, and occasionally intrusive dolerite, constitute the general nature, while along the river a hard clay, resting directly on shale, without any deep alluvial deposits, is found. A shallow soil occurs in the low levels, a hard clay overlying horizontal shale beds, and valueless for irrigation, although well covered with excellent natural grass. Such are the conditions on the farms Greefdale, Springbokfontein, Putsfontein, H.V.70, and probably also Klip Kopje, until the soil merges into that of which Nos. 1 (in the above list) and 6 (of the Barkly West Division soils) are types. No. 1 represents an even grained brown sand, typical of a wide tract of country; the sample was taken near the 710th mile post. Nos. 5 and 6 were taken, less than 100 yards apart, in the valley to the north-east of Mogogong native village. This land is stated to have yielded good crops of mealies and Kafir corn for many years. It is a red loam, verging upon the alluvial soil commonly known as "vlei-grond"; there may be from 3,000 to 4,000 acres of this land, almost flat, and surrounded on three sides by low hills. No. 5 is a rich-red sandy loam of considerable depth, and No. 6 a tough dark-red alluvial soil. Chemically the latter is far the better of the two.

On the opposite of the railway line, and about four miles south-east of Taungs railway station, Nos. 7 and 8 were collected, also near each other; the former from a mealie patch, the latter from virgin or long disused soil. These samples of red friable sandy loams were taken from the centre of a well cultivated area, covered with good crops, and of about 2,500 to 3,000 acres extent. The underlying subsoil is a yellow clayey loam of great depth. About five miles south-east of Taungs station this good land gives place to an obviously less fertile and uncultivated greyish soil, shallow, and resting upon schistose slates and sandstones, which often appear at the surface. Lime abounds there.

Just across the Harts River at this point, towards Thoming, there lies a wide, level, and apparently fertile expanse, from which, however, no samples were taken. This portion of the district would probably benefit largely by means of alluvial soil conveyed from the Campbell Rand to the west. Thoming, in fact, lies upon the limestone rocks of the Campbell Rand series.

(Privately collected.)

No.	Field cornetcy.	Farm or place.	Collector.
10.	No. 5.	Geluk.	H. Abt.
11.	No. 12.	Kuruman.	C. D. H. Braine.
12.	,,	,,	,,
13.	,,	,,	,,
14.	,,	,,	,,
15.	,,	,,	,,
16.	,,	,,	,,

A sample of somewhat sandy soil, No. 10, was collected at Geluk, about thirty miles W.S.W. of Vryburg; the remaining six soils were taken from the Crown Reserve about Kuruman township. Of the latter, three were collected within the property of the London Mission, and the other three around the Mission station. No. 11 was a red subsoil, taken two feet below the surface to the north-east of the station. No. 12 was taken from the surface near the central furrow in the middle of the Mission property; the spot was completely water-logged and overgrown with reeds. Sample No. 13 was collected in front of the Mission House, and represents a surface soil stated to have been under cultivation for over sixty years and not recently manured. No. 14 is also a surface soil, taken from the south-eastern portion of the Mission property. This ground was likewise under cultivation, but had not been manured of late. No. 15 was a subsoil, taken twelve inches below the surface, from the side of the stream in the Dakwent valley, south-east of the Mission property. No. 16 was taken three feet below the surface, outside, and south of, the Mission property, between the converging streams which join on the Mission station. It was intended to irrigate all the lands represented by these samples.

The large quantities of lime which these soils, in most cases, contain, are obviously derived from the geological formations to which Stow* gave the name of "The Campbell Rand Series." The Campbell Rand, a range of precipitous cliffs, which terminate the Great Kaap Plateau towards the south-east, and flank at first the Vaal and subsequently the Harts River for a distance of over a hundred miles from the junction of the former with the Orange River below Campbell, is composed of limestone and dolomite, which extend westwards and northwards as far as Vryburg.

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* "Notes on Griqualand West." Quarterly Journal of the Geological Society. Dec., 1874, page 613.

The results obtained by the analyses of the above described soils are as follows:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	93·8	·54	1·17	·002	·013	·034	·034	·009
2.	85·2	2·95	3·11	·003	·056	·220	·101	·063
3.	95·4	2·56	3·38	·003	·028	·162	·103	·055
4.	88·2	·51	1·31	·003	·028	·010	·030	·014
5.	73·5	1·04	2·13	·002	·013	·022	·024	·045
6.	82·5	2·47	3·91	·004	·098	·130	·118	·059
7.	76·6	1·22	2·19	·003	·013	·008	·041	·045
8.	80·9	1·78	2·47	·004	·084	·054	·074	·040
9.	73·0	·84	1·71	·003	·042	·006	·039	·032
10.	89·6	·91	1·63	·0025	·161	·062	·020	·013
11.	76·4	1·01	1·48	·0039	·029	·026	·024	·024
12.	100	13·56	38·22	·0123	1·435	3·66	·030	·132
13.	88·7	2·89	7·54	·0074	·200	4·80	·084	·088
14.	85·2	3·54	4·99	·0170	·108	6·32	·059	·056
15.	94·7	4·16	6·75	·0042	·193	14·04	·028	·059
16.	87·1	1·86	2·13	·0018	·071	·278	·068	·026

The results of the chemical analyses of the first nine soils are far from promising: taking them as a whole, the soils just escape an all-round poverty in plant-food by the fact that potash is present in fair amount. Nitrogen, lime and phosphates are all alike lacking.

No. 10 is very poor in potash and phosphoric oxide, and its lime-content leaves much to be desired. There is obviously nothing in its composition to show that it overlies the limestones of the Campbell Rand formation; on the contrary, in respect of plant-food it resembles many a Table Mountain sandstone soil, and is similarly made up of disintegrated quartzites or sandstones, which, in this case, would probably be derived from the quarzitic rocks of the Black Reef series.* A partial mechanical analysis of this soil is given under the head of "Physical composition of soils."

No. 11 is poor in every respect, and No. 16 is deficient in lime. Nos. 12 to 15 indicate soils rich in lime, and No. 12 also shows a fair amount of phosphoric oxide, but all these soils are below normal as regards potash. Of the last six soils in the above table, it will be noticed that the two samples (Nos. 11 and 16) taken two and three feet below the surface, contain very much less lime—in an available condition, at all events—than the three surface soils, Nos. 12, 13, and 14, but even these latter do not contain one half as much as No. 15, which was taken twelve inches below the surface. No. 11, it will also be observed, is the most gravelly of the six.

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* See 10th Ann. Rept. Geol. Commsision, 1905, p. 245.

WILLOWMORE.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Willowmore.	Van der Westhuyzen's Kraal.	G. Kilgour.

This sample was collected from lands which it was proposed to irrigate, on the farm Van der Westhuyzen's Kraal, adjoining the farm Klipfontein, and bordering on the Willowmore village commonage. The sample was taken in the vicinity of the southerly beacon on the first-named farm. The soil lies on a considerable and level extent of Bokkeveld beds, free from extraneous modifying influence, and should therefore be expected to yield better chemical results than even such soils as those from Wilgehouts Rivier and Roode Heuvel in the Uniondale Division.

According to the analysis below, there is a good reserve of phosphatic material in the soil in a condition available for plants:—

(Method II.)

	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through 3 mm. Sieve.		
No.	Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	2·55	4·87	·0044	·077	·336	·193	·171

WILLOWVALE.

(Officially collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Willowvale.	Government Plantation.	St. C. O. Sinclair.
2.	,,	,,	,,
3.	,,	,,	,,
4.	,,	—	,,

In the district of Willowvale three samples of soil were collected from the area intended for the Government plantation at this place. No. 1, a black clayey soil, was taken, to a depth of ten inches, from a hillside facing north. No. 2 represents a patch covered by a long coarse grass, which, in these parts, is regarded as an indication of great fertility. No. 3 is the subsoil underlying No 2. The soil in many parts of this plantation consists of a rich black earth, one to two feet in depth, below which is a layer of red gravel, containing a considerable quantity of ironstone pebbles. Under this there is a yellow pot-clay, or rock decomposing into clay.

No. 4 was a sample of black soil, taken about 12 miles west of Willowvale, and representative of a great part of the Willowvale district.

The following results were obtained by chemical analysis:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	100	1·94	6·36	·0375	·147	·016	·071	·022
2.	96·3	3·03	8·72	·0276	·203	·050	·193	·054
3.	100	2·45	6·46	·0354	·105	·024	·340	·068
4.	98·0	3·03	7·60	·0311	·175	·072	·024	·035

Here too phosphates are very low in quantity, being absolutely deficient in the first and last samples. No. 4 is, in fact, lacking in all mineral plant food. Nos. 2 and 3 contain fair proportions of phosphoric oxide, but are poor in lime; especially is this true of the subsoil No. 3; both these soils, however, have a satisfactory proportion of potash.

WODEHOUSE.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
1.	Groote Vlei.	De Boulogne.	R. F. Weir.
2.	,,	,,	,,
3.	,,	,,	,,

These three samples represent alluvial soils, and were collected on the farm De Boulogne, now known as Fair Hope, in a valley at the foot of the Stormberg Range, on the Indwe railway line, between Halseton Station and Birds River Siding. The soil is a clayey loam, apparently uniform to a depth of ten to fifteen feet. Under favourable conditions the lands have yielded heavy wheat crops, but needed frequent watering, as on drying deep cracks were apt to make their appearance.

The analyses of these soils resulted as follows:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve. Water.	Organic matter.	Chlorine.	Nitrogen.	Percentage of Soil sifted through ½ mm. Sieve. Lime.	Potash.	Phosphoric oxide.
1.	99·5	6·94	6·36	·0198	·130	·232	·341	·074
2.	98·3	10·08	10·75	·1372	·344	·852	·237	·069
3.	92·4	5·94	6·05	·0078	·158	·346	·235	·145

Here again, as in the Division of Queenstown, the soil is inclined to be brack; there are clear evidences of this in Nos. 1 and 2, if the proportions of chlorine in those soils be taken as indication. In other respects too the soils resemble those of the Queenstown Division; they are well furnished, for example, with lime and potash.

WORCESTER.

(Officially collected.)

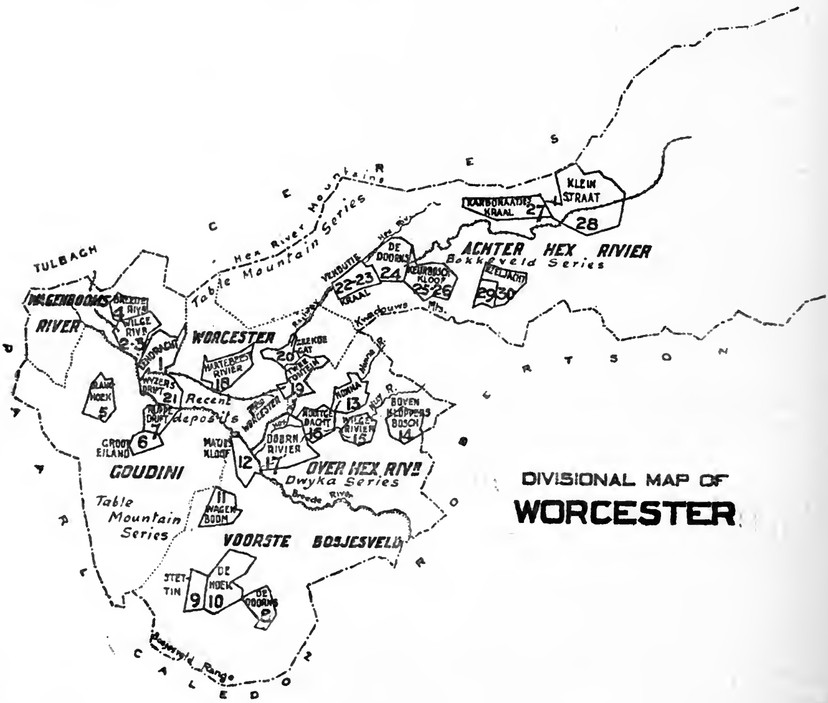
No.	Field Cornetcy.	Farm or place.	Collector.
1.	Wagenbooms Rivier.	Eendracht.	St. C. O. Sinclair.
2.	,,	Wilge Rivier.	,,
3.	,,	,,	,,
4.	,,	Breede Rivier.	,,
5.	Goudini.	Slanghoek.	,,
6.	,,	Groot Eiland.	,,
7.	,,	Klippe Drift.	,,
8.	Voorste Bosjesveld.	De Doorns.	,,
9.	,,	Stettin.	,,
10.	,,	De Hoek.	,,
11.	,,	Wagenboom.	,,
12.	,,	Matjes Kloof.	,,
13.	Over Hex River.	Nonna.	,,
14.	,,	Boven Kloppers Bosch.	,,
15.	,,	Wilge Rivier.	,,
16.	,,	Nooitgedacht.	,,
17.	,,	Aan de Doorn Rivier.	,,
18..	Worcester	Haartebeest Rivier.	,,
19.	,,	Tweefontein.	,,
20.	,,	Zeekoegat.	,,
21.	,,	Wyzers Drift.	,,
22.	Achter Hex River.	Vendutie Kraal.	J. Muller.
23.	,,	,,	,,
24.	,,	De Doorns.	,,
25.	,,	Keurbosch Kloof.	,,
26.	,,	,,	,,
27.	,,	Karbonaatjes Kraal.	,,
28.	,,	Klein Straat.	,,
29.	,,	Stinkfontein.	,,
30.	,,	Ezeljacht.	,,

Geologically, the Division of Worcester is even more varied than that of Robertson; rocks of the Malmesbury, Table Mountain, Bokkeveld, Witteberg, Dwyka, and Ecca series, as well as the surface deposits of limestone and Enon conglomerate, all find a place within the area of the division. With such a variety of rocks it is usual to find, not only soils of varied chemical composition, but also, in general, soils of considerable fertility, and this anticipation is borne out by the analyses tabulated below.

Proceeding from Cape Town by rail to the Hex River valley, five samples typical of soil under cultivation were collected. From Vendutie Kraal, the farm of Mr. W. Gie, two samples were taken—No. 22, an orchard soil, under cultivation, which had been slightly manured; and No. 23, a virgin sandy clay soil, taken from lands further up the river. Mr. Gie stated that he had used several fertilisers, and found that superphosphates gave the best results. No. 23, it will be observed, is very deficient in phosphoric oxide.

The next two samples were taken on the farm Keurbosch Kloof: No. 26, a virgin sandy clay, resembling No. 22, and No. 25, a soil of rather more clayey nature; this latter soil was, in appearance, similar to larger patches in the farms in the valley, where vines were being grown, but on a less shallow soil. It was apparently the larger amount of potash contained in this soil that led to its selection for the purpose of a vineyard. No. 24, a loose virgin sandy clay, was collected on the farm De Doorns; it was declared to be more productive than Nos. 22 and 23, and also than the soils lower down the valley. This statement probably had primary reference to the adaptability of the soil for the cultivation of vines; and in so far it is apparently correct, for of the three soils, this one is best supplied with potash, and the proportion of potash in the soil seems to increase as one ascends the valley: but there the superiority ends; in respect of other plant food, it is certainly not the best soil. This Hex River valley, so well known on account of its fine fruit, is almost covered with vineyards and orchards.

The next section of the Worcester Division to be visited, was the part bounded by the Hex River Range and the Touws River, where the following soils were sampled: No. 28 was taken on the farm Klein Straat;



DIVISIONAL MAP OF WORCESTER.

it represents a loose sandy clay soil, with a reputation for being fairly productive. It is very finely divided, as to texture, and has never been manured, although, judging from the chemical results, it is rather poor in lime and phosphates, due, evidently, to the close proximity of the sandstone mountains. On the way from here to the next farm, the sandstone formation is directly entered upon, and the poverty of the soil increases. From Karbonaatjes Kraal, No. 27, a sandy soil—found in practice to be rather poor—was collected: the chemical analysis showed it to be very deficient in plant food. The sample was taken from the centre of the cultivated land, and from the spot where the wheat, which was just then in ear, was poorest. The soil at this place is much coarser than No. 28, and affords a further instance of practical experience being abundantly confirmed by analytical results.

Crossing the line of railway, the next farm visited was Stinkfontein, about nine miles from Karbonaatjes Kraal, and six from Triangle Station. Here No. 29, an unmanured sandy clay, was taken from the orchard. There is a rather broad patch of the same soil under cultivation, and it has the reputation of being more fertile than any surrounding ground. From a chemical point of view it undoubtedly proves to be the best soil in the Field-cornetcy, and one of the best in the entire division, of all the soils analysed.

Ezeljacht, or Zout Rivier, was next touched at, and No. 30, a sample of virgin soil, taken from the corner of some lands situated along the road off the farm, and about two miles from the previous farm. The nature of the sour veld and soil is rather similar to that of No. 27, although slightly better; it is, however, less fertile than No. 28.

From the foregoing remarks, coupled with a reference to the table of analyses below, the general conclusion may be drawn that, within a certain area enclosed by lines drawn parallel to the railway on either side of it, between Triangle and Touws River Stations, the fertility of the soil increases as one approaches the Touws River. The fertile patch at Stinkfontein is an exception, and the surrounding soil is very poor. The geological formation is that of the Bokkeveld series, but the farms are flanked on either side by high sandstone mountain ranges. There is not much sowing done at any of the four farms mentioned in connection with this section of the division; they are subject to very severe frosts and cold, in consequence of which fruit trees are not plentiful, as the fruit very rarely grows to perfection. Four samples were taken to represent the Worcester Field-cornetcy; these were Nos. 18, 19, 20, and 21. No. 18 was taken from the farm Hartebeest Rivier, and typifies a clayey soil about two feet deep. Here both vines and oats are reported to do well. No. 19 was collected at Tweefontein, from one of the river terraces east of Worcester. The recent gravels and Enon formation which prevail render the soil rather coarse and sandy, but with grain it is stated to give good results, although here as elsewhere, rust has been known to damage the crop very considerably. As a rule, however, crops standing on this soil do not suffer from rust. No. 20 is a stiff red "Karroo" soil from Zeekoegat, and is regarded as suitable for vines. No. 21, on the other hand, taken from the opposite extreme of the Field-cornetcy, at Wyzers Drift—an area covered by the above-named gravels—is a sandy alluvial soil. Chemically it is very poor, although said to answer fairly well when planted with vines.

The soils of the Field-cornetcy Over Hex River are represented in Nos. 13, 14, 15, 16, and 17. Sample No. 13 was taken on the farm Nonna —a black alluvial soil—somewhat sandy—typical of much of the soil found along the Nonnas River. The subsoil is yellow and rather sandy, but where deep it proves very suitable for fruit culture; grain also appears to thrive on it. The farm Boven Kloppers Bosch is represented by soil No. 14. The local opinion was that it is a very rich soil—perhaps too rich for oats, it was said. Vines and fruit trees, as well as barley, are very successfully grown here. No. 15 is a sample of a dark fertile "vlei" soil used as a vineyard on the farm Wilge Rivier. This soil, too, is considered rather rich for oats. At Nooitgedacht a somewhat sandy brownish alluvial soil, No. 16, was taken, representing the third variety of soil found in these parts; the first variety being the Karroo soil, and the second, the dark "vlei" ground. At this place oats, wheat, vines, and potatoes—especially the latter—are stated to thrive very well. The successful culture of potatoes can be understood, as the soil is sufficiently sandy for the purpose, and potash—the kind of plant food most needed by these tuberous plants—predominates. No. 17 represents a brown soil, less sandy than the last, from the Dwyka formation on the farm Aan de Doorn Rivier. It is rather brackish, and becomes stiffer as the depth increases. At about two feet depth lime is found, overlying sand. When manured with guano, the soil represented by this sample has given good results as a vineyard. The veld around is sweet. From this sample an idea is obtained of the soils lying between the Nuy, Hex, and Nonnas Rivers.

The next tract of country visited was the Field Cornetcy Voorste Bosjesveld. Here samples 8, 9, 10, 11, and 12 were collected. In No. 8 is represented the soil of medium quality found on the farm De Doorns. This soil rests upon a clay subsoil, and, planted as a vineyard, is stated to yield good results. The farm Stettin contributed sample No. 9. The land whence it was taken gave very discouraging results when put under lucerne. The soil is somewhat clayey, overlying a white sandstone. This sample was expected to compare unfavourably with many of the previous samples, and the chemical results justify the anticipation. No. 10 was collected on the farm De Hoek, and represents a "Karroo" soil with a clay subsoil. Together with No. 17, it represents the soils of the Dwyka series in this division; these two soils have been found to contain more available lime than any others in the western part of the Division. No. 11 represents a sandy soil from Wagenboom, said to be rather fertile; it is a primary sandstone soil, and very coarse grained at that; both practical experience and chemical analysis generally find such soils to be very poor: the reputed fertility of this one is therefore somewhat enigmatical. It was intended to devote the lands represented by it to the cultivation of vines. At Matjes Kloof, No. 12, a sample of what is termed "Karroo" soil was taken. Soil of this type is being used for wheat. The "veld" in the vicinity is sweet, but the soil, which lies on the Witteberg formation, is of the poor and sandy type usually associated with the quartzites of the Witteberg series.

In the Field Cornetcy Wagenbooms Rivier, Nos. 1, 2, 3, and 4 were collected. This area forms, as it were, the root of the tongue of Malmesbury slate which protrudes between the two sandstone ranges into the Tulbagh Division.* Here, as there, it is flanked on either side by sandstone mountains, and, except for the Wilge Rivier soils, the results of the chemical analyses are similar. No. 1 is a very productive alluvial soil of good depth, taken on the farm Eendracht. Both vines and grain answer well on this soil. Nos. 2 and 3 come from Wilge Rivier, where No. 2 represents the surface soil about one foot deep, and No. 3 the underlying subsoil, a stiff yellow clay. This farm is famous for its vines; the vines endure drought well, and are planted so as to get their roots into the clay subsoil. On Mr. S. F. du Toit's farm Breede Rivier is found the soil represented by No. 4—a dark clayey soil, overlying a yellow clay. It is said to give good results with cereals, but Mr. Du Toit's intention was to utilise it as a vineyard.

In the Field Cornetcy Goudini, three soils were sampled. No. 5 was collected on the farm Slanghoek, and represents a dark clayey soil used for vines, and overlying a red clay subsoil. No. 6 was taken from a dark, somewhat sandy, alluvial soil, resting on a pot-clay subsoil, and representative of the land used as a vineyard at Groot Eiland. No. 7 was taken from the farm Klippe Drift, where a clay subsoil is brought to the surface during tilling.

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* See page 135.

(Privately collected.)

No.	Field Cornetcy.	Farm or place.	Collector.
31.	Achter Hex River	—	—
32.	,,	—	—
33.	,,	—	—
34.	,,	—	J. P. de Waal.

These additional soils were collected at various points on the property of the Cape Orchard Company, for the purpose of determining the proportions of available lime contained. The results of these determinations, together with those of the chemical analyses of the other Worcester soils above described, will be found in the table below:—

(Method I.)

No.	Percent. of Field Sample. Fine earth.	Percentage of Soil sifted through 1 mm. Sieve.				Percentage of Soil sifted through ½ mm. Sieve.		
		Water.	Organic matter.	Chlorine.	Nitrogen.	Lime.	Potash.	Phosphoric oxide.
1.	100	2·09	6·62	·0120	·158	·066	·037	·069
2.	53·7	2·19	7·55	·0099	·266	·150	·147	·093
3.	99·4	2·53	7·15	·0290	·071	·156	·015	·025
4.	83·4	1·34	3·77	·0074	·116	·086	·027	·034
5.	98·5	2·92	10·47	·0163	·203	·022	·028	·136
6.	76·3	1·27	4·30	·0255	·144	·066	·022	·171
7.	79·5	·96	2·84	·0142	·071	·024	·018	·044
8.	74·1	·62	2·48	·0130	·116	·048	·085	·052
9.	75·2	·96	3·38	·0064	·116	·044	·067	·047
10.	84·1	3·80	6·85	·0049	·137	1·640	·157	·065
11.	33·2	·17	·44	·0078	·036	·038	·015	·022
12.	70·7	·93	1·53	·0049	·071	·088	·041	·033
13.	75·5	1·45	3·64	·0219	·158	·156	·068	·063
14.	79·1	1·90	5·49	·0099	·172	·228	·084	·081
15.	87·6	2·55	6·45	·0810	·217	·262	·226	·096
16.	68·1	·44	1·13	·0237	·050	·060	·114	·035
17.	86·6	1·08	2·54	·0081	·100	·386	·119	·052
18.	70·9	·79	3·47	·0095	·081	·016	·091	·051
19.	70·0	·78	2·98	·0262	·094	·038	·158	·078
20.	89·6	1·59	4·04	·0198	·144	·260	·195	·089
21.	70·2	·56	2·00	·0163	·073	·024	·011	·034
22.	87·2	1·15	4·64	·0042	·112	·102	·077	·074
23.	88·6	·69	3·03	·0113	·091	·086	·048	·033
24.	81·6	·69	3·14	·0028	·091	·050	·113	·049
25.	71·7	·96	4·67	·0060	·105	·136	·164	·086
26.	79·0	·98	3·89	·0021	·112	·442	·139	·077
27.	52·2	·09	·57	·0046	·014	·016	·034	·024
28.	93·8	·57	3·01	·0046	·050	·022	·105	·054
29.	70·6	1·64	6·65	·0424	·182	·162	·324	·156
30.	77·0	·39	2·01	·0042	·057	·024	·077	·052
31.	79·4	—	—	—	—	·008	—	—
32.	87·7	—	—	—	—	·006	—	—
33.	82·9	—	—	—	—	·010	—	—
34.	70·3	—	—	—	—	·018	—	—

The results of these analyses of Worcester soils show that, as a rule, there is a fair amount of lime, potash, and phosphoric oxide in the soil, and also a good proportion of nitrogen. As to the separate Field Cornetcies, generalising with all due caution from these few results, we may say that there are fair quantities of all three inorganic plant food constituents in the Wagenbooms River district, which is, moreover, rich in nitrogen. At Goudini there are good quantities of nitrogen and phosphates, but the soil is poor in lime and potash. At Voorste Bosjesveld, the phosphates are deficient, but there are fair proportions of potash and nitrogen and the lime is normal in amount. The Over Hex River area shows a normal amount of potash, with lime and phosphoric oxide in fair quantity, and a good percentage of nitrogen. The potash content is also normal in the soils of the Worcester Field Cornetcy, and the phosphoric oxide and nitrogen fair, but lime is, on the whole, rather poor. The Field Cornetcy of Achter Hex River contains in its soils a fair quantity of all four constituents. Of all the soils examined in this division, only in two cases may it be said that nitrogen is absolutely deficient, namely, in the soils from Wagenboom and Karbonaatjes Kraal. These two soils are most characteristic Table Mountain sandstone soils; they are coarser in texture and less retentive of moisture than any other soil of the series; they contain smaller proportions of nitrogen, and of organic material generally; they are the poorest in phosphates, and amongst the poorest in lime and potash.

PART IV.—COMPARISON OF EXTRACTION METHODS.

Although there have been, during these investigations, but very few opportunities of comparing the relative solvent powers of different extraction media upon one and the same soil, it will still be possible to draw some conclusions from the analyses of soils which may well be assumed to be of similar chemical composition.

Of the different methods applied in the course of the investigations, two, *i.e.*, Methods III. and IV., may be expected to result in a greater solvent action than that adopted as the standard method, and one, Method v., would obviously exert a lesser dissolving power. For these reasons it seemed needless to seek by experiment for a confirmation of what was so patent; at the same time the question still remained open in what ratio the solvent action of the one exceeded that of the other, and whether, in fact, there could be said to be a definite ratio at all. Less evident, however, did it appear whether there would be any appreciable difference between Methods I. and II., and, although here again no comparative tests have been made on any particular soil, yet soils of such similar type have been treated, some by the one and some by the other method, as to afford a fairly safe means of comparing the two methods.

The only instance of comparison between Method IV. (Hilgard's) and any other, is that afforded by the four soils 21, 22, 23, and 24 from the experiment station at Robertson. These soils were extracted by Methods I., IV. and V., and in one case also a determination of lime in an aqueous extract of the soil was made. Comparing Methods I. and IV. we find that, with regard to lime, Method IV. extracted practically no more than what was extracted by Method I., in fact, it may be said that in the case of No. 21 and also of No. 24, which was a patch in the area represented by No. 22—the proportions extracted were really identical. Apparently in such cases Method I. extracted the entire reserve stock of lime, using the word "reserve" as Prof. Hilgard uses it. The lime, it must be noted, occurs here largely as carbonate. As far as concerns potash, the quantities extracted by Method IV. were, in soils 21 and 22 about five times those removed by Method I., and in No. 23 nearly four times as much, while from the brack soil, No. 24, Method IV. took out nearly seven times as much potash as Method I. removed. From the results with regard to potash obtained by Method IV. one might be disposed to infer that the soil was very well supplied with potash in an available form, but practical experiments with cereals on the farm have shown that to supply the soil with phosphates was unavailing unless potash was also given, indicating that although phosphatic fertilisers may increase the stock of *phosphates* up to the limits of adequacy, yet the law of the minimum still operated in respect to *potash*. It also illustrates the remark already made, that in this Colony results arrived at by Method IV. rather overstate the stock of available plant food in the soil.*

Turning now to Method III. we may expect to find an even wider divergence from the results of Method I., inasmuch as the solvent action on the soil is of necessity still more energetic. No comparative tests between these two methods on absolutely identical samples of soil have been made, but Nos. 1, 2, and 3 of the George Division soils, are, for all practical purposes, the same as Nos. 20, 21 and 22 in the same list: the former three were extracted by Method III., and, as pointed out when dealing with the soils of that Division, yielded much higher figures than the latter three, which were treated by Method I.† The soils of George,

* See page 12. † See page 59.

unlike those of Robertson, are acid in character, or at least in tendency, and the lime is probably present in a different state of combination: at all events, the boiling and evaporation of the soil, according to Method III., with concentrated Hydrochloric and Nitric acids, yielded from twice to six times as much lime as agitation with diluted Hydrochloric acid in the cold, as prescribed by Method I. In the case of potash the difference was even more marked, Method III. extracting from six to eleven times as much as Method I. It will be noticed that the difference between the two methods was greatest, not only with regard to lime, but also in respect to potash, in the third members of the two sets of soils, namely Nos. 3 and 22, and it was least in the second, *i.e.*, Nos. 2 and 21.

If, for the reasons already given, Method I. is locally preferable to Method IV., much more then is it to be preferred to Method III.

In addition to the three George soils, most of the samples taken in the Mossel Bay and Riversdale Divisions were extracted according to Method III. No soils from the latter two divisions have been examined by Method I., but they may be expected to yield results not widely differing from and rather below those of the Swellendam soils. The means of comparing the methods in these areas are not very full, the only Swellendam soils examined by Method I. being those of the Tradouw, in which the average proportions of lime so obtained fall greatly below those yielded by Method III. for the Riversdale and Mossel Bay soils. In this respect, as also in regard to potash, the latter show results very similar to those obtained from the George soils by the same method, and so the general conclusion may be drawn that the method yields results too high to be sufficiently comparable with those attained by natural methods, and hence that considerable diminutions will have to be made in its figures if the chemical aspects of soil fertility are to be judged by them. The proportions of lime and potash, for instance, yielded by No. 5 of the Mossel Bay Division soils, poor and acid as it is reputed to be, would, if obtained by Method I., have gained for it the declaration of being a soil adequately provided with these plant food elements, and practical experience would have dissented from such a view. A similar observation may be made regarding Nos. 16 and 17 of the Mossel Bay soils, and Nos. 18 and 24 of those from Riversdale.

The obvious reasons for discarding methods which were inherently more energetic than that eventually adopted did not seem to apply to Method II., and hence it was given a somewhat extensive trial. It is difficult to conceive why it should have yielded results frequently so much higher than those of Method I. In both cases the extraction process has been conducted, at the ordinary temperature, with almost similar proportions of acid to soil, the acid used being, in Method I., approximately of 23½ per cent. strength (1·115 sp. gr.) and 25 per cent. (1·126 sp. gr.) in Method II.: in fact this, and the sifting of the soil through a 3 m.m. instead of a ½ m.m. sieve are the only apparent reasons for the higher proportions both of potash and lime obtained from the soils by the latter method.

In the Witteberg soils of the Albany Division, for instance, an average percentage of ·1 of lime was obtained by Method II. Only in soils of fairly good fertility has this proportion been yielded when the first method was made use of. In the sandstone soils of Humansdorp, too, such a result was noticed.

The high results obtained in some cases by Method II. are noticeable in the soils from the Bredasdorp Division, practically all of which were examined by this method (the single exception analysed by Method I. yielding lower results) and in those from the Caledon Division, although it is to be observed that even by Method II. the Caledon soils show up badly. In the Cape Division, too, it will be seen that the analyses by Method II. give much higher results on the whole than those by Method I. Clanwilliam and Knysna are Divisions where the Table Mountain sandstone series predominates; and yet here too the second method of extraction took considerably more lime and potash from the samples subjected to this treatment than could have been done by crops. In the sandy soils of Eerste River in the Stellenbosch Division this difference is also visible.

In the Hanover soils may be noted the large quantities of lime extracted by the second method from soils belonging to the Karroo system. No analyses of any soils from this area have been made by the first method, but where that method was applied to soils of more or less the same nature, for instance those from the neighbouring districts of Aliwal North, Albert, Graaff-Reinet, Richmond, and Colesberg, more limited proportions of lime were extracted. In the Division of Steynsburg, where a number of soils were analysed by both these methods, a similar disproportion with regard to lime will be noticed.

Something of the same kind may be observed in respect to the soils of the Robertson Division, where, however, the geological formation belongs to a different system. The Robertson soils analysed by Method I. showed a distinctly lower average of lime.

The amounts of the phosphoric oxide extracted by Method II. do not differ materially from the proportions extracted in cases where Methods I., III. and IV. were applied: in these latter cases, it will be noted, the phosphoric oxide was not determined in the hydrochloric acid extract, but was extracted by a special process.

In one case (a granite soil from Kuiken Vallei, Stellenbosch Division) the extraction process was varied, boiling Hydrochloric acid being employed: apparently, however, no larger quantities of plant food constituents are thus removed from the soil than by Methods II. and III., but it is difficult to avoid coming to the conclusion that the method adopted as a standard, fitting in as it does so well with the opinions of practical men, is, on the whole, a much safer guide.

Of course, it is evident that, under certain circumstances, Methods II., III. or IV. may not extract from the soil any more of a certain plant food constituent than Method I.; but that may be because Method I. extracts all that there is to extract. This may be expressed by saying that in such a case probably all of that plant food constituent in the soil falls easily within the limits of what has been termed grade II.* or the reserve stock.

The poor Witteberg soils of Albany, which yielded so small amounts of phosphoric oxide to Hydrochloric acid, naturally could not be expected to show to advantage by the citric acid method, and the results thus obtained are of course exceedingly low, but one of the three soils, which gave a fair proportion of phosphoric oxide on extraction by Method III., yielded ·026 by Method V., in other words the result was well over Dyer's proposed minimum limit of ·010 per cent.† In one of the soils collected at Elsenburg, Stellenbosch Division—both potash and phosphoric oxide showed poorly—only ·024 per cent in each case—by Method I.: in this instance Method V. yielded ·017 per cent of potash, but only ·0036 per cent. of phosphoric oxide, while extraction with water gave only ·0013 per cent. of the latter. The soil was, according to both methods, clearly lacking in both these two elements of plant food. The three soils from the Herbert Division extracted by Methods I. and V. afford further instance of mutual confirmation. On the basis of Method I., soil No. 1

* See page 9. † See page 17.

has a fair reserve of potash and phosphates, but not much to spare: No. 2 has about double that quantity in reserve, and is therefore satisfactorily supplied: No. 3 is just on the border of potash-poverty, but has a moderate supply of phosphoric oxide. Judging, by Method V., of the immediate availability of these constituents, No. 2 again is satisfactory both in potash and lime, No. 1 has about half the proportions of each, and No. 3 is particularly weak in phosphates. In each of these three soils the proportions of potash extracted by Method V. was about one-sixth that extracted by Method I., and in two cases out of the three the latter method gave about three times as much phosphoric oxide as the former.

Of the four Robertson soils, Nos. 21, 22, 23 and 24, No. 23, which proved the best when examined by Method I., also turned out the best when extracted by Method V., but all of them are lacking in reserve of phosphates when judged on the basis of the former method, and in immediately available phosphates on the basis of the latter method. Method V. extracted from one-sixth to one-third as much potash, and from one-sixth to one-twelfth as much phosphoric oxide as the standard method. The lime extracted by Method V. was practically the same in amount as that taken out by Method I., indeed, strange though it may seem at first sight, in two cases, Nos. 21 and 22, the citric acid method extracted slightly more lime than the Hydrochloric acid method. This is explained by the fact that the lime in the soil consists chiefly of carbonate and so dissolves readily in either acid, and that the soil sifted through the 3 m.m. sieve, for the purpose of Method V., would contain a larger proportion of the coarser grades than the $\frac{1}{2}$m.m. product used for Method I., and hence more calcium carbonate, since the coarser particles in this case consisted almost wholly of that material.

PART V.—GEOLOGICAL RELATIONS AND PLANT FOOD.

When these soil investigations were commenced the work of the Geological Commission had not advanced to the stage it has now attained, and the results of that work were not available, as they are at present, for the purposes of our own investigation. The Geological survey of the Colony cannot but be of great worth to the scientific agriculturist, the more so when supplemented by investigations such as these; in fact, it is not too much to say that, in great part, it becomes thus fully valuable only when so supplemented. The detailed and instructive maps issued by the Geological Commission, showing, in very many cases, the boundaries of the farms surveyed, cover largely the ground traversed by the chemical staff, and are comparable with the maps issued by my own office, in connection with which it has ever been the endeavour to mark, as accurately as possible, the farm boundaries and all localities whence samples of soil have been collected. Hence the soils analysed can often be assigned to their proper geological formations, and deductions can be drawn accordingly. Facilities were thus afforded whereby it became possible to arrange the figures in the subjoined tables in classified lists.

Before any further reference is made to these figures, the extreme difficulty of obtaining samples of soils typical of definite geological formations must be mentioned. It does not need much discernment to classify as a Table Mountain series soil one taken from the top of Table Mountain, or as a Malmesbury series soil one from the upper slopes of Lion's Rump. But when a valley composed of beds of the Bokkeveld series is flanked by sandstone mountains, it becomes less easy to predicate to what extent each has influenced the chemical nature of the soil; still more complicated is the problem when dealing with such districts as Robertson, where, in parts, quite a large number of rocks contribute to the formation of the soil.

Had the samples of soils examined been so selected as specially to typify certain definite geological series, it is highly probable that ere now much more would have been learnt regarding the nature—from the farmer's standpoint—of the soils derived from each of these series; but circumstances have all along rendered any such system of collection impracticable; indeed, geographical rather than geological considerations perforce ruled the selection of areas to be investigated.

In spite of the fact that conditions were not propitious for the selection of typical samples, it has been possible to sort out from the many soils that have been analysed some to typify various geological formations, and the chemical composition of the soils so sorted out on the whole bear out the reasonableness of the classification. For the purpose of these comparisons only analyses conducted by the standard method adopted in our laboratories have been made use of.

I propose, first of all, to consider the soils derived from the geologically oldest rocks, and to follow the upward sequence thence, as circumstances permit, ending with the superficial deposits.

Beginning, then, with the pre-Cape rocks, as the Geological Commission has termed them, which underlie the Table Mountain and correlated series, the soils derived from the Malmesbury series require first notice. No analyses, performed by the standard method, of sufficiently typical soils collected within the Division which gives its name to this geological series, are available, but from the Malmesbury beds of the Cape, Paarl, and Stellenbosch Divisions, the sixteen soils enumerated below were taken, in such places as to be practically representative. The series of rocks from which these are derived consists mostly of hard, close clay slates; the chemical composition of the latter is, for the most part, silicate of alumina, and, therefore, practically void, not only of actual plant *food*, but even of plant food *constituents*.

Attention is directed chiefly to the percentage proportions of lime, potash, and phosphoric oxide in the soils, but there are also incorporated in the list the percentages of moisture retained in the air-dried soils: this is expressed in terms of the soil sifted through a 1 mm. sieve, while the determinations of plant food are calculated upon the fine earth. The percentages of this fine earth in the sample, as collected in the field and air-dried, are also given below.

I. Malmesbury Series.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Cape.	Hooge Kraal.	82·1	1·78	·608	·887	·046
,,	,,	82·4	1·33	·107	·551	·035
Paarl.	Matjes Kuil.	51·0	·29	·024	·010	·017
,,	Groenfontein.	81·2	·67	·012	·029	·027
,,	Kuilenberg.	53·6	1·13	·072	·045	·061
,,	,,	55·1	1·72	·100	·073	·055
,,	Lange Rug.	65·3	1·11	·034	·041	·046
,,	Knolle Vallei.	79·6	1·72	·098	·044	·056
,,	,,	68·7	·32	·012	·013	·010
,,	Driefontein.	50·6	·52	·022	·048	·019
,,	Burgers Drift.	60·3	1·20	·026	·075	·054
,,	Dryvers Vallei.	51·8	1·48	·014	·039	·055
,,	Lange Hoogte.	55·8	·63	·010	·042	·027
Stellenbosch.	Elsenburg.	80·2	·95	·065	·024	·024
,,	,,	57·7	·63	·044	·024	·050
,,	Nooitgedacht.	92·2	·81	·008	·039	·046

These Malmesbury series soils, it will be noticed, exhibit, almost throughout, an all-round poverty in plant-food. The first on the list, however (which is No. 33 of the Cape Division soils, whereof some details were given on page 43), stands out markedly from the rest on account of its higher plant-food content. The pebbles associated with this soil point to its being derived from a rock of almost uniformly dull greenish grey tint, and differ clearly from the various coloured fragments found in connection with the next soil (No. 34), which includes brighter red sandy ironstone* and white quartz. The unusual richness—for this part of the country—of the former soil makes it desirable to trace its geological horizon more closely, but for the present, owing to imperfect knowlegde of the sequence within the Malmesbury series, it must suffice to record the existence therein of beds capable of producing soils of more than ordinary quality. The percentages in the above sixteen soils average as follows:—

	All-inclusive.	Omitting the first two soils.
Lime	·079	·039
Potash	·124	·039
Phosphoric oxide	·039	·039

Commencing near the village of Robertson, a tongue of the Malmesbury beds runs at first westward for about thirty miles, and afterwards northwards, as a depression between two sandstone ranges, for a distance of nearly forty miles, forming the Tulbagh valley. (See sketch map attached.) As will be pointed out later on, when dealing with the soils of the Table Mountain series, the soils of the northern portion of this valley, being practically encircled by mountains composed of Table Mountain

* Some of which contain flakes of white mica (muscovite) pointing to granitic origin.

sandstone, are bound to be poor all round. It would, in fact, be difficult to understand whence they could derive any natural fertility: the root of the tongue, nearer Worcester, is less dominated by the sandstone, and the calcareous matrix of the Enon conglomerate, which prevails there, exercises an undoubtedly advantageous effect upon the soil. The following are the analyses of the soils collected from this strip, beginning with the sandstone-encircled tip and working downwards:—

II. Tongue of Malmesbury Series extending from the vicinity of Robertson to the Winterhoek Mountain North of Tulbagh.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Tulbagh.	Misgund.	73·4	·95	·044	·032	·023
,,	Knolle Vallei.	61·4	1·49	·068	·038	·047
,,	,,	98·7	5·75	·008	·030	·023
,,	Kluitjes Kraal.	94·8	2·92	·070	·095	·070
Worcester.	Breede River.	83·4	1·34	·086	·027	·034
,,	Wilge Rivier.	53·7	2·19	·150	147	·093
,,	Eendracht.	100	2·09	·066	·037	·069
,,	Hartebeest Rivier.	70·9	·79	·016	·091	·051
,,	Zeekoegat.	89·6	1·59	·260	·195	·089
,,	Tweefontein.	70·0	·78	·038	·158	·078
,,	Nonna.	75·5	1·45	·156	·068	·063

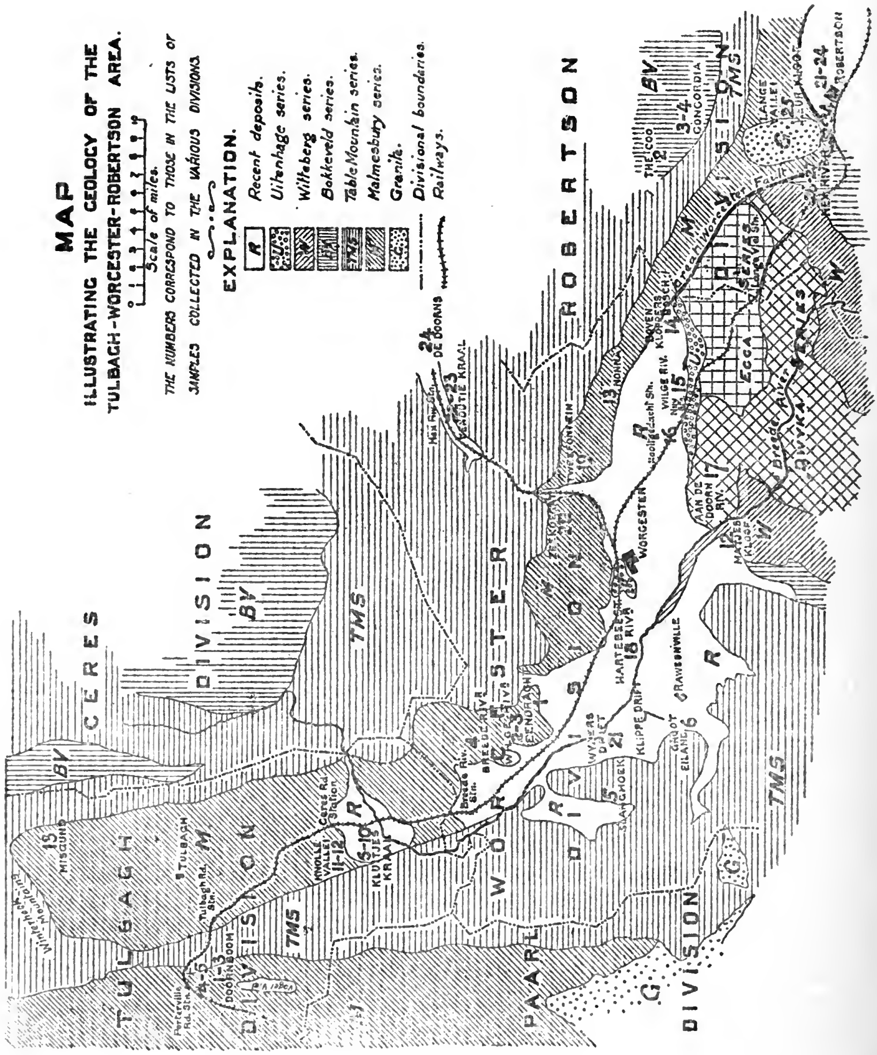
In many places the soils resulting from the rocks of the Malmesbury series are diversified by the intrusion of granite. The consequent diversity is more than becomes evident at first sight, for, although poverty in plant food is practically inherent in the soils of the Malmesbury series, it is otherwise with those derived from granite. The latter possess at least the *potentiality* of fertility. This is owing to the fact, that, while the Malmesbury rocks are deficient in plant food constituents, the intrusive granite is not, and thus the resulting granitic soils impart to the clay slate soils, when mixed with them, not only plant food *constituents*, proportionate to the relative quantities in which the two classes of soil are mixed, but also actual plant *food*, proportionate to the amount of decomposition that the granite has undergone. Where the granite has not been sufficiently decomposed, the elements of fertility contained in its constituent minerals are not available for the plant. In other words, sufficiency of plant food *constituents* may then be present in the soil while there is lack of plant *food*. The diversification of the clays derived from the Malmesbury slates, consequent upon the introduction of granite as a soil-forming factor, is therefore dependent not only on the relative quantities wherein these two classes of rock contribute to the formation of any particular soil, but also on the stage which the mechanical disintegration and chemical decomposition of the granite has reached.

These facts naturally add to the difficulty of laying down anything like a typical composition even for unmixed granite soils. Of several granite soils that had been analysed by Professor Hahn, in one—an alluvial soil—the constituent minerals of the granite had completely decomposed, and the results of the analysis of this soil were:—

Lime	·281
Potash	·151
Phosphoric oxide	·172

The averages of the others, which were primary granitic soils, twenty in number, were:—

Lime	·037
Potash	·025
Phosphoric oxide	·014



It was not, let it be emphasised, that the latter *contained* less lime, potash, and phosphoric oxide than the former, but that those substances were largely present in the first soil in the condition already (see page 9) described as grade II., whereas in the others the greater part existed as plant food constituents of the third grade. With this explanation there should be no cause for surprise that most of the nine primary granite soils whose analyses follow are shown as deficient in mineral plant food.

III. Granite Soils.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
George.	Diepkloof.	94·7	·97	·028	·034	·020
Malmesbury.	Alexanderfontein.	72·0	1·57	·146	·121	·061
,,	,,	73·8	1·15	·072	·075	·072
,,	,,	80·0	1·47	·096	·095	·073
,,	,,	72·2	1·01	·014	·114	·049
,,	,,	68·0	1·09	·014	·045	·028
,,	,,	76·0	1·28	·014	·095	·055
Paarl.	Vredehof.	61·5	·87	·034	·014	·055
Stellenbosch.	Neethlingshof.	69·1	1·26	·024	·023	·018

The averages of these soils work out as follows:—

Lime	·049
Potash	·069
Phosphoric oxide	·048

The result of the partial decomposition of the felspar contained in the granite is seen in the relatively larger percentage of potash when these analyses are compared with those of the clay slate soils, and to such a cause may also be due the relatively large proportions of potash in the two Hooge Kraal soils of the Malmesbury series.

More recent, geologically, than the slates of the Malmesbury series, are what have been termed the Cango beds, in the Oudtshoorn Division. They consist of quartzitic pebbles embedded in a slaty matrix, which at some places becomes calcareous. It may be expected that the former type will produce a comparatively poor soil, while a correspondingly better class of soil will be produced where the calcareous matrix prevails. Unfortunately, the sandstone range of the Zwartbergs so overshadows the localities whence were collected the only three of our samples which represent the area of the Cango beds, that the exact extent to which they typify these beds cannot yet be arranged. The following are the three soils referred to:—

IV. Cango Beds.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Oudtshoorn.	Lemrick.	58·6	1·11	·068	·194	·123
,,	Welgevonden.	76·0	1·90	·084	·144	·067
,,	Matjes Rivier.	61·6	3·15	7·460	·087	·166

Nothing need be said to lay stress on the great difference between the first two and the last of these three soils.

We have now to turn our attention to a class of soils of still more pronounced calcareous type. As in the south-western corner of the Colony the pre-Cape rocks comprise largely the Malmesbury clay-slates and shales, so in the northern part we have the series of rocks which, over thirty years ago, Stow associated with the name of the Campbell Rand,* and into the composition of which limestone and dolomite enter largely. In the soils representative of this series we would consequently expect to find large quantities of lime. Here and there, however, the effects of the

* See page 143.

quartzites and sandstones of the superimposed Griquatown series, not to mention the vast superficial deposits of sands and surface quartzites, become apparent, and considerably diminish the proportions of available lime.

The following table shows the results of analyses of these soils:—

V. Campbell Rand Soils.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Vryburg.	Kuruman.	76·4	1·01	·026	·024	·024
,,	,,	100·	13·56	3·66	·030	·132
,,	,,	88·7	2·89	4·80	·084	·088
,,	,,	85·2	3·54	6·32	·059	·056
,,	,,	94·7	4·16	14·04	·028	·059
,,	,,	87·1	1·86	·278	·068	·026
,,	Geluk.	89·6	·92	·062	·020	·013

Stow† distinguished between the rocks of this series and the olive shales, as he termed them, deposited unconformably over the ancient schistose rocks underlying the crystalline limestone of the Campbell Rand. The analyses given in the next table are those of soils which may be taken as representing this deposit of shales.

VI. Quartzites and Shales East of Campbell Rand (Stow's Olive Shales).

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Hopetown.	Fluitjes Kraal.	90·0	·73	·048	·065	·020
Barkly West.	H.V. 75.	97·3	·66	·020	·046	·013
,,	,,	94·6	·63	·036	·035	·014
,,	Ganzepan.	94·6	4·74	3·768	·187	·101
Vryburg.	Salisbury.	93·8	·54	·034	·034	·009
,,	Middle Park.	95·4	2·56	·162	·103	·055
,,	,,	88·2	·51	·010	·030	·014
,,	Mogogong.	73·5	1·04	·022	·024	·045
,,	,,	82·5	2·47	·130	·118	·059
,,	,,	76·6	1·22	·008	·041	·045
,,	,,	80·9	1·78	·054	·074	·040
,,	Banksdrift.	73·0	·84	·006	·039	·032

Although one or two of the soils enumerated in Table VI. are of fairly good quality, nearly all of them show a deficiency in potash and phosphoric oxide, while several lack lime as well. The Ganzepan soil forms a remarkable exception, and its chemical richness is doubtless due to the fact that it was collected at the very foot of a great doleritic outcrop, from a valley whose brown loam is evidently largely derived from the surrounding dolerites. For this reason it would be misleading to include the soil referred to amongst the averages of the above shale-derived soils, which are as follows:—

Lime	·048
Potash	·055
Phosphoric oxide	·031

† Geol. Soc. Quarterly Journal, Dec. 1874.

The above table of shale soils has been taken out of its proper geological order because of the local association of these soils with those of the Campbell Rand. Strictly speaking, it should be considered along with the soils of the Dwyka series, of which these shales seem to form part: chemically, however, the above soils differ greatly from the Dwyka soils examined; to these reference will be made at a later stage.

Another geological formation which it will be convenient to allude to here, but which belongs to a much earlier geological age, is that of the Pniel Volcanic series, a group of rocks that make their appearance still further east, *i.e.*, on the opposite side of the shales to the Campbell Rand. From this formation the soils enumerated in the following table were collected:

VII. Pniel Volcanic Series.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Barkly West.	Brady's.	92·2	·94	·044	·050	·031
,,	,,	84·4	1·16	·020	·112	·045
,,	Patrys Kraal.	83·4	2·02	·082	·056	·038
,,	,,	93·4	3·33	·240	·123	·031
,,	Zwartputs.	98·3	·79	·020	·037	·022
,,	,,	96·8	2·02	·082	·056	·038
,,	H.V. 67.	96·6	6·82	1·037	·054	·195
,,	H.V. 63.	97·6	6·03	·461	·027	·154
Vryburg.	Luxmore.	85·2	2·95	·220	·101	·063

The Pniel group underlies the limestones of the Campbell Rand series, and, including as it does amygdaloids and diabase, it appears to be capable of producing chemically rich soils, but only under the condition already pointed out in conection with the granite soils,—mere disintegration does not suffice; it needs to be accompanied by chemical decomposition in order to render the resulting soil fertile.

The following are average results of the analyses of the Pniel series soils:—

Lime	·245
Potash	·068
Phosphoric oxide	·069

Of the rocks of the Cape system, the lowest are those of the Table Mountain series. Table Mountain sandstones and quartzites constitute the greater part of the lofty mountain ranges which extend for hundreds of miles along the south-western part of the Colony: they tower above all other rocks for very many miles around, and it is, therefore, a safe assumption to make that the virgin soils, collected from these high altitudes, are quite uninfluenced by any other geological formations. Furthermore, the rocks of the Table Mountain series consist of little else than silica, namely, sandstones and quartzites, with occasional shales. It may accordingly be anticipated that the soils thence derived will not be of very complex chemical composition, but will, on the contrary, lack the essential elements of plant food. Such we actually find to be the case. The following is a table of analyses of 46 soils collected either directly from areas formed of this sandstone, or from valleys so completely dominated by ranges of the Table Mountain series as to render it practically certain that no other rocks could have appreciably contributed to their composition.

VIII. Table Mountain Series Soils.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Bredasdorp.	The Hope.	90·6	1·75	·064	·017	·045
Caledon.	Gloria.	73·5	·47	·010	·017	·037
,,	,,	64·3	·86	·006	·008	·028
,,	,,	52·5	·34	·008	·008	·015
,,	Geelbeks Vlei.	81·6	·58	·044	·014	·009
,,	Isaaks Rivier.	—	1·01	·014	·09	·05
Ceres.	Riet Vallei.	97·0	·36	·072	·015	·022
,,	,,	80·7	·37	·010	·015	·028
,,	,,	98·3	·27	·010	·012	·010
,,	,,	98·0	·56	·008	·017	·032
George.	Outspan Reserve	97·8	1·62	·034	·016	·022
,,	Woodville.	98·2	1·41	·024	·010	·015
,,	Diep River.	97·0	1·12	·026	·016	·031
,,	Grootfontein.	66·8	2·78	·040	·041	·095
,,	Schoonberg.	81·9	2·84	·030	·066	·068
Knysna.	Geelhoutboom.	96·0	1·17	·032	·012	·020
,,	Roode Kraal.	98·5	·86	·044	·011	·013
,,	Balmoral.	94·7	·97	·050	·014	·018
,,	Millwood.	96·6	1·59	·074	·017	·031
,,	Portland Heights.	95·6	3·84	·032	·028	·056
,,	Portland.	98·2	1·27	·028	·014	·046
,,	Ashby.	97·0	·66	·028	·023	·010
,,	Holt Hill.	98·0	1·20	·082	·030	·018
Oudtshoorn.	Saffraan River.	76·3	·40	·074	·035	·040
Paarl.	Keerweder.	77·9	2·16	·010	·039	·042
,,	,,	70·4	1·40	·042	·087	·042
,,	La Dauphine.	57·8	81	·008	·013	·038
,,	La terre de Luque.	65·1	·97	·008	·013	·022
,,	,,	56·9	1·56	·006	·015	·017
,,	Zand Drift.	86·3	1·41	·058	·019	·038
Robertson.	Concordia.	66·4	·81	·030	·027	·036
,,	,,	62·4	·59	013	·060	·045
,,	Rietvallei.	60·3	·21	·010	·036	·010
Swellendam.	Tradouws Hoek.	76·8	·77	·024	·033	·023
Tulbagh.	Doornboom.	24·4	·27	·008	·020	·019
Uniondale.	Gold Diggings.	57·1	1·78	·054	·050	·077
,,	Avontuur.	83·4	·71	·058	·030	·036
,,	Misgund.	35·8	·76	·050	·062	·052
,,	Klipheuvel.	94·2	·74	·030	·038	·026
,,	Krakeel River.	92·4	1·07	·040	·054	·044
Worcester.	Slanghoek.	98·5	2·92	·022	·028	·136
,,	De Doorns.	74·1	·62	·048	·085	·052
,,	Stettin.	75·2	·96	·044	·067	·047
,,	Wagenboom.	33·2	·17	·038	·015	·022
,,	Vendutie Kraal.	88·6	·69	·086	·048	·033
,,	Karbonaatjes Kraal.	52·2	·09	·016	·034	·024

It will be observed that in no single instance does the reserve stock of either lime or potash rise as high as ·1 per cent., and only in one case, that of the soil from the farm Slanghoek, in the Worcester Division, does the percentage of phosphoric oxide exceed ·1. The average percentages of the reserve plant food in these 46 sandstone soils are as follows:—

Lime	·034
Potash	·031
Phosphoric oxide	·036

Lying comformably above the Table Mountain series are beds of what is known as the Bokkeveld series. These consist of alternate layers of shales and sandstones, the lower bands of the series being fossiliferous. It would, perhaps, have been difficult to predict, without previous practical agricultural experience, what would be revealed by chemical analysis of soils derived entirely from the Bokkeveld beds; nor is it easy to tabulate—bearing in mind the circumstances under which the samples were collected—a list of soils formed solely from the beds in question; for, to the reasons which operate against this in other cases, there must here be added this, that the Bokkeveld beds occur *mostly* in valleys, and the resulting soils are, therefore, as a general rule, diluted, or otherwise influenced, by the disintegration and decomposition products of the rocks composing the surrounding hills and mountains. Hence, there are very special difficulties involved in sorting out many Bokkeveld soils that could really be called typical, from the samples that have been dealt with in our laboratories. I have, however, made a choice of eighteen, which may fairly be considered to represent solely Bokkeveld-derived soils; the results of the analyses of these are given in the following table:—

IX. Bokkeveld Soils.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Ladismith.	Buffelsfontein.	86·8	1·66	·150	·274	·073
Robertson.	Harmonie I.	80·5	1·23	·122	·153	·079
,,	Harmonie II.	83·9	1·07	·564	·095	·047
,,	Het Kruis.	80·8	1·13	·114	·250	·120
,,	,,	95·2	1·49	·742	·202	·193
,,	Baden.	49·3	1·93	·808	·331	·148
,,	,,	94·7	1·28	·600	·247	·139
Swellendam.	Poortfontein.	62·7	·31	·046	·176	·036
,,	Uitvlugt.	81·0	2·04	2·518	·416	·234
,,	Doorn Rivers Vallei.	72·8	1·21	·042	·262	·134
,,	,,	80·3	1·18	·106	·272	·151
,,	Lemoens Hoek	89·0	1·21	·170	·197	·122
Uniondale.	Kamnassie Wagen Drift.	57·9	1·54	·102	·182	·095
,,	Wilgehouts Rivier.	93·2	1·09	·048	·212	·104
,,	Roode Heuvel.	81·7	·87	·098	·255	·122
Worcester.	Keurbosch Kloof.	71·7	·96	·136	·164	·086
,,	,,	79·0	·98	·442	·139	·077
,,	Stinkfontein.	70·6	1·64	·162	·324	·156

On comparing the above Tables VIII. and IX., it immediately becomes plain how greatly the Bokkeveld soils differ from those of the Table Mountain series. While the proportions of lime, potash and phosphoric oxide practically never *exceed* ·1 per cent. in the sandstone soils, they rarely fall *below* that figure in the typical soils of the Bokkeveld series. The average percentages of plant food in these eighteen soils work out as follows:—

Lime	·387
Potash	·231
Phosphoric oxide	·118

It is difficult to say, in default of a previous thorough investigation of soils which are *known* to be productive in this Colony, what proportions of plant food may be considered to render a soil either chemically rich or of normal fertility, but, basing our opinions on European and American standards, we may affirm that, while the sandstone soils shew an all-round poverty, our analyses reveal the average Bokkeveld soil to be satisfactorily provided with all three of the essential inorganic elements of plant food.

Just here we touch upon a somewhat curious feature. As far as can be gathered, the soils in Table VIII. represent undoubted sandstone soils, and those in Table IX. purely Bokkeveld soils, but in various localities a number of soils have been taken from near the line of junction between the Table Mountain and Bokkeveld series. In some of these instances the underlying rock belongs to the former series, in others to the latter, but in both cases a peculiarity is noticeable in the composition of these "junction" soils, the nature of which will become evident upon glancing through the next table.

X. Bokkeveld near Junction with Table Mountain Sandstone; or *Vice versa.*

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Ladismith.	Papenkuilsfontein.	60·5	·64	·056	·136	·042
Robertson.	Donkerkloof.	90·1	1·08	·064	·126	·061
,,	,,	80·9	·65	·032	·180	·068
,,	Harmonie I.	70·2	·98	·016	·147	·050
,,	Het Kruis Pad.	71·1	1·20	·038	·125	·079
,,	,,	64·7	·90	·050	·078	·074
Swellendam.	Het Goed Geloof.	62·5	2·00	·074	·210	·201
,,	Barrydale.	83·4	1·16	·040	·250	·096
Worcester.	De Doorns.	81·6	·69	·050	·113	·049
,,	Klein Straat.	93·8	·57	·022	·105	·054
,,	Ezeljacht.	77·0	·39	·024	·077	·052

Unfortunately, not more than eleven soils are available for the purpose of illustrating the point involved. It will, however, be seen that, while these eleven soils resemble those of the Table Mountain series in regard to the amounts of lime and phosphoric oxide contained, they approach the Bokkeveld soils in respect of their potash content. This feature is, perhaps, better distinguished on taking the averages, which, for Table X., are as follows:—

Lime	·042
Potash	·141
Phosphoric oxide	·075

If these were simply Bokkeveld soils diluted by alluvial sand from the Table Mountain series, one would expect a lowering of *all* three of the plant food constituents in the *same proportion*; but, as we see, the reduction of lime and phosphoric oxide is proportionately much greater than that of the potash. It was puzzling at first to account for this, but one explanation seems feasible. Dr. Corstorphine, in his second report on the Geological Survey of the Colony,* remarks on the distinctive character of the lowest beds of the Bokkeveld series, which enables one with little or no difficulty to draw the line of separation between it and the Table Mountain series below. The basement beds of the Bokkeveld series, he says, are felspathic and micaceous, and quite different from the hard compact quartzite of the older series. I am not aware whether it is *potash* felspar that is here alluded to, and our analyses, as before observed, do not furnish data with regard to the *total* amounts of the plant food constituents in the soil, but it seems just possible that in this fact lies the explanation of the predominance of potash in what appear to be primary soils collected near the common horizon of the two series. It would certainly be of interest to investigate the subject more closely, so as to confirm or disprove the hypothesis here suggested. For this purpose samples of soil would have to be collected in such a manner as to render it absolutely certain that they were primary soils representing the vicinity of the line of junction; in the past the collection of soils has been carried on largely without regard for geological considerations. The time has now arrived, I think, for greater precision in this respect.

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* Ann. Rept. Geol. Commission, 1897, p. 16.

It may be pointed out just here that one of the soils classed as a true Bokkeveld soil, viz., that from Poortfontein, in Table IX., bears a considerable resemblance in chemical composition to those enumerated in Table X. Its potash, compared with the deficiency of lime and phosphoric oxide, is high, but not so high as the general run of true Bokkeveld soils, and in both lime and phosphoric oxide it is the poorest of the Bokkeveld soils. It has been here classed among the latter because of its geographical position, but it would appear almost certain, upon the basis of the reason just stated, that it must have been derived from the basement beds of the Bokkeveld series.

Above the Bokkeveld beds, and therefore geologically of more recent date, are those of the Witteberg series. They consist of quartzites associated with shales, and the soils thence derived would, therefore, be expected to conform in chemical character with those resulting from the older Table Mountain series. I regret that only four of the soils analysed in our laboratories can be assigned with any definiteness to this formation. The results of their analyses are as follows:—

XI. Witteberg Soils.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
King William's Town	Evelyn Valley.	97·5	6·26	·050	·082	·105
Ladismith.	Elands Vallei.	85·3	·93	·036	·071	·068
Victoria East.	Hogsback.	99·6	5·87	·028	·038	·055
Worcester.	Matjes Kloof.	70·7	·93	·088	·041	·033

On account of their fewness, it would scarcely be permissible to compare these four soils with the forty-six derived from the Table Mountain series; but, as has already been remarked, it is one of my purposes to point out the need of greater exertion, and, on that ground, it may not be unfitting to emphasise paucity of information, so as to induce fuller investigation. There are vast tracts of country dominated and influenced by ranges of mountains built up of the Witteberg beds, and, if the investigations proposed by me over a dozen years ago had been both embarked upon and prosecuted with the alacrity fondly pictured at the start, it is possible that the soils of extensive areas would ere now have been mapped out in such a way as to shew, at all events in some respects, how they answer chemically to the requirements of fertility.

These observations come in most suitably just at this stage, because it was precisely in connection with the Witteberg soils that I was first led to propose to the Government of the day that a systematic agricultural survey of the Colony's soils should be taken in hand, impelled thereto by the results of analyses I had made of soils from the Albany and Humansdorp Divisions, in both of which areas that bone disease in stock, vernacularly termed "lamziekte" (literally "lame sickness") prevailed.

The soils of a great part of the Albany Division, and of the adjoining divisions of Bathurst and Willowmore, are apparently largely derived from the quartzites of the Zuurberg range, a mountain chain entirely built up of the Witteberg series; while almost throughout the whole of the Humansdorp Division the soil is the result solely of disintegration of the great ranges of Table Mountain sandstone which extend along the south coast from George, and eventually die out in the Zitzikama range. These sandstones and quartzites contain practically nothing capable of affording nutriment to plants, and are almost devoid of the very mineral salts essential for the production of bone material. It would be of more than interest to have the areas that are covered by these poor soils mapped out as exactly as possible, so as to shew their extent, and yet these all-important investigations have been absolutely dormant these seven or eight years past.

The average results of the above Witteberg soils may well be added for comparison with those already given. They are as follows:—

Lime	·051
Potash	·058
Phosphoric oxide	·065

These soils, as before remarked, may be expected to resemble those from the similar sandstones of the Table Mountain series. There is, however, more clayey material in the Witteberg rocks, and hence—if the subject were more closely investigated—we should probably discover that the soils derived from them do not exhibit *quite* the absolute poverty of the Table Mountain sandstone soils. It is true that the above four analyses, representing the Witteberg series, are along the line of this view, but they are altogether too few in number to add any confirmation thereto.

The soils derived from the Dwyka series, which overlie the Witteberg beds, lead us from the Cape into the Karroo system, where we meet with an all-round richer type of soil than the average of the older system. Of the soils which represent the Dwyka beds of shales and conglomerates we have unfortunately examined only two that can be taken as in any way typical, and both of these were collected within the Worcester Division. Their analyses resulted as follows:—

XII. Dwyka Soils.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Worcester.	De Hoek.	84·1	3·80	1·640	·157	·065
,,	Aan de Doorn River.	86·6	1·08	·386	·119	·052

We cannot, of course, generalise from the results of two analyses; all that can here be said is that these two differ from those of the Table Mountain and Witteberg sandstones, on the one hand, by shewing adequate proportions of lime and potash, and from the Bokkeveld soils, on the other, in their relatively low phosphoric oxide. The matrix of the rocks constituting the conglomerates is composed of quite a variety of minerals—amongst which felspar, augite and calcite are prominent—and would probably disintegrate into just such soils as are typified in the above two analyses.*

Passing over the intervening rocks of the Karroo system, in respect of which it would be difficult, for several reasons, to submit any analyses of typical soils at the present stage, we have next to glance briefly at the upper series of this system, namely, the Stormberg series, which we may group with the Burghersdorp or uppermost beds of the Beaufort series just below them. These consist of sandstones, shales and clays, interspersed with calcareous rocks, and producing soils of a red or purplish colour.† I do not think that we can assign any of these soils, that have hitherto been analysed, as definitely to certain geological series, as in the case of the older rocks, partly because many of the samples were not officially

* The Dwyka series consists of three members; (1) the upper shales, (2) the boulder beds, and (3) the lower shales: the resemblance to Stow's "olive shales" noted on an earlier page (162) refers to the shale beds, which may be expected to yield soils differing markedly from those resulting from the boulder beds with their calcareous matrix

† See page 89.

collected. At the same time a selection has been made of soils taken from localities where the influence of the Stormberg and Burghersdorp formations was most likely to have been traced in the composition of the soil. These are comprised in the following table:—

XIII. Burghersdorp Beds and Stormberg Series.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Albert.	Odendalstroom.	94·6	2·44	·540	·048	·138
,,	,,	95·2	2·10	·424	·051	·089
Aliwal North.	Aliwal North.	99·5	3·23	·376	·079	·088
,,	,,	99·4	4·07	·276	·123	·087
,,	,,	98·0	3·61	·192	·128	·057
,,	,,	97·7	5·08	·036	·123	·056
Colesberg.	Oorlogspoort.	91·1	2·49	·046	·156	·068
,,	,,	92·7	2·67	·094	·165	·072
,,	,,	93·8	2·94	·114	·183	·070
,,	,,	97·6	4·40	·506	·203	·115
,,	,,	98·1	2·33	·066	·184	·073
,,	,,	94·7	3·51	·216	·136	·069
Steynsburg.	Zout Kuil.	94·8	6·19	·042	·195	·031
,,	,,	92·9	2·89	·448	·152	·038
,,	,,	97·8	5·65	·062	·181	·089
,,	,,	97·5	4·28	·062	·213	·121
,,	,,	91·1	4·00	·044	·189	·097
,,	,,	98·0	5·58	·066	·257	·093
,,	Klerks Kraal.	98·4	4·33	·238	·196	·013
,,	Middel Water.	98·8	4·27	·130	·192	·037
,,	Van Vuurens Kraal.	98·0	3·99	·188	·161	·080
Wodehouse.	De Boulogne.	99·5	6·94	·232	·341	·074
,,	,,	98·3	10·08	·852	·237	·069
,,	,,	92·4	5·94	·346	·235	·145

The most remarkable feature about these soils is that they are all very uniform in texture and fine in grain, as may be noticed on glancing down the column headed "fine earth." The *effect* of the calcareous rocks is seen in the relatively large proportions of lime in some of the soils; their *irregular occurrence* in the very small percentages exhibited by some others. There is, in fact, much less range in the potash than in the lime of these soils.

The averages for these Burghersdorp and Stormberg soils are as follows:—

Lime	·233
Potash	·172
Phosphoric oxide	·078

The next class of soils that we have to deal with belongs to the Uitenhage series, and more particularly to the geological base of that series, namely, the Enon conglomerate. This formation is of a more recent date than any of those previously considered, and we here pass from the Karroo to the Cretaceous system. The Uitenhage series consists of shales, clays and sandstones, with limestone bands and marls. A fair proportion of lime may, therefore, be expected in the soils to which these rocks give rise, and in the following table this anticipation will be seen to prove correct:—

XIV. Uitenhage Series.

Division.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Knysna.	Ganze Vallei.	99·5	2·19	·116	·054	·045
,,	Witte Drift.	90·8	1·60	·112	·069	·044
,,	Matjesfontein.	84·4	1·33	·112	·039	·078
Oudtshoorn.	Vlakte Plaats.	89·5	2·06	1·170	·299	·150
,,	Riet Vallei.	56·0	·65	·154	·100	·074
,,	Oudtshoorn.	69·9	3·73	·100	·149	·058
,,	Blauwboschkuil.	91·5	1·97	·530	·211	·134
,,	Welbedacht.	91·0	·87	·606	·144	·124
,,	Jan Fourie's Kraal.	95·9	·84	·172	·161	·063
,,	Welgerust.	91·1	1·57	·170	·170	·063
,,	Adjoining Buffels Vlei.	81·9	·44	·046	·098	·049
Uitenhage.	Upper Landdrost.	99·5	2·70	·182	·292	·073
,,	,,	98·9	·79	·156	·197	·068
,,	Gouvernements Belooning.	99·1	1·92	·718	·333	·143
,,	,,	98·3	1·07	·078	·108	·075
,,	Klaas Kraal.	93·2	·94	·392	·239	·116
,,	,,	100·	1·35	·592	·226	·086
,,	,,	98·4	·90	·066	·178	·068
,,	,,	99·6	1·02	·182	·185	·092
,,	Malmaison.	95·8	1·22	·278	·276	·087
,,	,,	99·2	1·18	·338	·278	·132

It is interesting to note how closely these Uitenhage soils resemble those of the preceding table in respect of their plant food content. In each case the average is slightly higher than in the Burghersdorp and Stormberg soils, namely:—

Lime	·299
Potash	·181
Phosphoric oxide	·087

Of soils representative directly and solely of recent superficial deposits not many analyses have been made. Two samples, one of which is a type of the blown sands that cover the Cape Flats, yielded the results given below:—

XV. Sand Downs.

Division.	Farm.	Fine earth.	Water.	Lime	Potash.	Phosphoric oxide.
Knysna.	Sidgefield.	96·4	·56	·090	·050	·051
Stellenbosch.	Eerste Rivier.	98·1	—	·066	·010	·003

Both of these, it will be seen, are very poor in plant food generally.

Of quite a different type are the silts transported, some of them over distances of hundreds of miles, by streams and rivers. The composition of our river silts is far too vast a subject to discuss at this stage, but it is one that calls for much close study and patient investigation. Silts are proverbially fertile, a circumstance which is due, not only to their chemical composition, but to their mechanical condition as well. To this fact the Oudtshoorn Division, whose soils are so largely made up of the silts and clays brought down from the Karroo by the Gamka and Olifants Rivers, owes its productiveness. Amongst all the soils that have been analysed in the Government Laboratories, none occupy a higher place than those of the Oudtshoorn Division, and much of the rich soil of that area is now being carried away into the sea by the Gouritz River, especially at times of disastrous flood, although, as previously observed, some of it is retained and deposited in the Mossel Bay and Riversdale Divisions as the river passes through them on its seaward course.*

Eleven analyses of such river deposits have been made by means of the standard method, with the results below given:—

XVI. Alluvial Silts and River Deposits.

Division.	River.	Farm.	Fine earth.	Water.	Lime.	Potash.	Phosphoric oxide.
Gordonia.	Orange.	Upington.	100	3·23	·582	·093	·061
,,	,,	,,	100	1·68	·400	·065	·052
Albert.	,,	Odendalstroom.	100	3·46	1·372	·042	·149
Prieska.	,,	Zeekoebaard.	100	5·99	1·444	·473	·221
Kimberley.	Vaal.	Warrenton.	91·5	2·50	·278	·108	·074
,,	,,	,,	88·2	6·29	·346	·094	·070
Ladismith.	Buffels.	Buffelsvallei.	65·0	·93	·332	·166	·106
,,	,,	Zeekoegatsdrift.	97·5	·92	·344	·187	·097
Swellendam.	Touws.	Zevenfontein.	97·2	·64	·220	·146	·082
Knysna.	Keurbooms.	Matjesfontein.	97·1	3·05	·544	·105	·110
Port St. John's	St. John's.	Isinuka.	97·2	2·73	·520	·171	·137

They show considerable variety, both in texture and in chemical composition. The proportions of lime, potash, and phosphoric oxide average as follows:—

Lime	·584
Potash	·153
Phosphoric oxide	·106

The following is a summary of the average results obtained from the various types of soil reviewed. It may serve to bring out more clearly the characteristic differences in respect of plant food. The low water-retaining capacity of the soils of the Malmesbury and Table Mountain series will be noted, as also the large amounts of moisture retained by the Upper Karroo soils of the Burghersdorp-Stormsberg type:—

XVII. Averages.

Geological formation.		No. of soils analysed.	Water.	Lime.	Potash.	Phosphoric oxide.
Pre-Cape rocks:	Malmesbury Series.	16	1·02	·079	·124	·039
	Granite.	9	1·19	·049	·069	·048
	Campbell Rand Series.	7	3·99	4·169	·048	·057
	Pniel Series.	9	2·90	·246	·068	·069
	Olive shales.	12	1·48	·048	·055	·031
Cape System:	Table Mountain Series.	46	1·08	·034	·031	·036
	Bokkeveld Series.	18	1·27	·387	·231	·118
	Common horizon of Table Mountain and Bokkeveld Series.	11	·93	·042	·141	·075
	Witteberg Series.	4	3·49	·051	·058	·065
Karroo System:	Dwyka Series.	2	2·44	1·013	·138	·059
	Burghersdorp Beds and Stormberg Series.	24	2·29	·233	·172	·078
Cretaceous System:	Uitenhage Series.	21	1·44	·299	·181	·087
Recent deposits:	Sand Downs.	2	—	·078	·030	·027
	Transported Silts and River deposits.	11	2·86	·584	·153	·106

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*See pages 91, 96, 108, and 109.

PART VI.—ALKALINITY OF SOILS.

Descending rain constantly carries clay particles from the surface down to the subsoil, and so enriches the latter with a supply of the *available* plant food which, as already observed, is generally contained in the finer soil grades, *i.e.*, the silt and clay. On the other hand, surface evaporation, causing an upward movement of the soil water, brings to the upper soil layers a constant supply of *readily* available plant food. Bearing in mind, then, the references made on a former page* to the different grades of plant food, it may be deduced that the subsoil is constantly being supplied from the surface with plant food constituents of grade II., while the surface soil receives an equally continuous increment from below of the plant food constituents of grade I. The former of these two processes takes place more especially during the wet season, while the latter becomes more marked during the dry, but in arid regions this increase of salts in the surface soil may proceed so far, and result in an accumulation of salts of such a nature, as to cause distinct injury to plant growth.

The extent to which these salts have accumulated in the surface soil can be definitely estimated only by chemical analysis,† but such analysis is from its very object of totally different nature from that which investigates the proportions of plant food or of plant food constituents present, for we are now dealing not with beneficial, but with harmful substances in the soil.

Thus the agricultural chemical analysis of soils, although as a rule confined to ascertaining whether they contain a sufficiency of plant *food*, may at times have to proceed beyond this limit, and determine whether there be not an excess of plant *poison*. This generally resolves itself into an investigation of the brackness or alkalinity of the soil.

What is generally called brack or alkali in soil consists in the presence of excessive quantities of certain sodium salts. These, under favourable conditions, dissolve in the rain-water and drain out of the soil, but they accumulate and act injuriously where circumstances are unfavourable to their removal by natural drainage. During a rainy season the salts are carried to varying depths, according to the penetrating capacity of the rain-water. The surface soil is thus left free from injurious salts. When dry weather sets in, however, the soil water rises to the surface as oil rises in a wick by capillary attraction, carrying the noxious salts with it from below. The water evaporates from the surface soil, leaving behind the salts as a white incrustation. There is, hence, a constant downward passage of these injurious alkaline salts during rain, and an equally constant upward movement during dry weather.

It will be easily understood that irrigation will tend to increase the accumulation of alkaline salts in the surface layers of a soil, seeing that the irrigation water will probably penetrate to greater depths than the rain, and carry to the surface larger quantities of salts. The danger is naturally augmented when the water used for irrigating is itself alkaline.

Hence, when adaptability of any tract of country for irrigation has to be pronounced upon, two chemical problems have to be decided: Firstly, does the soil contain any constituent which may render it brack or otherwise unproductive; and secondly, assuming a satisfactory answer to the first point, is the land sufficiently provided with the necessary components of the food of plants to make farming profitable?

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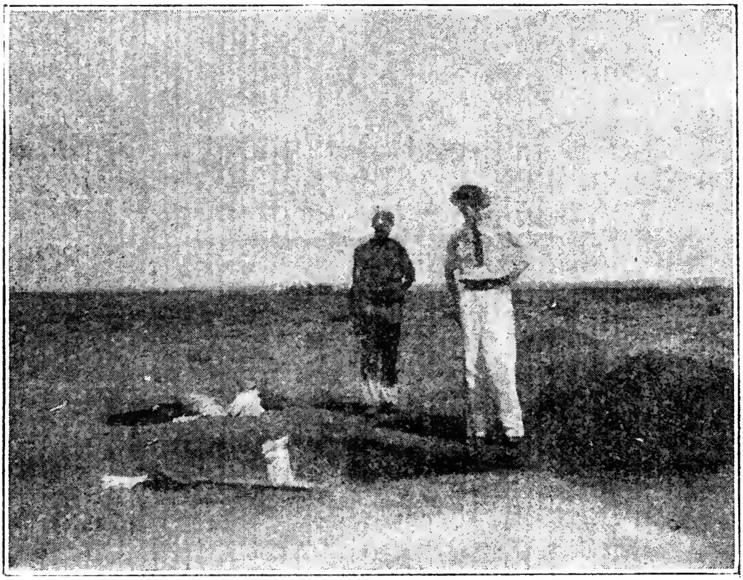
* See page 9.

† For the present purpose this term may be considered to include the electrolytic process of the United States Chemists.

When the amount of plant food in a soil is the only point at issue, one needs not to probe to a greater depth than the first foot or eighteen inches, but, it is obvious from what has been stated above, that in order to ascertain not only whether a soil is at present unproductive through brackness, but also whether it is liable to become so when irrigated, it is not enough to take merely a sample of soil from the surface and analyse that. It is essential to take samples at regular intervals below the surface to a depth at least equal to that which the irrigation water may possibly reach. There should be no omission that may leave a loophole for mistake. For this reason the method employed is to take samples representing successive sections of the soil vertically downwards from the surface to a depth of from four to six feet. Generally, one-foot sections are taken, but, in certain cases, ten inch, eight inch, or even three inch sections



Collecting Alkaline Soil at Thebus.

have been collected as occasion seemed to demand. Sometimes it has been advisable to sample solid blocks of soil, for instance, in the Thebus investigation, where the following method was used: —

A hole, several feet in diameter, was excavated to a depth of six feet, a solid pillar of earth being left untouched in the centre. From this central pillar six samples were taken in each case, every sample representing the average of one foot depth of soil. It will be readily seen that such a method of sampling involves more labour than scraping a couple of handfuls of soil from the surface, a method which has sometimes been employed with somewhat misleading results.

It is to the presence of alkaline salts, comprising the chloride, sulphate and carbonate of sodium, that the brackness of a soil is due. Of these salts, sodium sulphate is the least and sodium carbonate the most injurious, on account of the corrosive effect of the latter on the bark; and its puddling of the soil, and so interfering with tillage; the last-named salt is the cause of what is commonly termed black brack, the dark colour being due to the organic matter dissolved by the alkaline carbonate, while the chloride and sulphate, which do not dissolve organic matter, form what is called white brack. In small quantities these alkaline salts are contained in nearly all soils, being derived from the insoluble sodium silicates, which slowly decompose, under the influence of air, water, and the solar heat, into the soluble salts above mentioned. Hence there is ever going on a constant addition to the soil of soluble sodium salts, and, unless means exist for a removal of these salts, as constant and as rapid as their addition, they would in time so accumulate in the soil as to render it incapable of cultivation.

As a rule, natural drainage is sufficient to remove the noxious salts from the soil, and they are thus continually being carried down to the ocean by the rain water in which they are dissolved. Exceptions to this rule, however, exist: for, when the surface soil is porous but has an impermeable layer underneath, the alkaline salts accumulate as it were in a basin from which there is no outlet; or the soil may itself be so compact, or otherwise constituted, as to prevent proper drainage;* lastly, a high water table in the subsoil may prevent the exit of the injurious compounds†: in all these cases, unless a remedy be provided, there can be but one result, an accumulation in the soil of the salts which render it brack.

When, therefore, drainage of a soil intended to be irrigated, becomes impossible, the question to be considered is whether the alkaline salts are collected at any particular level, or whether, on the other hand, they are more or less evenly distributed throughout a mass of soil several feet in thickness. In such localities where rain is frequent and the temperature not excessive, the probability is that the salts will be fairly evenly distributed throughout the soil, so that comparatively little, if indeed any, injurious effect on the vegetation ensues. If, however, the rainfall is scanty and the climate warm, or if there even be a brief period of heavy rainfall succeeded by a dry season, time and opportunity are afforded for the harmful salts to rise to the surface, by capillary attraction, in the way already outlined, and accordingly the surface soil is charged with such an accumulation of salts that cultivation is greatly hindered, if not rendered absolutely impracticable.

Under these circumstances it becomes an important matter to consider what proportion of sodium salts a soil may contain and still be capable of successful cultivation. Professor Hilgard has devoted considerable time and attention to investigating this point in connection with the alkali soils of California, and he states (Bulletin No. 128): "Barley failed to grow where the total salts were ·203 per cent., but gave a full crop where they were ·159 per cent. (half of which was carbonate). Wheat is rather more sensitive; maize fails on slightly alkaline land; but certain sorghums do well on mild white alkali (*i.e.*, not containing much carbonate)."

In India, Dr. Leather's experiments have led him to conclude that germination was possible where the percentage of carbonate did not exceed ·4, nor the sulphate and chloride 1 per cent. In after growth ·2

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* Such a possibility demonstrates the importance of properly ascertaining, by mechanical analysis or otherwise, the physical condition of the soil all the way from the surface, down to a depth of from four to six feet, wherever an irrigation project is under consideration.

† This again shows that if a soil is likely to prove brack under irrigation, no investigation can be considered complete unless a series of determinations of the height of the water table in the subsoil has been made.

per cent. of carbonate was harmful, and ·4 generally fatal. Maize was least affected of the cereals. Wheat grew well in the presence of ·137 per cent. of carbonate, but was destroyed by ·2 per cent. Legumes are more affected than cereals, but even the latter were fatally affected if the soil around their roots contained a proportion of ·2 per cent. of sodium carbonate.

Methods of Analysis.

The chemical analysis of an alkaline soil is far from being as empiric in its nature, and in the method by which its results have to be interpreted as is the case with the investigations into the proportions of plant food in soils. There is therefore not always the same necessity, when tabulating results of analyses of alkaline soils to specify particularly the methods adopted by the analyst. And yet it is for many reasons not only convenient, but also advisable that the methods employed in Government Laboratories should be stated here. These methods, as now carried out, are as follows:—

1. *Preparation of solution:*

100 grammes of true soil (*i.e.*, the field sample sifted through a 3 m.m. sieve) are placed in a flask marked to contain 1,000 c.c. and the flask is filled up to the mark with distilled water and placed in a revolving continuous shaking apparatus for twenty to twenty-four hours. At the expiration of that time the solution is either filtered under pressure through a dry filter placed in a porcelain perforated plate funnel, or, preferably, by means of a Berkefeld candle filter.

2. *Determination of Total Soluble Salts:*

50 c.c. of the above soil solution are evaporated to dryness in a tared platinum dish, ignited at a temperature just below redness, so as to destroy any organic matter present, and weighed.

3. *Determination of Total Carbon Dioxide as Carbonates:*

An aliquot portion of the above soil solution is very cautiously titrated with N/50 sulphuric acid, a few drops of methyl orange or preferably of phenacetolin being used as indicator: from the quantity of acid used the total quantity of carbon dioxide present as carbonates is calculated.

4. *Determination of Sodium Chloride:*

To the aliquot portion used in the last determination a few more drops of N/50 sulphuric acid are added, then four drops of a chlorine-free Potassium chromate solution, and titration is carried on by means of N/100 Silver nitrate, all the chlorine thus determined being calculated as Sodium chloride.*

5. *Determination of Sulphuric Oxide:*

Another aliquot portion of the original soil solution is slightly acidulated by means of hydrochloric acid. If this causes the flocculation of clay, the mixture is filtered and the residue on the filter is thoroughly washed. The clear acidulated solution is heated to boiling, and a large excess of boiling barium chloride solution is then slowly added, the mixture being allowed to continue boiling for five minutes. After the precipitate has completely settled, the supernatant liquid is poured on to a filter; to the precipitate remaining in the beaker is added about 20 c.c. of boiling distilled water, with which it is after thus washing transferred to the filter. On the filter the precipitate is again washed, at first with distilled water slightly acidulated by hydrochloric acid, and ultimately with pure water. The filter is then dried, ignited and weighed.

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* As a proviso to this the footnote on page 176 should be noted.

6. *Determination of Sodium Sulphate and Carbonate:*

To an aliquot part of the soil solution a measured volume of N/50 sodium carbonate is added in excess of that required for complete decomposition of all calcium and magnesius sulphates, chlorides, and nitrates that may be present. The mixture is evaporated to dryness on a water bath, the residue being taken up with water and filtered, and the filter thoroughly washed. The sodium carbonate in the filtrate is then determined by titration with N/50 sulphuric acid. The quantity of N/50 sulphuric acid used in the titration, deducted from the total quantity of sodium carbonate originally added, gives the equivalents of Calcium and Magnesium sulphates present. The difference between the amount of sulphuric acid thus combined with Calcium and Magnesium and the total amount already found, gives the proportion combined as Sodium sulphate. Should more N/50 sulphuric acid be required than the quantity of Sodium carbonate originally added, the excess over such amount is calculated as Sodium carbonate. By "total alkaline salts" is understood the sum of the Sodium chloride, carbonate, and sulphate.

7. *Determination of Total Lime:*

To an aliquot part of the soil solution two or three drops of rosolic acid are added; then dilute ammonia by means of a dropping tube, and a sufficiency of ammonium chloride to redissolve any precipitated magnesia, after which the liquid is warmed, 20 c.c. of four per cent. ammonium oxalate solution are added, and the determination is further conducted exactly as in the extraction of the soil by hydrochloric acid. It may, however, be found preferable, especially when the quantity of lime is small, to dissolve the oxalate precipitate in dilute sulphuric acid and determine its amount by titration with N/100 Potassium permanganate.

8. *Calcium and Magnesium carbonates and sulphates:*

Any carbon dioxide which may be present in excess of that combined with soda, as Sodium carbonate, is calculated in the first instance as Calcium carbonate. Should this not yet account for all the carbon dioxide, the rest of the latter is calculated as Magnesium carbonate: on the other hand, if there still remains an excess of Lime unaccounted for, it is calculated as Calcium sulphate. Any excess of Sulphuric oxide which may still remain is assigned to Magnesia.*

Division of Herbert.

According to the methods outlined above, determinations of alkaline salts were made in the three samples of surface soil from Douglas, referred to in connection with the Division of Herbert (see p. 62). These determinations resulted as follows:—†

No.	Sodium chloride.	Sodium sulphate.	Sodium carbonate.	Total alkaline salts.	Calcium sulphate.	Calcium carbonate.	Magnesium sulphate.	Magnesium carbonate.	Total soluble salts. calculated.	Total soluble salts. found.
	%	%	%	%	%	%	%	%	%	%
1	·006	—	—	.006	·021	·028	—	—	·055	·048
2	·005	·002	—	·007	·001	·038	—	—	·046	·060
3	·006	·003	—	·009	—	·035	—	·003	·048	·056

* Should there be more Lime or Magnesia, or both, than required for the sulphuric oxide present, these are in such case calculated as chlorides, a corresponding deduction from the Sodium chloride being made. Under these circumstances the amount of chlorine combined with Magnesium may be checked by determining the chlorine in the heated "total salts" residue, and deducting the figure so obtained from that arrived at under (4), the difference between the two determinations being due to chlorine combined with Magnesium.

† The results are given in percentages, and, except where the contrary is indicated, blanks in the tables denote absence of the particular substances specified.

These results are favourable towards the suitability of the soil for irrigation, but, at the same time, had opportunity offered, it would have been desirable to extend the investigation to a depth of three or four feet lower down, for reasons already detailed in the manner illustrated above.

Division of Colesberg.

The six soils from the farm Oorlogspoort, in the Colesberg Division,* were also examined, with a view to ascertaining the proportions of soluble salts present. These were found to range between ·038 and ·090 per cent., and to average ·058 per cent. Such amounts are not sufficient to be harmful to plant life, even if the salts consisted entirely of sodium carbonate or "black alkali," the most injurious form in which alkaline salts are found in the soil.

Division of Britstown.

One of the first investigations into the possible alkalinity of lands proposed to be irrigated was carried out in connection with the farm Houw Water, in the Division of Britstown. Five sets of samples were taken in almost a straight line, nearly a mile and a half from end to end, from the lands intended to be irrigated below the site of the proposed dam. In each case samples were collected in the manner already described, to a depth of six feet. The physical nature of the soil may be gathered from the following table:—

Surface.	A.	B.	C.	D.	E.
1st foot	Fine loose loam	Fine loose loam.	Loose loam	Loose loam ...	Loose loam.
2nd foot	"	"	"	" ...	"
3rd foot	Stiff compact clay.	Stiff hard clay.	Stiff hard clay.	Rather stiffer loam.	"
4th foot	"	"	"	"	Rather stiffer loam.
5th foot	"	"	"	Stiff hard clay	Looser loam.
6th foot	Very loose loam	Very loose loam.	"	Loose loam ...	Moist loose loam.

The approximate distances apart of the points whence these samples were taken were as follows:—

Between A and B	... ...	430 yards.
" B " C	... ...	250 "
" C " D	... ...	850 "
" D " E	... ...	900 "

Time and circumstances did not permit of any thorough investigations into the depth of the water table below the surface, but as the average annual rainfall is very low—only about 5 inches—and as E was the only one of the five probings which showed a suspicion of moisture within six feet of the surface, there did not appear much probability of a high water level in the subsoil.

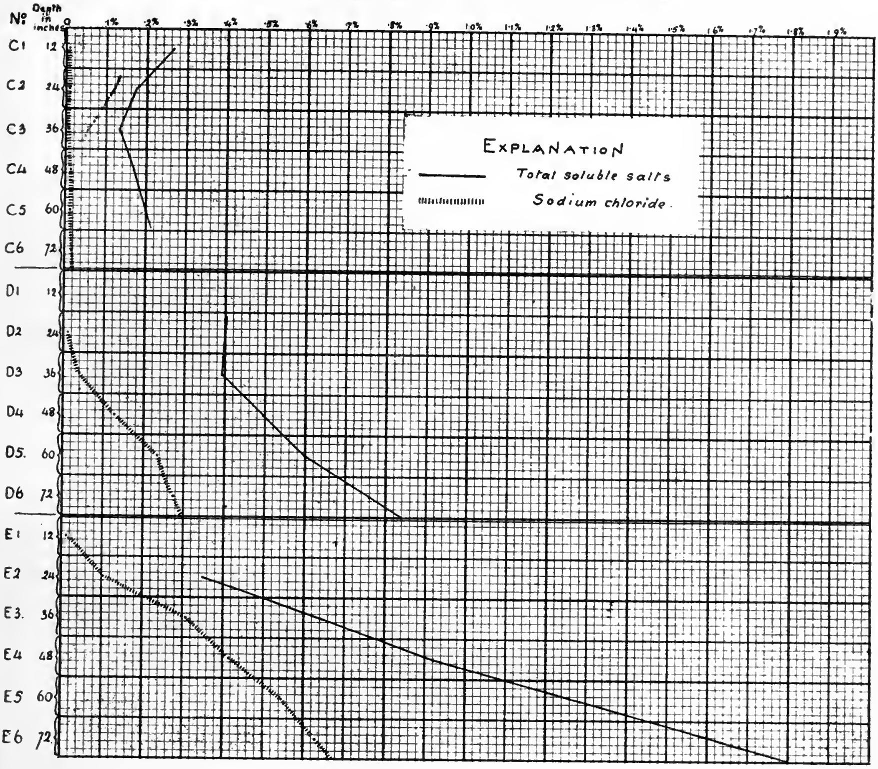
* See page 52.

The results of the chemical investigations into the alkalinity of these soils are given below; A 1, it should be explained, denotes an average sample of the soil, at the point A, from the surface to a depth of one foot; A 2 signifies the same soil between one foot and two feet depth, and so on.

No.	Total soluble salts per cent.	Sodium chloride per cent.	Sodium sulphate per cent.
A1	—	·0094	—
A2	—	·0069	—
A3	—	·0117	—
A4	—	·0279	—
A5	·244	·0980	·0488
A6	·280	·1587	—
B1	—	—	—
B2	·172	·0069	—
B3	—	·0076	—
B4	—	·0163	—
B5	—	·0350	—
B6	·376	·1447	—
C1	·264	·0058	—
C2	·176	·0069	—
C3	·136	·0076	—
C4	·168	·0117	—
C5	·200	·0117	—
C6	—	·0163	—
D1	—	—	—
D2	·400	·0094	—
D3	·392	·0398	—
D4	·496	·1261	—
D5	·600	·2357	—
D6	·760	·2754	—
E1	—	·0117	—
E2	·348	·1028	—
E3	·640	·3080	—
E4	·920	·4155	·4189
E5	1·284	·5438	—
E6	1·636	·6272	—

These analyses were somewhat tentative, and, owing to lack not only of time, but also of the necessary filtering and other appliances, the tables are studded with gaps. These drawbacks, however, do not prevent certain definite deductions. It is noticeable that, as a rule, the amounts of Sodium chloride, and of soluble salts generally, steadily increase as we proceed downward from the surface to the six foot limit, and that this downward increase becomes more rapid as we pass from A towards E.

Diagram illustrating soil alkalinity at Houw Water, Britstown Division.



Taking the entire 6 feet depth of soil in each case the average percentages of salts, as far as they may be based on the foregoing determinations, are as follows:—

	Total soluble salts.	Sodium chloride.
A	—	·0521
B	—	·0421
C	·189	·0100
D	·530	·1373
E	·966	·3348

The question now to be pronounced on is: What would be the effect of irrigation upon such soils? Broadly speaking, and having no regard to modifying causes, there can be only one answer. The result of irrigation would assuredly be to raise the bulk of the alkali salts, within the first four feet of soil, to the surface.

It appears most probable that the low rainfall in the district around Houw Water, accompanied by other causes, prevents the water from ever penetrating the soil to any great extent, and therefore from bringing up the salts during subsequent evaporation. Irrigation would very probably alter all this. The large volume of water led on to the soil is bound to penetrate, and, when evaporation follows, as it undoubtedly must, great quantities of salt will be carried up to the surface, and will accordingly render the surface soil more saline.*

In connection with some alkaline soils it has been found at Tulare in California that, although the salts in the soil have been drawn upwards, they have not been drawn right to the surface, and, in spite of the fact that a considerable amount of alkaline salts was present in the soil, there was not sufficient at the surface to cause any interference with the growth of shallow-rooted crops like barley, which flourished, to all appearances, satisfactorily. The reason for this is to be found in the fact that the surface soil was kept under constant cultivation, whereby evaporation from *the soil itself* was checked, and proceeded instead from *the verdure of the cultivated crops.* If the land can be kept under continuous cultivation, there would be two simultaneously operating causes at work to retard evaporation, and consequently to prevent the rise of alkaline salts to the surface. Evaporation from foliage instead of from soil would not be the only saving factor, but the shading of the ground by the crops keeps the temperature low, and so further still diminishes the tendency to evaporation from the soil surface.

It would appear that the most noxious of the Sodium salts, the carbonate, is practically absent from the Houw Water soils, the two compounds of Sodium which form the bulk of the alkaline soil constituents being the sulphate and the chloride. Professor Hilgard estimates that, for barley, sandy soils should not contain, within the first twelve inches, over ·10 per cent. of Sodium carbonate, ·25 per cent. of Sodium chloride, or ·45 to ·50 per cent. of Sodium sulphate; in clayey soils even smaller percentages may prove injurious. It has been calculated that the average proportion of total alkaline salts in the four feet nearest the surface should not exceed ·2 per cent. if barley is to be grown. According to Professor Hilgard's experiments, as already stated, barley thrived on a soil which contained on an average ·159 per cent. of alkaline salts in the first four feet; on the other hand, the cereal refused to grow where the average amount in the first four feet reached ·203 per cent. Now, of the Houw Water soils it seems likely that A would satisfy this condition, and so too possibly B; the average percentage in C is ·186, but both D and E are considerably on the worse side of the danger limit.

* These remarks are obviously made on the supposition that the drainage is inadequate.

Division of Steynsburg.

A similar investigation to that outlined above was made at Thebus, in the Steynsburg Division, a distance of about 160 miles E.S.E. of Houw Water. In this case, too, there was a proposal afoot to construct a dam, whereby the farm Zout Kuil and part of Van Vuurens Kraal with adjacent lands could be irrigated. As Parliament had voted £150,000 for the purpose, much depended on the suitability of the area. The last-named farm had been under cultivation for close on to half a century, and the occupant prided himself on the returns which he had obtained by means of irrigation. At a point within this cultivated area a set of samples was taken in order to ascertain, if possible, the effect of continuous irrigation on the soil, by comparing the analytical results yielded by the irrigated soil at this spot, which will be called K, with those of samples from the adjacent tracts which had never yet been irrigated. This point, K, was on the opposite side of the railway to that where the dam construction works were situated, and is rather more than three miles below the dam and 1½ mile from Thebus railway station; it constituted, in fact, the head of the area which it was intended to irrigate. Four samples, L, M, N, and P, were taken at other points in this area, on the farm Zout Kuil, extending altogether over a space about two miles in length.

The alkaline salts in these five samples were determined in similar manner to that employed with regard to those from Houw Water, only much more completely.

Thebus (Steynsburg Division) Soils.

In this way the following percentage results were obtained:—

No.	Sodium chloride.	Sodium sulphate.	Sodium carbonate.	Total alkaline salts.	Calcium sulphate.	Calcium carbonate.	Magnesium sulphate.	Magnesium carbonate.	Total soluble salts. Calculated.	Total soluble salts. Found.
K1	·034	—	—	·034	—	·006	·007	·024	·071	·204
K2	·033	·012	—	·045	—	·015	·004	·060	·124	·232
K3	·055	—	—	·055	—	·013	·049	·053	·170	·258
K4	·083	·210	—	·293	·283	·028	·212	—	·816	·872
K5	·073	·237	—	·310	·030	·029	·121	—	·490	·496
K6	·103	·181	—	·284	·067	·031	·274	—	·656	·700
L1	·191	·048	—	·239	—	·019	·017	·023	·298	·372
L2	·161	·181	—	·342	·144	·035	·224	—	·745	·660
L3	·118	·120	—	·238	—	·026	·035	·015	·314	·230
L4	·173	·082	·002	·257	—	·019	—	·035	·311	·340
L5	·205	·108	·005	·318	—	·016	—	·043	·377	·380
L6	·102	·088	·039	·229	—	·011	—	·057	·297	·328
M1	·086	—	—	·086	—	·021	·013	·001	·121	·252
M2	·211	—	—	·211	—	·033	·025	·022	·291	·416
M3	·277	·101	—	·378	—	·026	·020	·028	·452	·582
M4	·224	·293	—	·517	·051	·035	·080	—	·683	·800
M5	·242	·037	—	·279	—	·021	·159	·031	·490	·508
M6	·291	·304	—	·595	—	·024	·030	·034	·683	·880
N1	·213	·071	—	·284	—	·013	·004	·034	·335	·348
N2	·234	·208	—	·442	—	·034	·071	·012	·559	·594
N3	·181	·131	·063	·375	—	·010	—	·079	·464	·568
N4	·221	·127	·056	·404	—	·010	—	·072	·486	·480
N5	·251	·096	·058	·405	—	·008	—	·088	·501	·452
N6	·193	·070	·048	·311	—	·013	—	·072	·396	·394
P1	·225	·115	·012	·352	—	·008	—	·040	·400	·664
P2	·271	·762	—	1·033	·572	·023	·279	—	1·907	2·160
P3	·193	·146	·111	·450	—	·010	—	·101	·561	·608
P4	·159	·104	·111	·374	—	·008	—	·116	·498	·604
P5	·205	·055	·129	·389	—	·009	—	·125	·523	·672
P6	·216	·023	·156	·395	—	·019	—	·142	·556	·570

DIAGRAM ILLUSTRATING SOIL ALKALINITY AT THEBUS, STEYNSBURG DIVISION.

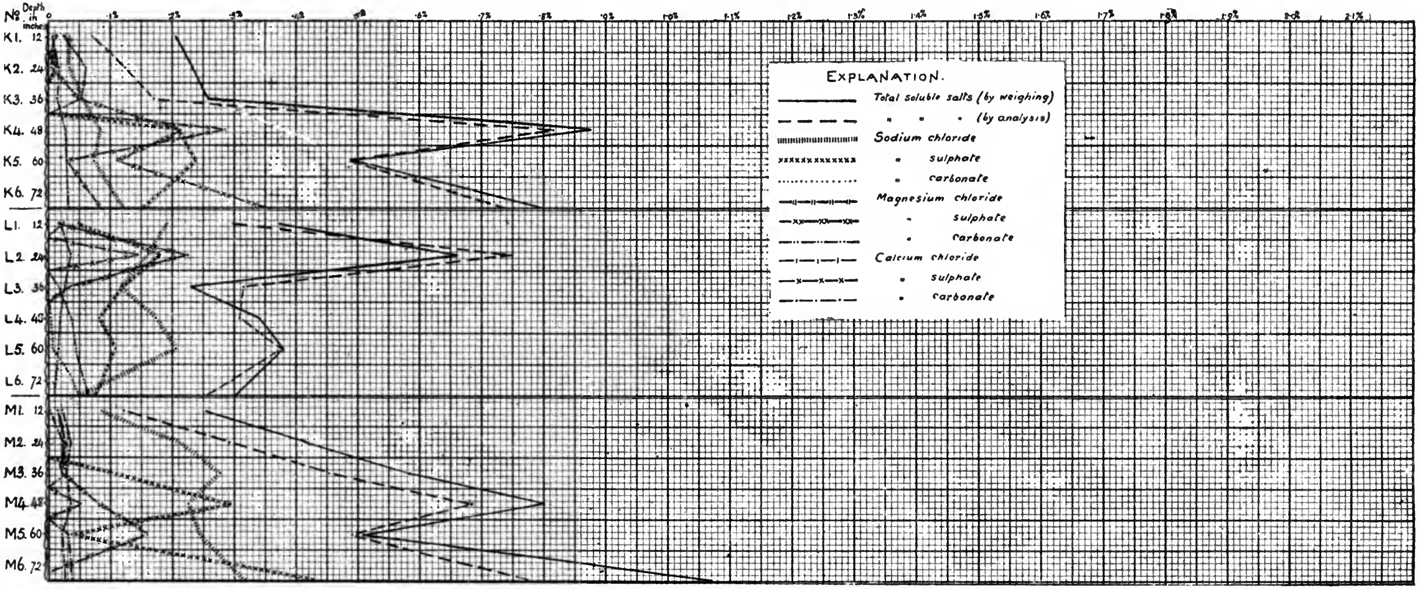
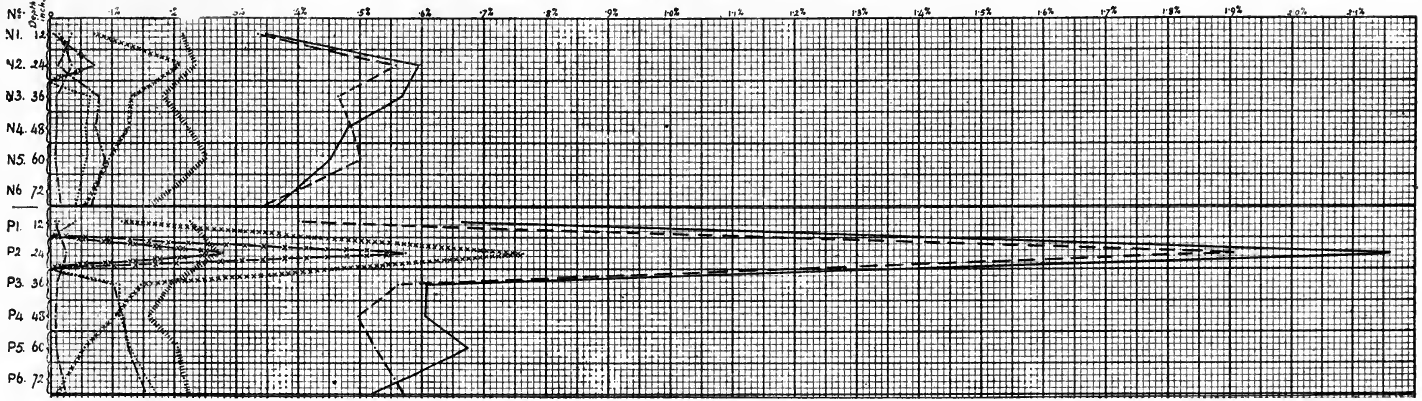


DIAGRAM ILLUSTRATING SOIL ALKALINITY AT THEBUS, STEYNSBURG DIVISION.



Apart from the fact that the samples taken at K* represent a soil that had already been under irrigation for a long period, it is plain that of the five places where samples were collected K is altogether the best, and that the conditions grow worse as one proceeds down the valley from K to P. Taking the entire six feet depth of soil in each case, the average percentages of alkaline salts at the various spots were as follows:—

Spot.	Sodium chloride.	Sodium sulphate.	Sodium carbonate.	Total alkaline salts.
K	·062	·107	Nil.	·169
L	·159	·104	·008	·271
M	·215	·122	Nil.	·337
N	·215	·117	·037	·369
P	·211	·201	·087	·499

This confirms the views of local men with regard to the alkali in the soil, the opinion on the spot being practically unanimous that the lower part of the valley is unfit for cultivation; the only difference between one man's view and another's is that ideas vary as to the *extent* of the unproductive area.

It should be noted that irrigation, followed by a period of abstinence from water, will tend to bring the soluble salts to the surface, and thus cause the surface soils to approximate to the composition just given in the above averages. In the first four feet of the soils under consideration these averages are as follows:—

K	·105	per cent.
L	·270	,, ,,
M	·288	,, ,,
N	·376	,, ,,
P	·552	,, ,,

It will be seen that the soil at K is the only one which falls within the limits of safety as laid down by Professor Hilgard, in fact K is the only soil which one could expect to yield a profitable return, and the fact that farming has been carried on there with fair success *does not, therefore, settle the matter for the entire valley.* The lower layers of the soil at K contain a fair proportion of gypsum (calcium sulphate), which has converted the noxious sodium carbonate into the less harmful sulphate. There is a general prevalence of carbonate of lime throughout these soils, and in nearly every case a stratum of gypsum runs through the soil at various levels; this stratum appears in the fourth foot at K and M, and in the second at L and at P. It is invariably accompanied by an increase in the proportion of other soluble salts, including those which produce brack, and although the gypsum in these layers may minimise to some extent the evil effects of the black brack, by converting it into sodium sulphate, it is not probable that it will do away with these effects entirely.†

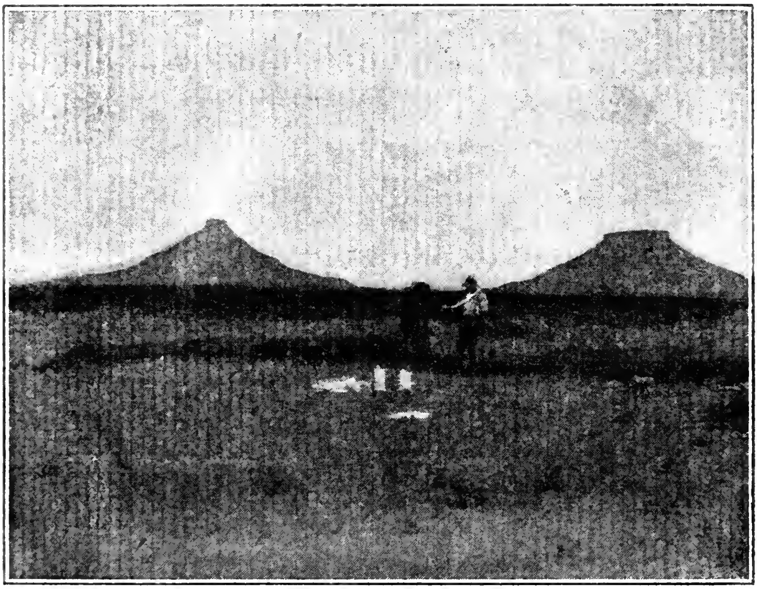
* The surface soils at K, L, M, N and P correspond respectively with Nos. 9, 5, 6, 7, and 8 of the Steynsburg soils in the section dealing with determinations of plant food (See p. 127).

† From the diagrams which illustrate the distribution of salts in the soil mass it will be seen very clearly that the soil layers in which calcium sulphate acquires greater prominence are also characterised by augmented proportions of the other sulphates, *i.e.*, of magnesium and sodium.

There is a general resemblance between the soils K and M, the former being an improvement on the latter. The worst kind of brack, sodium carbonate or black brack, occurs in the soils L, N, and P. At L it makes its appearance at the fourth foot, at N it rises to the third, and in larger proportions, while at P it appears at the surface and averages in amount from two to three times that in the corresponding levels at N.

It will be noticed that the Magnesium salts exceed on the whole the lime salts in quantity, and here may be said, what does not appear from the figures already given, that the soils K and M show a small proportion of the rather undesirable Magnesium chloride in the first couple of feet.

The amounts of alkaline carbonates in the Thebus samples are lower than in the soils of the Tulare Experiment Station, California, as reported by Professor Hilgard, and the alkaline salt present in largest proportion is sodium sulphate, at K, and sodium chloride at the other points where



Character of Alkaline Soil at Zoutkuil, Thebus. (The truncated mountains in the background are Thebus and Koffiebus.)

samples were taken, but then the Tulare Station may be taken as representing an extreme case, and there is no saying whether much worse instances than the present may not be found at Thebus if a more complete investigation be undertaken.

It will be noticed how irregularly the soluble salts are distributed through the soil; this irregularity is caused by the varying permeability of the soil layers, and by the bands of gypsum which traverse the valley. To this variability is due the peculiar nature of the results obtained by analysis from the samples collected at Thebus, and numbered 10 to 19 (see p. 127). These samples were evidently not typical, and may even, in some cases, have been taken out of the very bands of gypsum just mentioned, hence their abnormal percentages of lime. Irregularities of this type are of common occurrence in alkali soils: King (*Irrigation and Drainage*, page 283) states that

"in examining soils for alkalies, it is a matter of the utmost importance to recognise that the distribution of them is extremely liable to be capricious, and that it is easy to overlook their presence by stopping the sampling of the soil just short of the level at which all the alkalies had chanced to be concentrated; or, again, by taking a sample of the 1st, 2nd and 4th feet, or of the 1st, 3rd and 4th feet, when, owing to the capricious distribution, all of the salts had been collected in the 2nd and 3rd foot, and thus were overlooked because it may have been thought not worth while to make a complete section of the soil in question."

An analysis was made of a sample of efflorescence from the soil in the neighbourhood of the Thebus works, obtained by enclosing a quantity of the soil, to a depth of several feet, with a metal cylinder, drenching the soil with water, and allowing it to dry by exposure. As was to be expected, evaporation of the water led to the appearance of a layer of salts on the surface, and this layer, on being scraped off, was found to have the following composition:—

Sodium chloride	40·16 per cent.
Sodium sulphate...	11·64 ,, ,,
Calcium sulphate	10·86 ,, ,,
Calcium carbonate...	Trace.
Magnesium sulphate	37·21 ,, ,,

Here, too, it will be seen that of the alkaline salts, that present in largest amount is sodium chloride, and that the Magnesium compounds exceed those of Calcium (Lime) in quantity. In the absence of sufficient lime this magnesia may prove harmful.*

Two similar samples of efflorescence mixed with earth, collected by Dr. Nobbs near the same spot, were analysed, with the following results:—

Total soluble salts...	1·209 per cent.	1·495 per cent.
Sodium chloride	·058 ,, ,,	·491 ,, ,,
Sodium sulphate	1·122 ,, ,,	·895 ,, ,,
Magnesium sulphate	—	·048 ,, ,,
Magnesium carbonate	·008 ,, ,,	—
Calcium carbonate	·010 ,, ,,	·020 ,, ,,

Here, it will be seen, sodium sulphate prevailed.†

In a sample of water, taken from a pit on the site of the proposed dam, the total dissolved salts amounted to 50·40 grains per gallon; of these salts the following are the principal ingredients:—

	In grains per gallon.	In parts per thousand.
Sodium chloride...	6·35	·091
Sodium sulphate...	6·76	·097
Sodium carbonate	6·68	·095
Magnesium carbonate	16·54	·236
Calcium carbonate	8·87	·127

---

* See Storer: *Agriculture in some of its relations with Chemistry.* Vol. II., pp. 518 and 519.

† From the farm Culmstock, in the Division of Middelburg, and lying about twenty miles south of Thebus, a sample of effloresence, such as frequently occurs on the surface of brack soils, was collected. Analysis showed it to contain, inter alia,

Chlorine	7·8 per cent.
Carbon dioxide	6·2 per cent.
Sulphur trioxide	33·8 per cent.

The salts present therefore consisted mainly of sulphates. In both these Divisions (Steynsburg and Middelburg) there are extensive plains of Karroo veld, which, but for the liability to brack, would answer excellently for irrigation and cultivation purposes.

Here again, as in the soils and also in the efflorescence taken from the surface of the soil, magnesium compounds exceed those of Calcium. Sodium carbonate is present in small quantity, the amount being apparently less than in the water from Thebus dam.

The latter yielded the following results in grains per gallon:—

Total salts...	45·2
Sodium chloride...	6·3
Carbon dioxide in combination	12·8

The water from the dam contains but small quantities of lime and magnesia, so that in all probability the carbon dioxide in it was combined with soda, forming sodium carbonate, and the use of this water, unless accompanied by effective drainage, would therefore tend to increase in the soil that most injurious form of alkali, "black brack." The water from the pit, on the other hand, had its carbon dioxide combined with lime and magnesia principally.

On page 266 of King's "*Irrigation and Drainage*" will be found a table, computed from Bulletin 29 of the Oklahoma Experiment Station, page 4, showing the composition of alkaline waters that may be regarded as safe and those which are considered unsafe to use for irrigation.

Bearing in mind that sodium carbonate represents what is called "Black Alkali" in King's tables, and that sodium chloride and sulphate together constitute "White Alkali," it will be seen that the amounts in the pit water are as follows:—

Black Alkali...	·095 parts per thousand.
White Alkali...	·188 ,, ,, ,,

Now, according to the tables in King's book, a water may be considered safe if the black alkali—which is the most harmful constituent—does not exceed, say, ·100 parts per thousand, provided the white alkali be not too high, but that if the former exceed the figure just mentioned the water cannot be regarded as safe. White alkali is less injurious, and up to about ·500 parts per thousand may be passed, but beyond this limit, even though the black alkali may be low (as in the case of sample 741 of King's tables, where the black alkali is ·026 and the white ·818 per thousand), it would be risky to make constant use of the water.

In the sample of water from the pit at Thebus the white alkali was well within the limits of safety, but the black alkali was on the border line, and in the sample of water from the dam the limit was apparently exceeded, although the smallness of the sample sent prevented this being definitely ascertained.

It must, of course, be kept in view that the figures with which the analytical results of the Thebus water are compared are derived from experimental data obtained in Europe and America. If the facilities for making such very necessary experiments existed here, figures obtained under local conditions might be found to differ from those obtained in Europe and in the United States, but this very fact makes it all the more necessary to exercise great caution in proceeding with extensive irrigation schemes.

Division of Robertson.

A series of determinations, similar to those conducted in regard to the Thebus soils, have also been made in connection with the soil of the Government Experiment Station at Robertson. When dealing with the determinations of plant food in the soils of that locality, it was stated

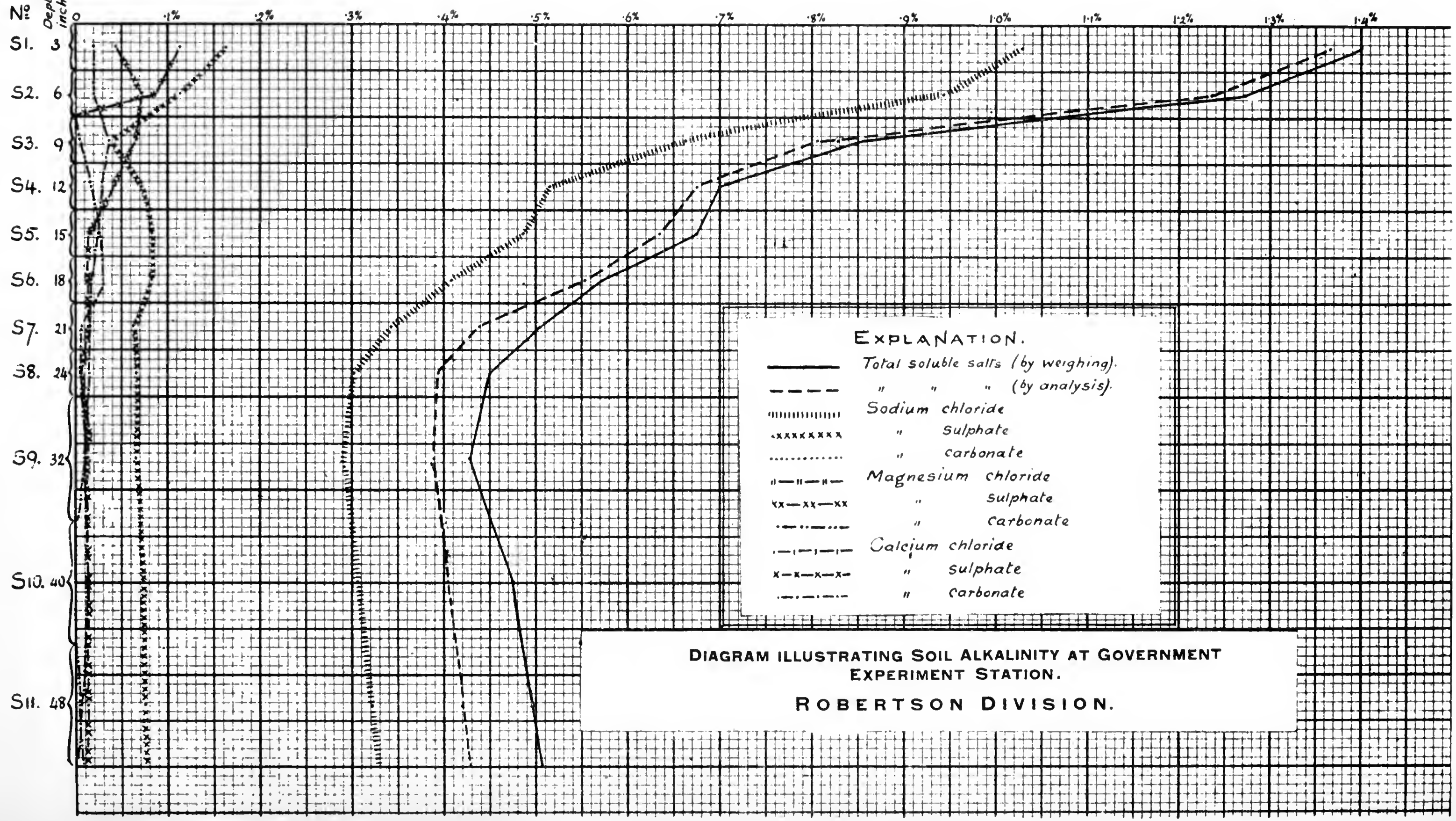


DIAGRAM ILLUSTRATING SOIL ALKALINITY AT GOVERNMENT EXPERIMENT STATION.

ROBERTSON DIVISION.

that four soils (Nos. 21, 22, 23 and 24) had been collected on the Station.* No. 21 was a red sandy loam and No. 22 a finer loam with a clayey subsoil and tending towards brackness in parts. From one of these brack patches No. 24 was taken. No. 23, a calcareous loam, showed brack water a short distance from the surface. Under these circumstances fuller investigations into the alkaline character of the soil were made. The spots R and S, whence the samples mentioned below were collected, are identical with those where Nos. 21 and 24, above referred to, were taken: in fact, Nos. 21 and 24 represent the surface soil, to a depth of eight inches, at R and S, respectively. In each case, the samples collected represented successive sections of the soil to a total depth of four feet: at R, six samples, each extending vertically through eight inches, were taken; at S, an alkaline patch with a superficial area of about 2,000 square yards, eleven samples were taken, of which the first eight represented three-inch, and the remaining three, eight-inch vertical sections.

The analyses made resulted as follows:—

No.	Sodium chloride.	Sodium sulphate.	Sodium carbonate.	Total alkaline salts.	Calicum sulphate.	Calicum carbonate.	Magnesium sulphate.	Magnesium carbonate.	Total soluble salts. Calculated.	Found.
R1	·024	—	—	—	—	—	—	—	—	·060
R2	·018	—	—	—	—	—	—	—	—	·044
R3	·010	—	—	—	—	—	—	—	—	·070
R4	·011	—	—	—	—	—	—	—	—	·062
R5	·011	—	—	—	—	—	—	—	—	·056
R6	·019	—	—	—	—	—	—	—	—	·080
S1	1·029	·162	—	1·191	·112	·020	·043	—	1·366	1·400
S2	·942	·114	—	1·056	·088	·020	·071	—	1·235	1·272
S3	·662	·037	—	·699	—	·037	·067	·003	·806	·858
S4	·516	·071	—	·587	—	·029	·041	·018	·675	·700
S5	·488	·082	—	·569	—	·024	·014	·027	·634	·674
S6	·409	·082	—	·491	—	·018	·014	·030	·553	·572
S7	·342	·062	—	·404	—	·016	·014	·005	·439	·504
S8	·301	·067	—	·368	—	·014	·007	·005	·394	·450
S9	·291	·066	—	·357	—	·009	·012	·011	·389	·428
S10	·307	·073	—	·380	—	·012	·012	—	·404	·476
S11	·321	·076	—	·397	—	·007	·012	·004	·420	·496

(The blanks in the *upper* part of this table signify "undetermined.")

In the case of the soil R, there was no necessity to push the investigation further, the total soluble salts being considerably below the danger limit. At S a very different condition of things exists, and a diagram is attached, showing the curves of the various soluble salts in the soil as we descend from the surface to a depth of four feet.†

Division of Carnarvon.

An investigation of the alkaline tracts near the large dam called Van Wyk's Vlei, 45 miles north-west of Carnarvon village, was conducted on lines somewhat similar to those already indicated. By means of this dam,

* See page 115.

† In connection with the curves shown in the accompanying diagrams, it will be noticed, each acid ion is indicated by a distinguishing feature in the line of curve as well as each basic ion: Thus carbonates are shown by *dots*, sulphates by *crosses*, and chlorides by *transverse* dashes. These are repeated *singly* in the case of CALCIUM compounds, in *pairs* for MAGNESIUM compounds, and *unintermittently* for SODIUM compounds.

which holds many thousand millions of gallons of water, fairly extensive irrigation has been practised for several years. Under this treatment the barren area has gradually spread, and at present the nearest land that is being cultivated below the dam is no less than seven miles distant therefrom. It is, nevertheless, estimated that about 20,000 acres of irrigable land of good quality are still free from any signs of alkalinity, and available for cultivation.

Two samples of water from artesian borings in the vicinity of the dam were analysed with the following results, stated in grains per gallon:—

	No. 1.	No. 2.
Sodium chloride	48·94	358·98
Magnesium sulphate	49·20	177·57
Calcium sulphate	53·26	76·86
Calcium carbonate	10·16	147·95

A specimen of water from the dam itself was found to contain chlorine —in combination as chlorides—to the amount of 1,154·6 grains per gallon, and, on another occasion, a sample similarly taken yielded the following figures:—

Sodium chloride	862·9	grains per gallon.
Sodium sulphate	226·3	„ „ „

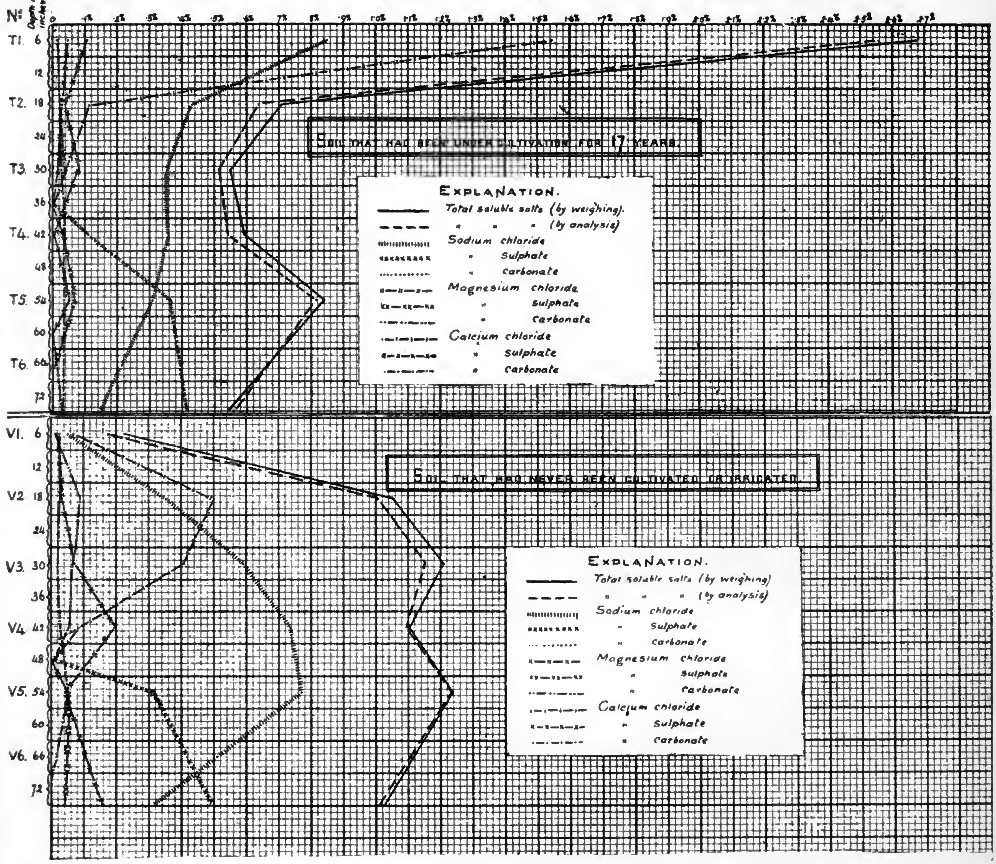
At some places in the neighbourhood, beds of limestone, containing gypsum, occur; specimens of these were analysed, but did not prove of good quality.

The land most affected by alkaline salts is that in the immediate proximity of the dam, and from there the saline area is working its way downwards by degrees, the lands being drenched with water during the season, and then left to the action of evaporation, which does not fail to draw the salts to the surface, with the consequence that, in the long run, one tract of land after another has been discarded as too salt for cultivation. Under such circumstances, the practice has been to transfer to a plot of virgin soil, until that, too, in turn, becomes too alkaline for use.

To test chemically the results that this mode of cultivation brings about, samples of soil, T and V, were taken, respectively, from Lot 111, which had been under cultivation for seventeen years, and had, during that period, grown fourteen crops of wheat, and from Lot 94, which had never been cultivated, at a spot 315 yards from that where T was collected. The crops at T were originally as good as could be desired, but have been gradually deteriorating. The sample taken at V is typical of the Van Wyks Vlei soil in its natural state.

The way in which these samples were collected was as follows: In each case an excavation was made to a depth of seven feet, and, down one side of the excavation, a vertical groove, of six inches square section, was cut by removing for analysis blocks of soil of six inches cube at six-inch intervals. The first sample of each series was taken from the surface to a depth of six inches, and then samples of each alternate six inches below that. In both cases, at a depth of six feet a stratum consisting for the most part of large-sized stones was encountered; of this it was not con-

DIAGRAM ILLUSTRATING SOIL ALKALINITY AT VAN WYKS VLEI, CARNARVON DIVISION.



sidered necessary to make analyses, but the soils taken from the higher levels were examined for alkaline salts, with the results tabulated below:—

No.	Sodium chloride.	Sodium sulphate.	Total alkaline salts.	Calcium chloride.	Calcium sulphate.	Calcium carbonate.	Magnesium chloride.	Magnesium sulphate.	Magnesium carbonate.	Total soluble salts. Calculated.	Found
T1	·849	—	·849	1·542	·106	·014	·046	—	—	2·557	2·672
T2	·432	—	·432	·114	·040	·022	·029	—	—	·637	·708
T3	·355	—	·355	·039	·081	·024	·017	—	—	·516	·548
T4	·359	·105	·464	—	·003	·038	—	·036	—	·541	·594
T5	·304	·363	·667	—	·049	·034	—	·065	—	·816	·840
T6	·214	·397	·611	—	—	·037	—	·007	·011	·666	·664
V1	·051	—	·051	·068	·019	·024	·012	—	—	·174	·222
V2	·355	—	·355	·500	·032	·026	·090	—	—	1·003	1·056
V3	·590	—	·590	·404	·071	·020	·066	—	—	1·151	1·210
V4	·736	—	·736	·082	·198	·026	·055	—	—	1·097	1·102
V5	·767	·318	1·085	—	·042	·048	—	·053	—	1·228	1·238
V6	·508	·419	·927	—	·105	·017	—	·049	—	1·098	1·116

The effect of irrigation, as practised at Van Wyks Vlei, on this type of soil is seen, in the case of soil T, by the accumulation of salts at the surface. In its natural condition the vertical distribution of the saline material is such as to leave the surface soil comparatively free, so that shallow-rooted crops may be cultivated without difficulty. In the irrigated soil the present failure to grow crops is easily explained by the existence of the chlorides of Calcium and Magnesium in the upper soil layers. The occurrence of these very soluble salts in "brack" is somewhat unusual, and can only take place in arid regions like Carnarvon. At Thebus too, where the rainfall is not abundant—although less scanty than in the Carnarvon Division—the presence of Magnesium chloride in the soil was noticed (see page 183). In the Robertson Division, on the other hand, where rain is more frequent, and the atmosphere more humid, a surface efflorescence containing these salts is an impossibility.

It will be noticed, especially from the appended diagram, that, in the irrigated soil, the chlorides are, for the most part, accumulated within the upper thirty inches, while the sulphates have remained at the lower levels.

Calculating from the figures in the last table, the percentage composition of the salt at the soil surface at T is as follows:—

Sodium chloride	33·20
Calcium chloride	60·30
Magnesium chloride	1·80
Calcium sulphate	4·15
Calcium carbonate	·55

With this may be compared the following results, quoted by Hilgard ("Soils: their formation, properties, etc.," p. 442), of an analysis of alkali occurring in California (Imperial):—

Potassium chloride	1·15
Sodium nitrate	8·21
Sodium carbonate	·58
Sodium chloride	31·82
Calcium chloride	58·42
Magnesium chloride	2·81

There is considerable resemblance in the respective percentages of Sodium, Calcium, and Magnesium chlorides.

PART VII.—PHYSICAL COMPOSITION OF SOILS.

The foregoing pages have been devoted all but entirely to the consideration of questions pertaining to the *chemical* nature of the soil, and more particularly to the proportions of plant food present therein. Important, however, as the chemistry of the soil is, there is often a danger of its looming so large in the field of vision that other factors which go to make up soil fertility are lost sight of. Chemical analysis alone can never suffice to measure a soil's fertility, and even still less its productiveness. The *fertility* of the soil depends upon other inherent properties besides the presence of plant food; for instance, its texture and general physical condition: its *productiveness* is dependent on variable environments and incidental circumstances, such as rainfall, atmospheric temperature, conditions of drainage, and methods of cultivation; in other words, on factors which are altogether extraneous to the soil itself. Hence a soil well supplied with plant food is not always fertile, and a fertile soil is not necessarily productive: the most fertile soil cannot be productive when climatic conditions are unfavourable, and the methods of cultivation adopted unsuitable. These distinctions require to be well kept in view. Leaving out of sight, however, the wider subject of crop production, and turning again to the more restricted one of soil fertility, it would be well clearly to understand that even the chemical aspects thereof are closely connected with the soil's mechanical condition. The supply of water which circulates within the soil, and which is there tenaciously retained for plant use, is directly dependent upon the state of subdivision of the soil particles, other conditions being equal. The very availability of the plant food constituents, moreover, as there has been occasion previously to remark, is regulated by the fineness of division in which they exist in the soil. Under these circumstances, as Dr. Wiley observes:—*

"It is not, therefore, a matter of surprise that the fertility of a soil is found, *cæteris paribus*, to be commensurate, to a certain limit, with the percentage of fine silt and clay which it contains. It is true that two soils, quite different in fertility, may have approximately the same silt percentages, but in such a case it is demonstrable that even in the poorer soil the measure of fertility is largely the percentage of fine particles in connection with its actual content of plant food. Many soils may have large quantities of plant food, but thse stores, owing to certain physical conditions, are not accessible to the rootlets of plants. . . . The full value of silt analysis will only be appreciated when many typical soils, from widely separated areas, are carefully studied in respect of their chemical and physical constitution and the character of the crops which they produce."

We see then how closely a study of the chemical composition of the soil must be interlocked with that of its mechanical condition. The one is never complete without the other, and it is much to be regretted that the exigencies of circumstances compelled the jettison of a systematic investigation into the mechanical nature of the various agricultural soils of the Colony at the time when the chemical survey was commenced.

In the mechanical analysis of a soil we aim at determining the relative proportions in which the different sizes of soil particles are present. There is, however, a sad lack of uniformity in the nomenclature by the medium of which these various grades are wont to be designated: it may hence prove profitable to examine into this subject somewhat closely.

In popular language the generality of soils has for many years been divided into "sandy soils" and "clay soils," as though all soils consisted essentially or solely of either sand or clay. For the purposes of rough-and-ready classification a broad differentiation on these lines may pass, but

* "Principles and Practice of Agricultural Analysis," Vol. 1, 2nd ed., 1906, p. 310.

when, apart from chemical composition and other modifying circumstances, the suitability of soils for cultivating certain kinds of crops has to be considered, a more complete and detailed discrimination becomes indispensable.

Thaer (see Dr. Wahnschaffe's "Anleitung zur wissenschaftlichen Bodenuntersuchung") had distinguished between the following seven classes, namely: stony, sand, loam, clay, marl, lime and humus soils, and as long ago as 1838, Schübler* classified soils, according to their mechanical condition, as follows:—

	Percentage of clay.	Percentage of sand.
Argillaceous soils	above 50	below 50
Loamy soils	30 — 50	50 — 70
Sandy loams	20 — 30	70 — 80
Loamy sands	10 — 20	80 — 90
Sandy soils	below 10	above 90

In the above classes the amount of sand was diminished proportionately when lime or humus was present in a soil.

Ingle† adopts the following classification:—

	Percentage of clay.
Clay	70 — 95
Loam	40 — 70
Sandy	below 10

To the above he adds marly, calcareous, and humic soils, the appellation being dependent upon chemical and physical conditions other than the size of their constituent particles.

Hilgard‡ proposes the classification given below:—

	Percentage of clay.
Heavy clay soils	35 and over.
Clay soils	25 — 35
Clay loams	15 — 25
Sandy loams	10 — 15
Ordinary sandy lands	3 — 10
Very sandy soils	½ — 3

Professor Whitney, Chief of the Bureau of Soils of the United States Department of Agriculture, puts forward no less than 16 classes of soil, viz.: stony loam, gravel, gravelly loam, dune sand, sand, fine sand, sandy

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* "Grundsätze der Agrikulturchemie."

† "Manual of Agricultural Chemistry," 1902, p. 56.

‡ "Soils; their formation, properties, composition, &c.," 1906, p. 84.

loam, fine sandy loam, loam, shale loam, silt loam, clay loam, clay, adobe, meadow, and muck and swamp.*

Snyder† refers to "sandy," "clay," and "loam" as the terms "used to designate the prevailing character of the soil." Sandy soils he classes as those containing 90 per cent. or more of pure sand. He mentions further, loam soils—*i.e.*, mixture of sand and clay; if clay predominates it is a clay loam; if sand, a sandy loam. Dealing with the preference of certain crops for particular classes of soil, he supplements his classification by mentioning the classes of soil which in a large number of cases and under average conditions (*e.g.* normal supply of plant food and an average rainfall) have proved to be satisfactory crop producers.

The better class of potato soils, according to him, are those which contain about 60 per cent. of medium sand, 20 to 25 per cent. of silt, and about 5 per cent. of clay. For fruit-growing purposes he recommends soils containing from 10 to 15 per cent. of clay, and not more than 40 per cent. of sand. He looks upon those as the strongest corn soils which contain from 40 to 45 per cent. of medium and fine sand, and about 15 per cent. of clay. Good grass and general grain soils should contain about 15 per cent. of clay and 60 per cent. of silt. For wheat production he discriminates between three classes of soils: those of the first class contain from 30 to 50 per cent. of clay; those of the second, about 20 per cent. of sand, 50 per cent. of silt, and from 20 to 30 per cent. of clay; to the third class are assigned those soils which are composed mainly of silt, containing thereof usually 75 per cent., together with from 10 to 15 per cent. of clay.

It will be noticed from the above how great is the variety in the class names applied by different investigators to the several classes of soil. But an even greater variety exists in connection with the grouping of the different grades of particles which go to make up any one soil, and which, when they preponderate, impart to that soil its special character. Such terms as medium sand, fine sand, silt, and clay have been used above: not only do investigators differ among themselves in the terms which they thus employ for any one grade of soil particles, but very frequently one and the same term has been applied to widely distinct grades. Snyder, for instance, uses the term "fine earth" to indicate that portion of the soil which passes through a sieve with openings ½ mm. in diameter, and then goes on to grade this fine earth as follows:—

	Diameter of particles.
Medium sand	·25 — ·5 mm.
Fine sand	·1 — ·25 ,,
Very fine sand	·05 — ·1 ,,
Silt	·01 — ·05 ,,
Fine silt	·005— ·01 ,,
Clay	below ·005 ,,

This, it may be observed, is exactly the grading adopted in the Government Laboratories here, and it is also employed by the United States

* In the 1906 Soil Survey Field-book issued by the U.S. Department of Agriculture, the following 11 classes are enumerated under the scheme of classification based on mechanical composition of soils:—Coarse sand, medium sand, fine sand, sandy loam, fine sandy loam, loam, silt loam, clay loam, sandy clay, silt clay, and clay (pp. 17 and 18).

† "The chemistry of soils and fertilisers," 1899, p. 24.

Bureau of Soils,* but is far from being in general use. Thus Wolff and Schöne designate as "fine earth" all the soil that passes through a sieve with holes 3 mm. in diameter: Knop applies the same term to that which passes a ¼ mm. mesh sieve. Whitney and some other American chemists generally take 2 mm. Hilgard and others again take ½ mm.

There is an equally great variety in the methods of classifying the several finer soil grades: thus Wollny† classifies the several grades as follows:—

	Diameter of particles.
Stones	over 10 mm.
Coarse gravel	5 — 10 mm.
Medium gravel	2 — 5 ,,
Fine gravel	1 — 2 ,,
Coarse sand	·5 — 1 ,,
Medium sand	·25 — ·5 ,,
Fine sand	·1 — ·25 ,,
Coarse silt	·05 — ·1 ,,
Medium silt	·025 — ·05 ,,
Fine silt	·005 — ·025 ,,
Clay	·0001 — ·005 ,,

The following is Hilgard's complete classification:—

	Diameter of particles.
Coarse grits	1 — 3 mm.
Fine grits	·5—1 ,,
Coarse sand	·4 ,,
Medium sand	·3 ,,
Fine sand	·16 ,,
Finest sand	·12 ,,
Dust sand	·072 ,,
Coarsest silt	·047 ,,
Coarse silt	·036 ,,
Medium silt	·025 ,,
Fine Silt	·015 ,,
Finest silt	·008 ,,
Clay	?

While there has been, of late years, a gradual approach to uniformity of nomenclature, a sufficiently wide variation still exists to render the use of mere *names* valueless unless the *method of analysis* is also distinctly stated.

Clay, for instance, is mostly determined by a process of sedimentation. In the investigations recorded in these pages, the soil water has been allowed to stand for 24 hours at a time, before drawing off the clay water, but many a soil analyst would terminate the sedimentation within a much shorter period; three hours, for instance, or one hour, or perhaps only fifteen minutes. Obviously results thus obtained are not comparable amongst themselves; and, as the finely divided clay exercises a most important influence on the agricultural value of the soil, it is very necessary to know how its proportion has been determined, and to be assured that what is called clay does not actually also include silt.

The importance of silt and clay as component parts of any soil is one of the chief reasons for the systematic mechanical analyses of soils. Not only does the clay bind together soil particles which would otherwise collapse into drift sands, but its own fineness of texture renders soils which

* Except for the coalescing of the "silt" and "fine silt" into one grade.
† *Vide* Experiment Station Record, vi, p. 762.

contain much clay all the more retentive of moisture, and of the nutritious substances therein, when sands, although abounding in mineral plant food, may be unfitted for cultivation simply through the lack of soil moisture.

Moreover, the finest particles of the soil are those which contain the largest amount of the elements of plant food in an available form, so that in every respect a soil containing a large proportion of silt and clay is thereby the better fitted for plant sustenance, and, altogether apart from any question of direct chemical analysis, the mechanical analysis of a soil will frequently be a good index to its probable fertility. Above and beyond all this it is to be remembered that a fine-grained soil not only presents its plant food in a form better fitted for the plant to assimilate, but *it generally has more of it to present.*

By "clay," it need hardly be said, is meant not only the term as used in the strictly chemical sense, namely, silicate of alumina, but, in a wider signification, it denotes that finely divided material which when stirred up with water, does not settle down readily, but remains suspended in the liquid for a long time,—a time generally to be measured by days—sometimes by weeks.*

Now the effect of rain beating upon the surface of the soil is to stir up the soil particles, and, as the water percolates down through the soil, it constantly carries with it in suspension a quantity of clay, naturally therefore in a rainy district the sub-soil becomes in time more clayey than the surface soil, and as clays contain more plant food than coarser gained soils, it also follows that the subsoil will, as a rule, be richer than its surface soil. Hence, too, subsoils are more retentive of moisture, and less easily penetrated by the rain owing to the accumulation of clay.

The mechanical analyses of soils are thus of far-reaching importance; not only does such an analysis serve its direct purpose of determining the proportion of particles of various sizes in the soil, but, indirectly, it sheds light upon the soil's power to retain moisture, and also upon its permeability to plant roots, and it even aids—as stated above—in forming a conjecture as to its chemical potentialities, since the soils that contain most silt and other fine grades of soil particles, are frequently the richest from a chemical point of view.

Dr. Wiley's words, already quoted, partially answer the question why soils of certain class are required in order to cultivate particular crops, but it does not solve the problem completely. Reference has been made to Snyder's apportionment of differently graded soils to specific crops, but just *why* such classes of soil should be so specially suited to some crops, and not to others, has not been fully stated. A partial solution may be found in the fact that it is a characteristic feature of each kind of plant to require for its development a certain degree of soil heat, and specific amounts of moisture: both of these are dependent upon the mechanical condition of the soil. Now, according to Snyder, soils of the class that he prescribes as best suited for potatoes are so suited because such soils generally contain from 5 to 12 per cent. of water; similarly, those which he recommends for fruit usually retain from 10 to 18 per cent. of water: those which are recommended for corn should, according to the same authority, contain about 15 per cent. of water; grain soils, he says, ought to hold from 18 to 20 per cent. of moisture. Now all these conditions, naturally, are intended to apply to certain parts of the United States of America. In the Cape Colony we know as yet neither (1) whether soils physically composed as above would retain the proportions of moisture stated, nor (2) whether such proportions would be the optima for the classes of crops mentioned. What

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* "As used in a physical sense 'clay' may be silica, felspar, limestone, mica, kaolin, or any other rock or mineral which has pulverised until the particles are less than ·C05 mm. diameter." (Snyder: "The Chemistry of Soils and Fertilisers," 1899, p. 13).

needs to be ascertained here is, first of all, what the mechanical condition of the soil is in localities where these crops do well, and next, how much moisture such soils are capable of retaining under the climatic conditions prevailing in this country. It was to give a start to research along these lines that the investigations recorded on the subsequent pages were initiated.

Method of Mechanical Analysis of Soil.

The *complete* sifting process used in the Government Analytical Laboratory for these investigations included the employment of the following sieves:—*

1. A brass-bottomed sieve with circular perforations 3 mm. in diameter.
2. A similar sieve with perforations 2 mm. in diameter.
3. Another similar sieve having perforations 1 mm. in diameter.
4. A Kahl's (Hamburg) "Messingdrahtsieb No. 50."
   Lateral measurement of meshes ... ... ·35 mm. — ·39 mm.
   Diagonal measurement of meshes ... ... ·45 mm. — ·50 ,,
5. A Kahl's (Hamburg) "Messingdrahtsieb No. 100."
   Lateral measurement of meshes ... ... ·14 — ·17 mm.
   Diagonal measurement of meshes ... ... ·22 — ·24 mm.
6. An Ehrhardt & Metzger's (Darmstadt) "Florsieb No. 16."
   Lateral measurement of meshes ... ... ·09 mm.
   Diagonal measurement of meshes ... ... ·11 mm.

For the mechanical analysis of soils all the above sieves are used, and the sifting process is further supplemented by sedimentation in water. When a *chemical* analysis is the chief object, sieves Nos. 1, 3, and 4* only are employed, according to the method already described.

In carrying out the mechanical analysis of a soil, a weighed average quantity (generally from five to eight pounds) of the field sample is taken and dry sifted through sieve No. 1. The pebbles left on the sieve are washed and dried, and their weight noted for ultimate calculation in percentage of the water-free field sample. All that passes through sieve No. 1 is denominated "true soil."

250 grammes of this true soil are placed in a porcelain dish; about half a litre of distilled water is poured on, and the dish is allowed to digest on a water-bath for at least two hours, the contents being frequently stirred. When the soil has been so softened that it can be washed through the sieves by the aid of a small brush, the actual sifting operation is proceed with as follows:—

Sieve No. 4 is held over a dish containing distilled water; the moistened soil is placed in the sieve, and the latter is immersed with its perforated bottom about one inch or more below the water level in the dish. By means of a small brush the soil is now stirred until particles no longer pass through, after which the residue in the sieve is washed with distilled water. This residue is next washed on to and through sieve No. 3. That which passes through the latter sieve is dried and weighed as "coarse sand," while the term "gravel"—using the word as conveying the idea of dimension and not that of nature—is assigned to the residue upon this sieve.

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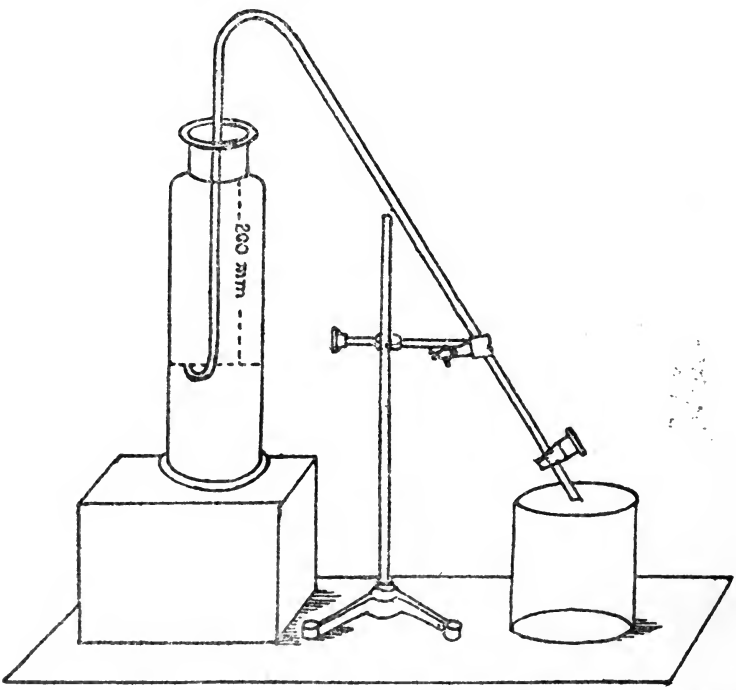
* Sieve No. 4 is now definitely replaced by a brass bottomed sieve with circular perforations ½ mm. in diameter.

The partial mechanical analysis outlined above thus separates every soil sample thereby treated into the following grades:—

Field sample
- pebbles > 3 mm.
- true soil < 3 mm.
  - gravel 3 — 1 mm.
  - earth < 1 mm.
    - coarse sand 1 — ·5 mm.
    - fine earth < ·5 mm.

Both the gravel retained by the 1 mm. sieve, No. 3, and the fine earth which passed through sieve No. 4, have to undergo further differentiation. The former—by means of sieve No. 2—is separated into "coarse gravel" and "fine gravel," and from a fresh quantity of the "true soil"—50 grammes in weight—a sufficient amount of fine earth is obtained by sifting (as the 250 grammes were sifted before) through sieve No. 4. This new quantity of fine earth is now well stirred and washed, in a manner similar to that already described, through sieve No. 5. To the residue on this sieve the term "medium sand" is applied. The sifted product obtained in this way is brought into sieve No. 6 and again carefully washed: the name "fine sand" is given to what remains on the sieve. All the products remaining on each of the sieves are weighed after drying at 105°C.



The fine grained material which has passed through sieve No. 6 is placed in a syphon cylinder of the construction indicated in the annexed sketch. The height of the cylinder is about 40 centimetres, and the internal diameter is six centimetres. This cylinder is marked near the neck, and another mark is made at a level 200 millimetres below the first one. When the sifted soil has been placed in the cylinder the latter is filled with water to the upper mark, after which it is stoppered, inverted, and well shaken: it is then placed at rest in its normal position for twenty-four hours, after the expiration of which time the water, together with the clay still in suspension, is syphoned off. It may be necessary to refill the cylinder with water and repeat several times the process of shaking, subsidence, and drawing off, until no more clay can be removed. All the liquid thus drawn off is evaporated, and the clay which it retained in suspension is then weighed. The sediment in the cylinder is again treated with water and shaken as before, but now the liquid is syphoned off after a subsidence of 100 seconds, and this operation is repeated until a practically clear liquid comes over. What now remains in the cylinder is washed out, dried, weighed, and returned as "very fine sand," while that which passes over with the syphon-water is again returned to the cylinder for a fresh treatment as before, except that a 1,000 seconds subsidence is now permitted. What remains in the cylinder at this stage is called "silt," and that which is syphoned off is "fine silt," both being now dried and weighed.

The following scheme illustrates the entire sifting and sedimentation process:—

Dry sifting. — Wet sifting. — Wet sifting and sedimentation.

- Field sample
  - pebbles > 3 mm.
  - true soil < 3 mm.
    - gravel 3 — 1 mm.
      - coarse gravel 3 — 2 mm.
      - fine gravel 2 — 1 mm.
    - earth < 1 mm.
      - coarse sand 1 — ½ mm.
      - fine earth < ½ mm.
        - medium sand ·5 — ·25 mm. } By wet sifting.
        - fine sand ·25 — ·1 mm. } By wet sifting.
        - very fine sand ·1 — ·05 mm. — 100″ sedimentation.
        - silt ·05 — ·01 mm. — 1000″ „
        - fine silt ·01 — ·005 mm. — 24 h. „
        - clay < ·005 mm. — in suspension

Results of Mechanical Analyses.

In most of the samples collected, and enumerated in the foregoing pages, where any mechanical separation at all has been made, it has been only of a rudimentary description; that is to say, it has consisted simply in grading the soil into two portions, the one comprising the "fine earth" and the other the coarser soil. And yet, elementary though these operations have been, they have elicited figures that do not entirely lack interest. For instance, if we look at the soils taken from the south-western corner of the Colony, where the Malmesbury and Table Mountain geological series prevail, we find, on the whole, a coarser type of soil than that of the area within which, for the most part, the Bokkeveld series occurs; and this again, yields a soil of coarser texture than the rest of the country from which soils have been examined, and covered chiefly by rocks of the Karroo system, more particularly by those of the Beaufort series.

In the very broadest sense possible, then, the soils examined may be grouped in these three sections, and so we get the results shown below.

1. Soils of the Malmesbury and Table Mountain Areas.

Division.	No. examined.	Percentage of Fine Earth.
Caledon	4	68·0
Cape	21	70·2
Malmesbury	7	67·7
Paarl	51	65·0
Piquetberg	1	72·4
Stellenbosch	26	80·5
Tulbagh	9	56·3
Summary	119	69·1

2. Soils of the Bokkeveld Area.

Division.	No. examined.	Percentage of Fine Earth.
Bredasdorp	1	90·6
Ceres	7	89·8
George	23	84·3
Ladismith	16	73·8
Mossel Bay	17	87·2
Oudtshoorn	19	79·1
Riversdale...	24	73·4
Robertson	22	77·7
Swellendam	9	78·4
Uniondale...	12	69·3
Worcester	34	77·9
Summary	184	77·0

3. Soils from the Rest of the Colony.

Division.	No. examined.	Percentage of Fine Earth.
Albert	3	96·6
Aliwal North	4	98·7
Barkly West	13	93·7
Beaufort West	1	94·0
Butterworth	7	94·1
Carnarvon	2	96·1
Cathcart	28	97·8
Colesberg	6	94·7
Elliot—Slang River	4	96·2
Fort Beaufort	4	85·6
Gordonia	2	100
Graaff-Reinet	3	95·2
Herbert	3	94·3
Hopetown	2	96·0
Idutywa	1	97·6
Kenhardt	4	86·4
Kimberley...	6	91·1
King William's Town	1	97·5
Knysna	16	94·9
Komgha	27	97·0
Mafeking	2	76·9
Middelburg	1	27·5
Mount Currie	2	60·0
Mount Frere	2	98·3
Port St. John's	1	97·2
Prieska	4	97·5
Queenstown	6	95·5
Richmond	2	88·7
St. Mark's...	4	81·5
Somerset East	2	99·3
Steynsburg	9	96·4
Uitenhage	10	98·2
Umtata	2	98·8
Umzimkulu	2	99·1
Victoria East	1	99·6
Vryburg	16	85·7
Willowvale	4	98·6
Wodehouse	3	96·7

It will be observed that the 22 soils from the divisions of Kenhardt, Mafeking, and Vryburg—a widely extended area where the geological formation may be said to correspond in some sort to that of the south-western corner of the Colony, inasmuch as sandstone and quartzite enter largely into the composition of the soil—are again of a coarser texture, their proportion of fine earth averaging 85·0.

The Division of George is naturally divided into a northern and a southern portion by the great range of the Outeniquas: the northern part continues into the Uniondale Division, and of the southern the Knysna Division is the natural continuation. In each case there is a corresponding similarity in the texture of the soil, as the following shows:—

Area.	No. of samples examined.	Percentage of fine earth.
George, northern part	9	69·2
Uniondale...	12	69·3
George, southern part	14	94·0
Knysna	16	94·9

While fairly complete mechanical analyses have been comparatively few, a number of soils have been graded in greater detail than those referred to above; some of these are tabulated below:—

Division.	Serial No. in list of samples.	Pebbles% > 1 mm.	Coarse sand% 1 — ½ mm.	Fine earth < ½ mm.
Albert	1	nil	nil	100
"	2	1·5	3·9	94·6
"	3	2·0	2·8	95·2
Barkly West	10	0·7	1·1	98·2
"	11	3·2	0·2	96·6
"	12	1·5	0·9	97·6
Caledon	38	0·8	17·6	81·6
Graaff-Reinet	1	1·2	4·0	94·8
"	2	·9	3·6	95·5
"	3	·9	3·7	95·4
Port St. John's	1	nil	2·8	97·2
Malmesbury	65	15·8	12·2	72·0
"	66	10·1	16·1	73·8
"	67	10·0	10·0	80·0
"	68	12·0	15·8	72·2
"	69	14·6	17·4	68·0
"	70	12·4	11·6	76·0
Richmond	1	7·7	6·0	86·3
"	2	5·8	3·1	91·1
Tulbagh	1	34·9	15·8	49·3
"	2	54·6	6·5	38·9
"	3	54·0	21·6	24·4
"	6	2·1	3·1	94·8
Uitenhage	1	nil	0·5	99·5
"	2	nil	1·1	98·9
"	3	nil	0·9	99·1
"	4	0·4	1·6	98·3
"	5	0·4	5·4	93·2
"	6	nil	1·6	98·4
"	7	0·2	0·2	99·6
"	8	0·5	3·7	95·8
"	9	0·2	0·6	99·2
"	10	nil	nil	100
Vryburg	10	2·1	8·3	89·6

In the three orchard soils, Nos. 31, 32, and 33, collected in the Worcester Division, the proportions of silt and clay were found to be respectively 17·3, 14·2, and 10·0. Soils of this description, containing over 75 per cent. of fine earth, whereof less than 20 per cent. is composed of silt and clay, and hence containing at least 55 per cent. of more or less fine sand, may very well be classified as medium sands.

Of the four soils representing the Elliot-Slang River District, a partial mechanical analysis was made of one, No. 3, with the following results:—

Pebbles	... ...	> 3 mm.	·38%
Coarse gravel	... ...	3 — 2 mm.	·58%
Fine gravel	... ...	2 — 1 mm.	1·39%
Coarse sand	... ...	1 — ½ mm.	6·87%
Fine earth ...	... ...	< ½ mm.	90·78%

The sample examined, as previously stated, typifies a red soil of fine texture, and one of the most productive in the district: chemically, there are other soils in the neighbourhood which are better, but in these soils the conditions of environment more than counterbalance their chemical superiority.

Similar mechanical analyses have been made in the case of the soils from Elsenburg numbered 3 to 19 in the Stellenbosch Division list. The following are the results of these analyses:—

No.	Pebbles > 3 mm.	Coarse gravel 3 — 2 mm.	Fine gravel 2 — 1 mm.	Coarse sand 1 – ½ mm.	Fine earth < ½ mm.
3	2·38	·37	1·76	12·11	83·38
4	1·55	·49	1·68	9·31	86·97
5	1·47	·68	2·30	11·59	83·96
6	1·18	·72	2·40	11·35	84·35
7	1·64	·40	1·80	16·37	79·79
8	2·12	·22	1·36	14·53	81·77
9	14·02	2·82	7·06	15·30	60·80
10	22·90	1·57	4·55	11·89	59·09
11	13·19	5·55	11·96	15·48	53·82
12	12·85	5·44	10·96	15·64	55·11
13	1·96	·79	3·34	15·20	78·71
14	1·34	·95	3·25	15·70	78·76
15	1·17	·83	3·90	10·83	83·27
16	1·91	1·17	3·06	5·37	88·49
17	2·96	2·35	7·11	15·49	72·09
18	13·11	3·61	4·07	7·78	71·43
19	1·62	1·83	3·60	9·32	83·63

Nos. 18 and 19 of these soils contained a great proportion of ironstone gravel, and, on reference to their chemical analyses, it will be seen that they are both very poor.

Fourteen soils representing the Paarl Division were examined in like manner, with the results stated in the following table. As in the last table, the serial reference number connects each analysis with the sample in the list of Paarl soils already given:—

No.	Pebbles > 3 mm.	Coarse gravel 3 — 2 mm.	Fine gravel 2 — 1 mm.	Coarse sand 1 — ½ mm.	Fine earth < ½ mm.
20	13·8	15·0	23·4	10·8	37·0
21	5·4	9·4	15·0	13·0	57·2
22	7·2	3·0	5·8	15·0	69·0
23	3·2	1·0	2·0	5·2	88·6
24	Nil.	·1	·2	·4	99·3
25	13·6	·6	1·4	6·6	77·8
26	2·4	3·0	9·6	14·8	70·2
28	3·2	6·8	22·0	21·2	46·8
30	9·8	9·2	19·8	13·6	47·6
31	12·8	16·4	36·4	13·4	21·0
32	·2	4·6	14·8	14·2	66·2
33	4·6	4·8	12·6	12·4	65·6
34	19·6	21·8	35·8	14·2	8·6
35	28·1	15·1	23·3	14·0	19·5

In the Division of Steynsburg ten samples of soil were collected on the farm Groene Vlei, in the Brak River Field Cornetcy, north of the railway line near Thebus Station, by Mr. W. B. Gordon, late Director of Irrigation. They are not included in the list of soils collected in the above mentioned division,* and were examined by mechanical analysis with the following results:—

No.	Pebbles and gravel > 1 mm.	Sand 1 — ·05 mm.	Silt and clay < ·05 mm.
A	36·18	14·22	49·60
B	42·42	28·54	29·04
C	44·92	23·92	31·16
D	25·14	35·34	39·52
E	37·82	30·72	31·46
F	46·14	16·96	36·90
G	28·72	35·84	35·44
H	23·72	32·86	43·42
I	24·96	49·06	25·68
J	23·68	39·06	37·26

The soils in the neighbourhood may be generally described as sandy loams, with a very distinct tendency towards alkalinity, and rather calcareous in parts.

More comprehensive than any other series of mechanical analyses undertaken in the Government Analytical Laboratories was the investigation into the physical composition of the different types of soil which occur on the Government Experiment Station at Robertson. In dealing with the chemical analyses of the soils from the division named, mention was made of four samples, Nos. 21, 22, 23 and 24, taken from the grounds of the Experiment Station. When the surface soils, which were subsequently chemically examined, had been removed to a depth of eight inches, further samples were collected at each spot, representing every succeeding eight inches in depth, up to a total depth of four feet, thus making six samples as representing the soil-profile at each of the four spots, or 24 samples in all. In the tables below, the numbers 21, 22, 23, and 24 signify the surface soils to eight inches deep; Nos. 21a, 22a, 23a, and 24a mean the second eight inches of soil, and so on.†

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* See page 126.

† It may be explained that the figures in the following tables are all the results of direct determinations upon the air-dried soil. Any loss of material would therefore be included in the "moisture," which would represent the total weight of the air-dry soil less the sum of the weights of the different grades of soil particles.

Mechanical Analyses of Robertson soils

PERCENTAGE OF DRIED SOIL.

No.	Soil class.	Pebbles > 3 mm.	Coarse gravel 3 — 2 mm.	Fine gravel 2 — 1 mm.	Coarse sand 1 — ·5 mm.	Medium sand ·5 — ·25 mm.	Fine sand ·25 — ·1 mm.	Very fine sand ·1 — ·05 mm.	Silt ·05 — ·01 mm.	Fine silt ·01 — ·005 mm.	Clay < ·005 mm.
21	Sandy loam ...	·15	·21	·94	8·44	10·99	40·40	11·45	9·87	8·88	8·67
21a	„ ...	·12	·27	·84	13·13	13·74	33·80	11·77	7·95	9·55	8·83
21b	„ ...	2·26	·83	1·06	11·66	12·13	29·59	9·09	6·17	7·51	19·70
21c	Loam ...	·54	·37	·63	7·38	8·17	26·58	13·69	9·13	10·76	22·75
21d	„ ...	1·08	·27	·58	6·32	6·98	21·99	13·65	13·36	15·61	20·16
21e	„ ...	·09	·06	·39	5·73	5·54	24·16	7·47	19·91	16·91	19·74
22	Fine sandy loam	·68	·22	·92	8·21	9·65	51·88	8·29	7·51	6·28	6·36
22a	Sandy loam ...	·07	·13	·62	12·70	9·50	38·70	8·54	9·95	11·09	8·70
22b	Sandy clay ...	·04	·09	·66	13·22	8·95	32·99	7·82	7·30	8·01	20.92
22c	„ ...	·01	·08	·50	11·37	7·83	30·09	5.74	4·98	8·73	30·67
22d	„ ...	·18	·21	·61	11·30	7·59	28·96	6·25	7·59	7·46	29·85
22e	„ ...	·15	·13	·61	11·93	8·29	28·72	6·75	7·83	7·97	27·62
23	Sandy loam ...	·11	·22	·79	9·89	12·33	29.36	9·77	10·46	14·47	12·60
23a	„ ...	·09	·21	1·00	11·49	10·47	35·05	6·69	9·44	11·40	14·16
23b	„ ...	·24	·16	·85	10·47	8·98	28·73	7·05	14·90	14·74	13·88
23c	Fine sandy loam	2·82	1·46	2·11	8·83	8·36	26·74	4·41	11·41	25·87	7·99
23d	„ „	3·80	·81	1·28	5·55	6·21	27·04	6·17	16·59	23·85	8·70
23e	„ „	15·35	·92	1·72	4·23	6·24	21·58	8·23	15·06	23·70	2·97
24	Sandy clay ...	15·04	1·49	2·00	6·76	6·34	31·50	7·37	5·24	4·73	19·53
24a	„ ...	3·81	·85	1·73	8·85	7·83	34·22	5·57	3·71	4·20	29·23
24b	„ ...	4·90	1·21	1·64	7·15	9·42	33·72	7·84	3·48	4·13	26·51
24c	„ ...	·77	1·03	2·08	2·87	10·34	38·41	8·50	4·05	1·57	27·38
24d	„ ...	·72	·76	1·98	2·82	10·30	35·26	7·77	3·20	4·57	32·62
24e	„ ...	·94	1·19	2·15	2·96	9·16	34·07	8·29	4·27	4·53	32·44

Diagram illustrating mechanical Analyses of Soil No. 21 from the Government Experiment Station, Robertson.

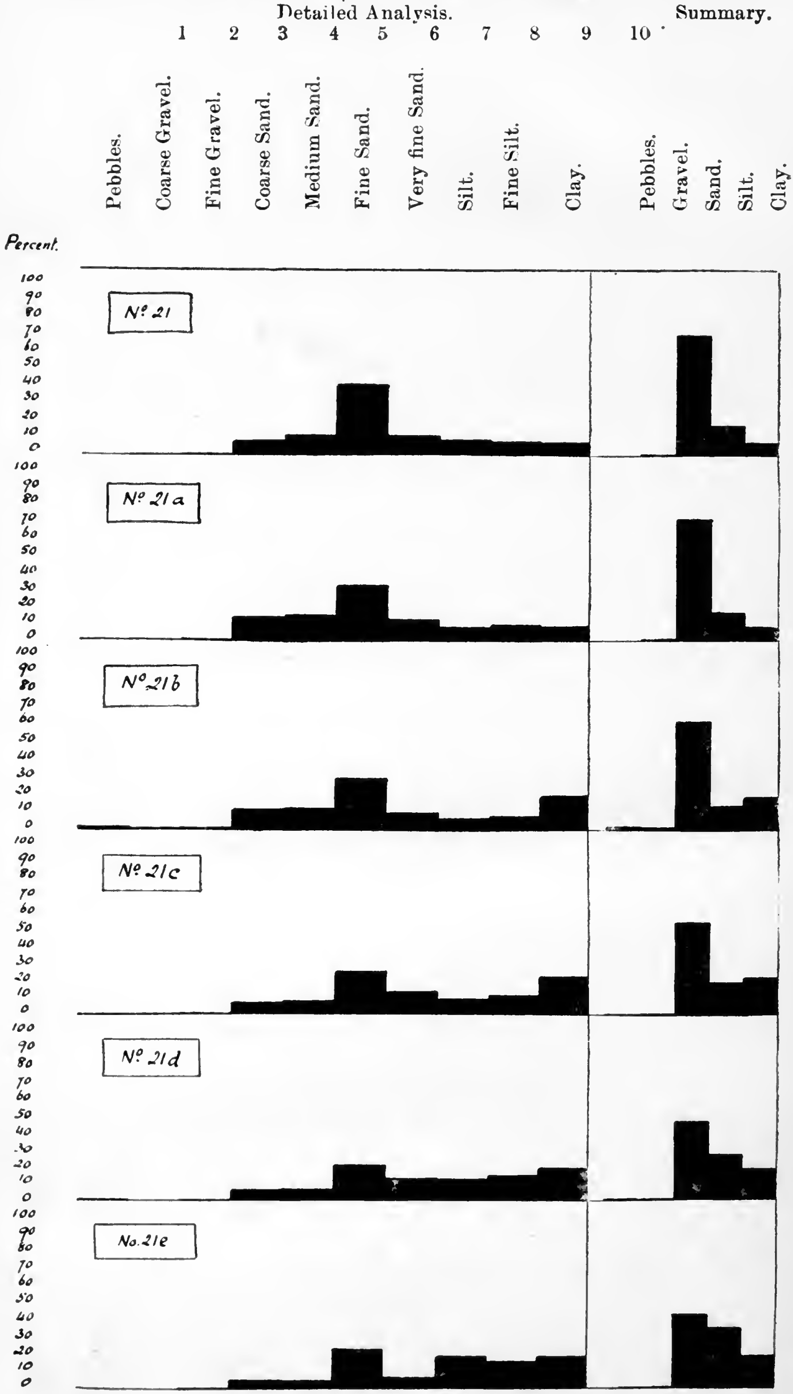


Diagram illustrating mechanical Analyses of Soil No. 22 from the Government Experiment Station, Robertson.

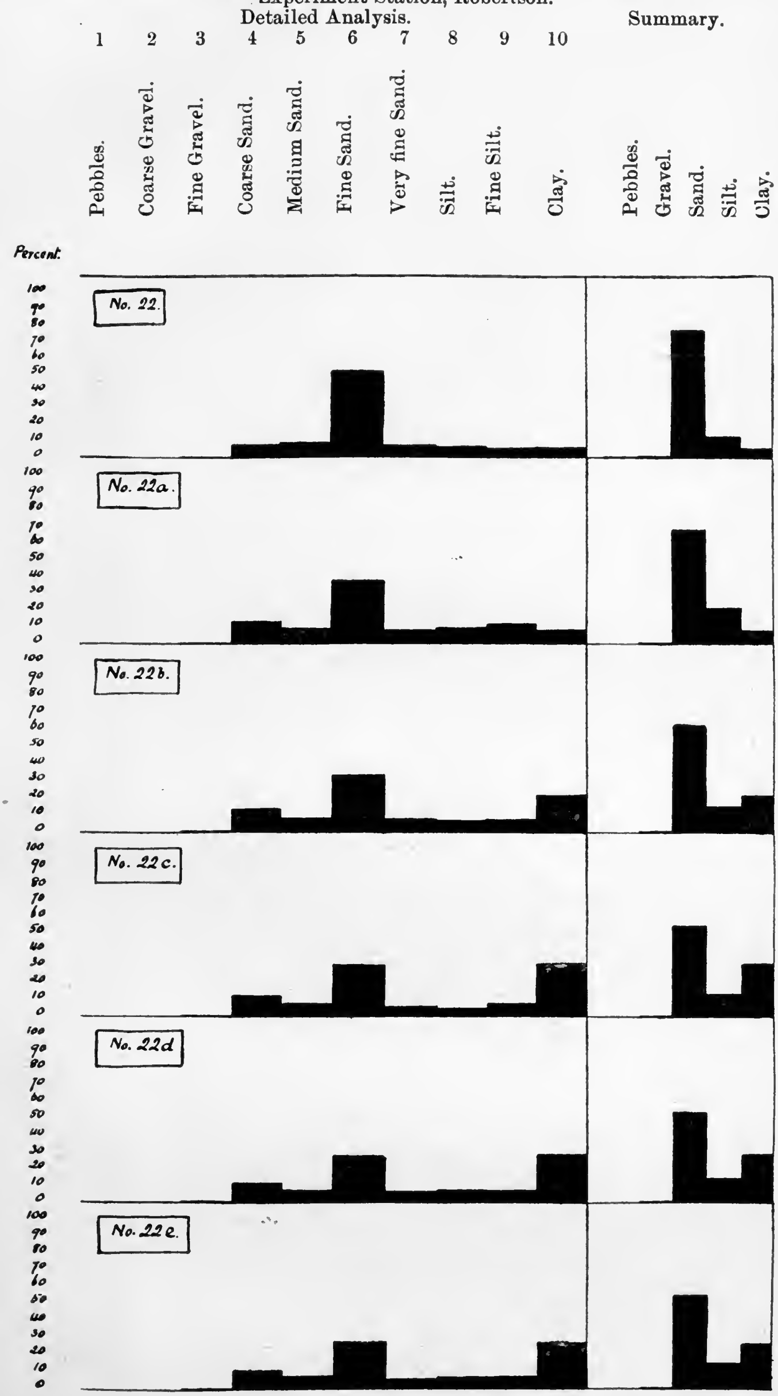


Diagram illustrating mechanical Analyses of Soil No. 23 from the Government Experiment Station, Robertson.

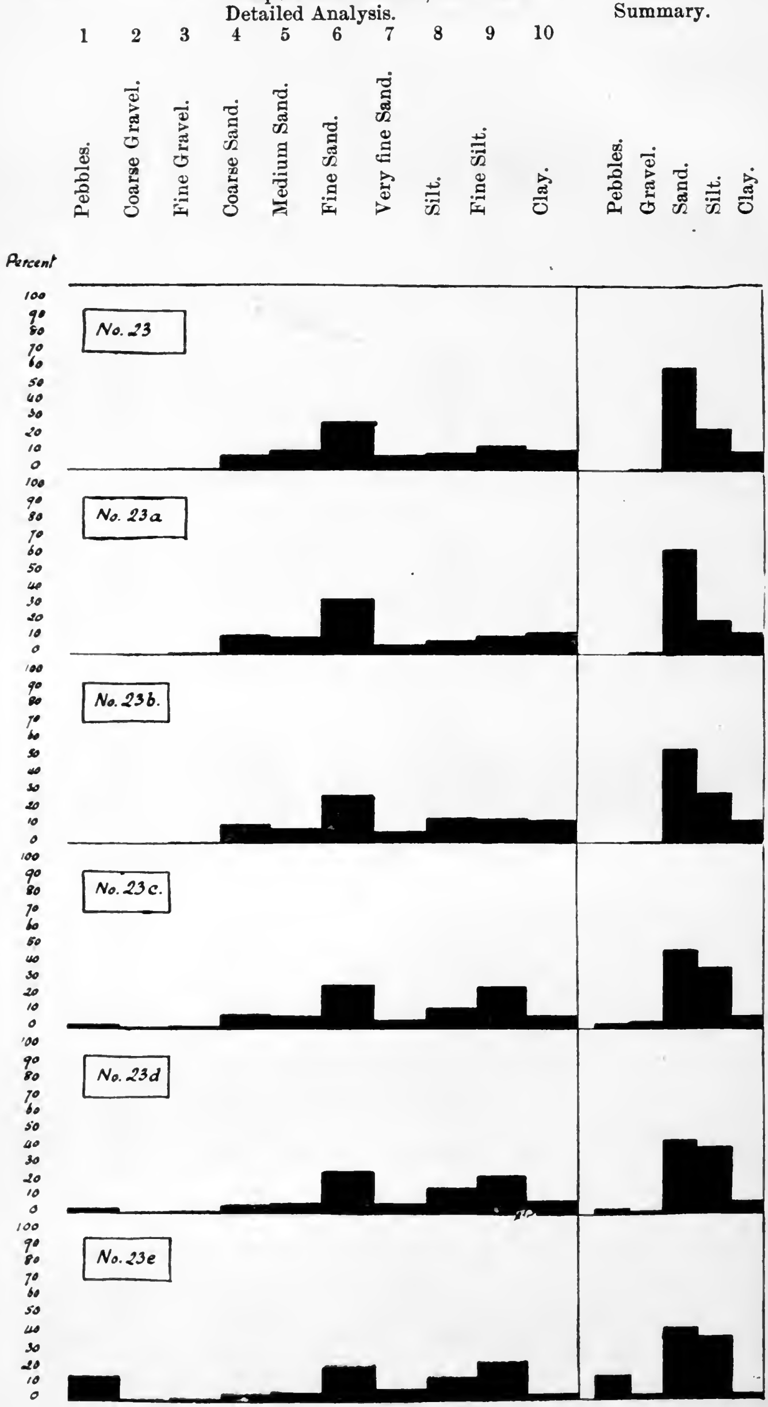
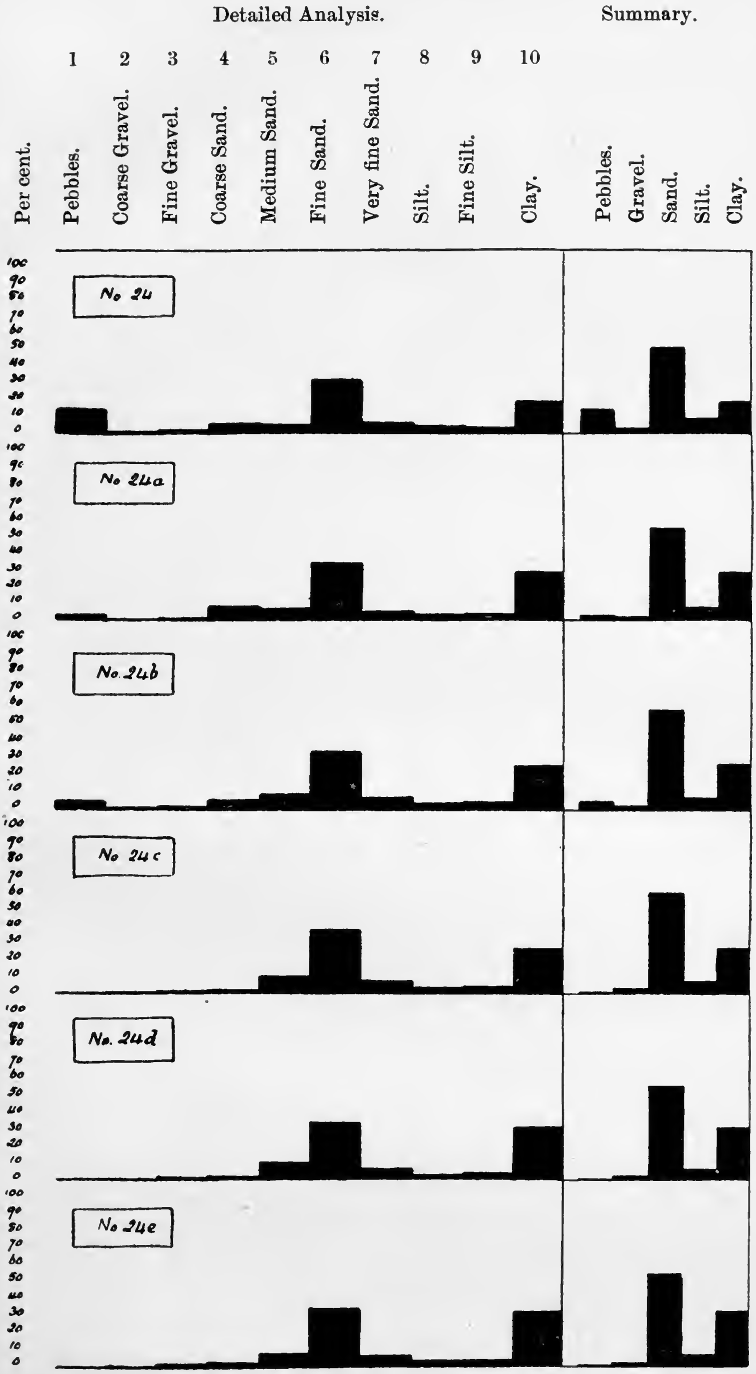


Diagram illustrating mechanical Analysis of Soil No. 24 from the Government Experiment Station, Robertson.



The results detailed in the foregoing table may be summarised as follows:—

No.	Pebbles > 3 mm.	Gravel 3 — 1 mm.	Sand 1 — ·05 mm.	Silt ·05 — ·005 mm.	Clay < ·005 mm.
21	·15	1·15	71·28	18·75	8·67
21a	·12	1·11	72·64	17·50	8·83
21b	2·26	1·89	62·47	13·68	19·70
21c	·54	1·00	55·82	19·89	22·75
21d	1·08	·85	48·94	28·97	20·16
21e	·09	·45	42·90	36·82	19·74
22	·68	1·14	78·03	13·79	6·36
22a	·07	·75	69·44	21·04	8·70
22b	·04	·75	62·98	15·31	20·92
22c	·01	·58	55·03	13·71	30·67
22d	·18	·82	54·10	15·05	29·85
22e	·15	·74	55·69	15·80	27·62
23	·11	1·01	61·35	24·93	12·60
23a	·09	1·21	63·70	20·84	14·16
23b	·24	1·01	55·23	29·64	13·88
23c	2·82	3·57	48·34	37·28	7·99
23d	3·80	2·09	44·97	40·44	8·70
23e	15·35	2·64	40·28	38·76	2·97
24	15·04	3·49	51·97	9·97	19·53
24a	3·81	2·58	56·47	7·91	29·23
24b	4·90	2·85	58·13	7·61	26·51
24c	·77	3·11	60·12	8·62	27·38
24d	·72	2·74	56·15	7·77	32·62
24e	·94	3·34	54·48	8·80	32·44

It will be observed that the alkaline patch, which is also chemically the poorest of the four in plant food, contains very much less silt than the others, whereas No. 23, the soil best supplied with plant food, is likewise the richest in silt.

In order to illustrate the character of these soils the better, a diagram showing the texture curves of soil No. 24, for each eight inch section, is appended. Such diagrams reveal to the eye, at a glance, more clearly than mere figures can, how, on descending from surface to sub-soil, in No. 21, the sand diminishes in proportion, while the silt and clay increase; in No. 22 sand also diminishes, while clay increases; in No. 23 both sand and clay diminish, but silt increases; and in No. 24 the proportion of clay increases, and there is a diminution of pebbles.

On a former page reference was made to the Orange River clay collected in the Prieska Division (No. 1, Prieska Division soils): the chemical analyses of soils from farms situated along the river banks lower down were also given (Nos. 2, 3, and 4): these three samples, in each case, represented the surface soil to a depth of twelve inches, but opportunity was taken at the same time to secure specimens of the subsoil to a depth of three feet, and mechanical analyses of all these were made, with the results stated below:—

No.	Pebbles > 3 mm.	Gravel 3 — 1 mm.	Sand 1 — ·05 mm.	Silt ·05 — ·005 mm.	Clay < ·005 mm.
1	nil	nil	·29	28·53	71·18
2	nil	·05	77·81	16·58	5·56
2a	nil	·10	60·46	31·37	8·07
2b	nil	·03	38·26	53·29	8·42
3	nil	·04	36·14	45·53	18·29
3a	nil	nil	55·91	32·15	11·94
3b	·08	·18	59·78	25·64	14·32
4	1·61	3·64	50·65	30·63	13·47
4a	·06	·44	59·05	28·31	12·14
4b	·17	·57	53·88	31·36	14·02

These results are set forth in greater detail in the next table:—

Mechanical Analyses of Prieska soils.

PERCENTAGE OF DRIED SOIL.

No.	Soil class.	Pebbles > 3 mm.	Coarse gravel 3 — 2 mm.	Fine gravel 2 — 1 mm.	Coarse sand 1 — ·5 mm.	Medium sand ·5 — ·25 mm.	Fine sand ·25 — ·1 mm.	Very fine sand ·1 — ·05 mm.	Silt ·05 — ·01 mm.	Fine silt ·01 — ·005.	Clay < ·005 mm.
1	Clay	nil	nil	nil	nil	nil	·04	·25	3·25	25·28	71·18
2	Fine sandy loam...	nil	·02	·03	·11	·77	48·26	28·67	12·21	4·37	5·56
2a	,, ,, ...	nil	·03	·07	·40	2·46	27·34	30·26	22·64	8·73	8·07
2b	Loam	nil	nil	·03	·13	·57	12·89	24·67	41·90	11·39	8·42
3	Loam	nil	·01	·03	·11	1·81	17·72	16·50	25·61	19·92	18·29
3a	Fine sandy loam...	nil	nil	nil	·13	2·01	30·23	23·54	20·92	11·23	11·94
3b	,, ,, ...	·08	·03	·15	1·11	4.86	39·21	14·60	12·84	12·80	14·32
4	Fine sandy loam...	1·61	1·35	2·29	4·84	4·77	21·70	19·34	15·60	15·03	13·47
4a	,, ,, ...	·06	·16	·28	1·68	6·67	32·15	18·55	15·65	12·66	12·14
4b	,, ,, ...	·17	·22	·35	1·05	4·01	30·95	17·87	17·89	13·47	14·02

Diagram illustrating mechanical Analyses of Orange River Clay and of Soils from the farm, Stof Kraal, in the Prieska Division. adjacent to the Orange River.

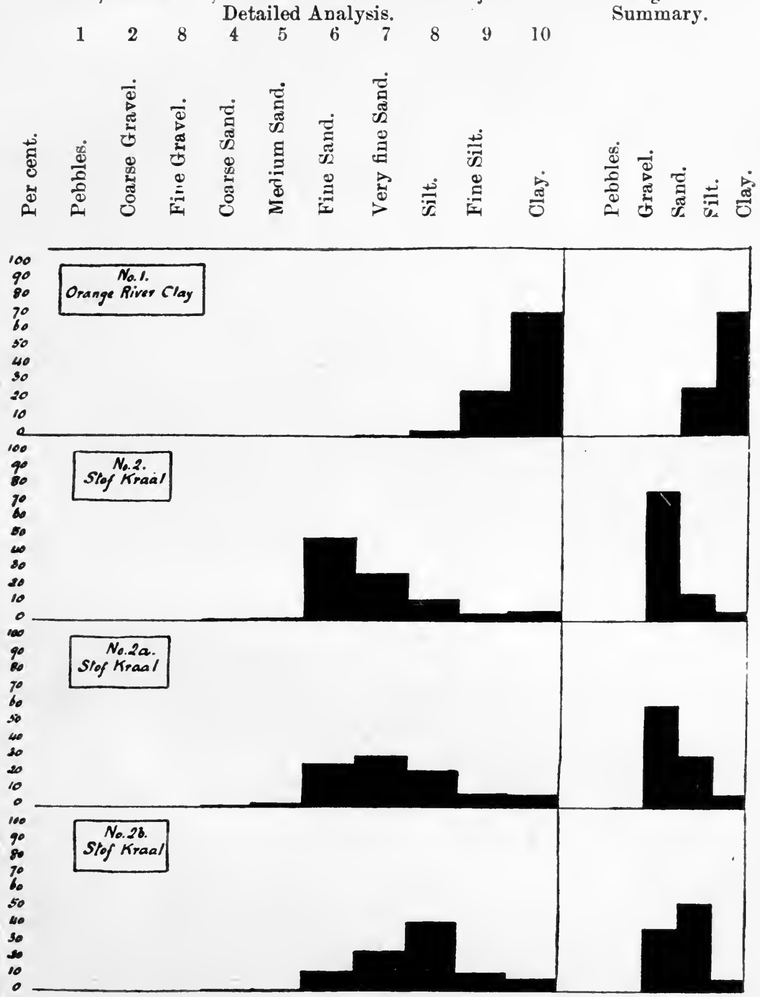
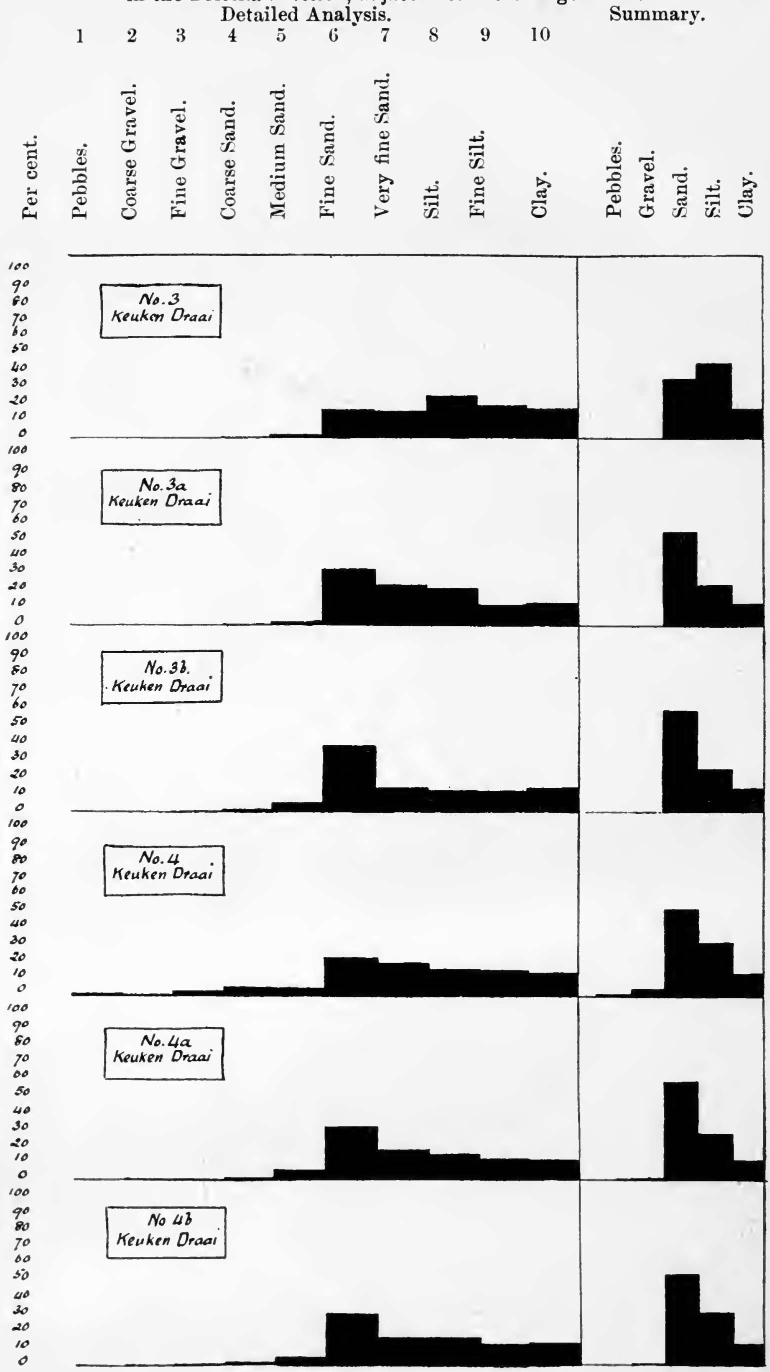


Diagram illustrating mechanical Analyses of Soils from the farm Keuken Draai, in the Prieska Division, adjacent to the Orange River.



Rich though it may be chemically, the Orange River deposit contains too much clay—and is therefore too dense and heavy—to enable it to be advantageously used in its original condition; but when deposited on the surface of a sandier soil, with which it may be manipulated, it would add considerably to the agricultural value of the latter. If it could be directed on to a very sandy soil, containing, say, 90 per cent. of sand, a single flooding of the lands would—assuming a half-inch annual deposit—increase the proportion of silt and clay in the soil to about 17, and diminish its sandiness proportionately; after a second flooding the soil so treated would consist of 76 parts of sand and 24 of silt and clay, and the third year would see the sandy soil converted into a loam composed of 70 per cent. of sand and 30 per cent. of clay.

At a previous stage a remark of King in connection with the Rio Grande deposits was quoted; he continues the passage as follows*: —

"When such sediments are laid down upon coarse sandy soils, it will be readily appreciated that the gain to the field is far greater than that due to the mere plant food which the sediments contain; for such sediments, being composed of very fine grains, their influence in improving the texture of the soil is quite as great as that due to the fertilisers contained."

The Orange River clay, although rather heavier, appears in some degree to resemble what has been called Vergennes clay, a type that occurs on the terraces surrounding Lake Champlain, and consists of deep-water sediments deposited in post-glacial times. The subsoil of this clay, which more particularly resembles that from the Orange River, is a heavy drab or light-brown clay, somewhat tenacious when wet, but extremely stiff, compact, and intractable when dry. The Vergennes clay is said to be an excellent soil for hay, while corn, oats and barley are also profitably grown; it yielded, when mechanically examined by the United States Department of Agriculture, the following results: —

	Surface soil.	Subsoil.
Fine gravel: 2—1 mm.	2	0
Coarse sand: 1—·5 mm.	3	1
Medium sand: ·5—·25 mm.	2	2
Fine sand: ·25—·1 mm.	3	2
Very fine sand: ·1—·05 mm.	3	2
Silt: ·05—·005 mm.	18	22
Clay: less than ·005 mm.	69	71

Nos. 2, 3 and 4 illustrate the effect of the Orange River clay being deposited on and mixed with the Kalahari sands which prevail for many miles around; these sands are brick red in colour, and constitute the coarser portions of the soils on the neighbouring farms. In the process of mechanical separation into grades, the point of transition from the coarser red sands, contributed to the soil by the Kalahari, to the finer-grained drab-coloured silts, derived from the river deposits, is readily distinguished. This sharp contrast of colours enables one to draw the inference that the silt deposits are often more coarsely grained than that of which No. 1 is a sample. In each of the three soils sampled the particles of greater diameter than ·1 mm. are of local origin, whereas those below that size are river-borne sands, silts and clays. No. 2, as the table of results shows, becomes less sandy as one penetrates deeper, but Nos. 3 and 4 are sandier lower down than at the surface.

As representing some of the choicest lands in those districts which have been termed the Granary of the Colony, the two Koeberg soils numbered 33 and 34 amongst the Cape Division samples (*vide* page 39), were chosen for mechanical analysis. They have already been described, and their chemical condition referred to.† Each of these two soils was sampled, in twelve-inch vertical sections, to a depth

* "Irrigation and Drainage," 2nd ed., 1902, p. 259.

† See pp. 40 and 158.

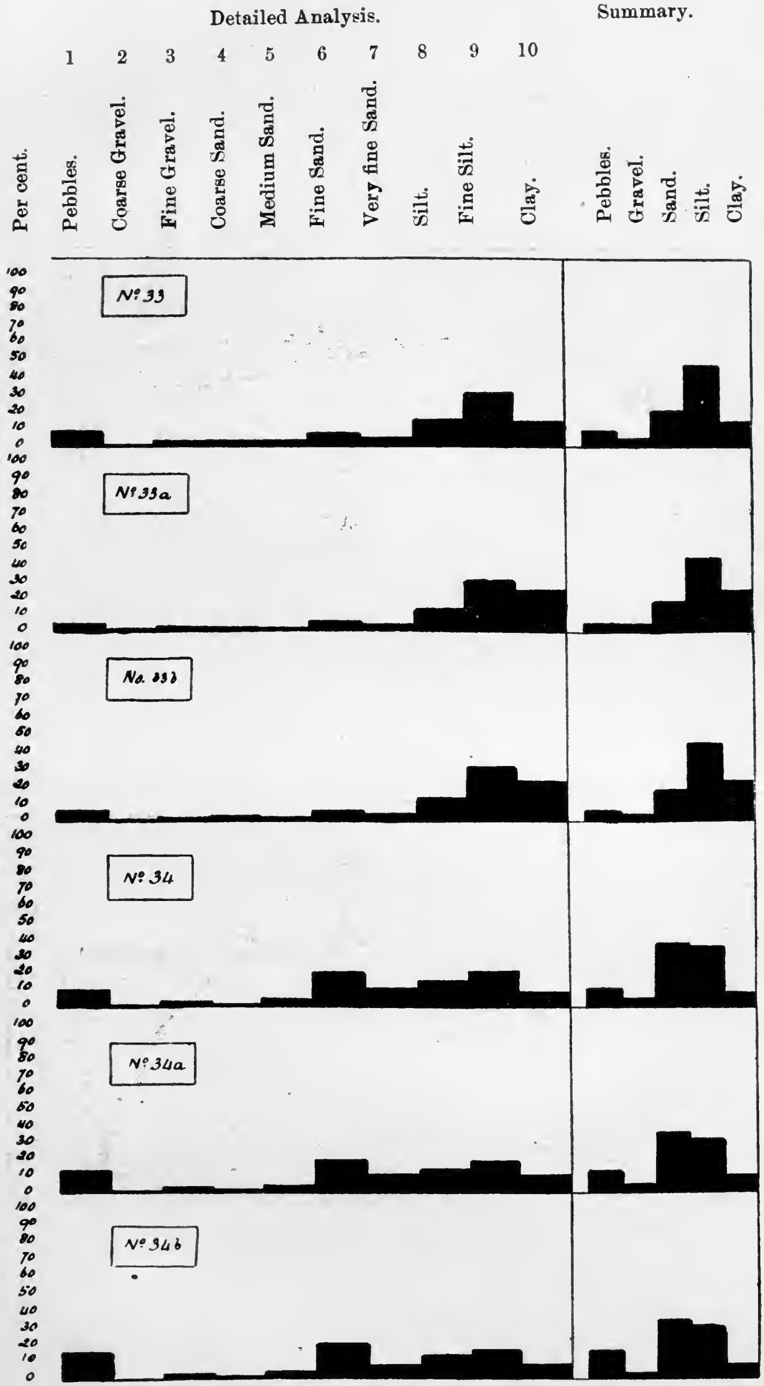
of three feet, and from the samples so collected the following results were obtained by mechanical analysis:—

Mechanical Analyses of Koeberg (Cape Division) Soils.

PERCENTAGE OF DRIED SOIL.

No.	Soil class.	Pebbles > 3 mm.	Coarse gravel 3—2 mm.	Fine gravel 2—1 mm.	Coarse sand 1—·5 mm.	Medium sand ·5—·25 mm.	Fine sand ·25—·1 mm.	Very fine sand ·1—·05 mm.	Silt ·05—·01 mm.	Fine silt ·01—·005 mm.	Clay < ·005 mm.
33	Loam	9·86	1·58	3·21	3·58	3·56	8·44	5·79	16·35	32·28	15·35
33a	Clay loam	5·27	1·81	3·36	3·04	2·75	7·36	5·44	14·19	31·16	25·62
33b	,, ...	7·65	1·48	2·77	3·71	2·73	7·28	5·50	14·19	31·17	23·52
34	Fine sandy loam ...	10·16	1·75	3·65	2·29	4·63	20·86	11·20	15·96	20·61	8·89
34a	,, ...	13·71	1·63	3·87	2·01	4·41	20·18	11·10	13·97	19·01	10·11
34b	,, ...	17·65	·53	3·37	2·18	4·80	20·87	9·08	14·57	17·74	9·21

Diagram illustrating mechanical Analyses of Soils from the farm Hooge Kraal in the Cape Division.

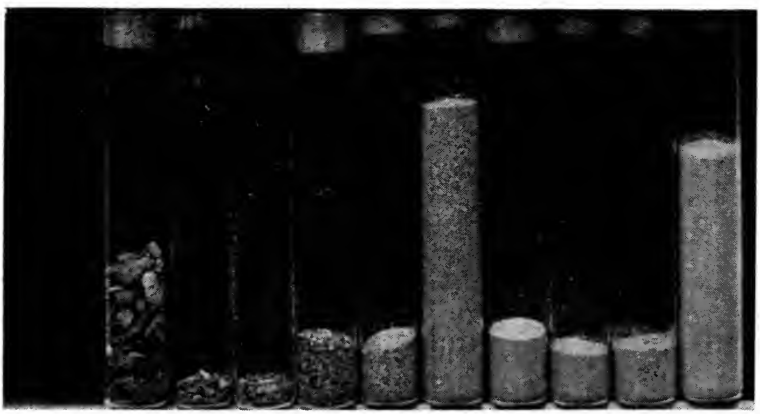


No. 33.—Cape Division—Loam.

Soil Grade.	Pebbles.	Coarse Gravel.	Fine Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very fine Sand.	Silt.	Fine Silt.	Fine Clay.
Per cent.	9·86	1·58	3·21	3·58	3·56	8·44	5·79	16·35	32·28	15·35

No. 24.—Robertson Division—Sandy Clay.

Per cent.	15·04	1·49	2·00	6·76	7·34	31·50	7·37	5·24	4·73	19·53



The figures of the table on the preceding page are summarised below, and the results are also presented in diagrammatic form in order to facilitate comparison with the other Colonial soils similarly examined.

No.	Pebbles > 3 mm.	Gravel 3—1 mm.	Sand 1—·05 mm.	Silt ·05—·005 mm.	Clay <·005 mm.
33	9·86	4·79	21·37	48·63	15·35
33a	5·27	5·17	18·59	45·35	25·62
33b	7·65	4·25	19·22	45·36	23·52
34	10·16	5·40	38·98	36·57	8·89
34a	13·71	5·50	37·70	32·98	10·11
34b	17·65	3·90	36·93	32·31	9·21

It will be found of interest to compare these results with the figures quoted from Snyder (see page 190) as the most satisfactory for wheat production. As before observed, it does not by any means follow that the optima of mechanical composition for wheat soils in the United States of America are also the optima in the Cape Colony; in fact, it would be strange if such were the case, in view of the widely different climatic conditions.

By way of supplementing the diagrams which illustrate what I have termed the "texture curves" of some of the soils examined, a photograph is appended showing the actual proportions of the several grades of soil particles separated by the above described processes from the former of the above two soils, and from No. 24 of the Robertson soils.* It will be interesting to compare this photograph with the diagrams drawn from the calculated results of the mechanical analyses of the respective soils.

Concluding Observations.

In bringing this record to a conclusion, the writer must express his sense of its incompleteness. True, no investigations of this nature can ever bear the impress of finality, they must perforce continue incomplete as long as agricultural chemistry has room to progress. But the incompleteness that attaches to this special record is the inseparable adjunct of contingencies which have all along restricted to one pair of hands at a time the work of investigating the chemical problems of the soil in a country so vast and varied, and possessing such diversities of temperature, rainfall, and geological conditions, as this Colony presents. When, above all, this investigation had to be sandwiched in amongst multifarious other calls on time and attention—or passed on to assistants, when time failed entirely, as it did almost at the very outset, and the work had then to be fitted in amongst *their* other duties—the difficulties were greatly increased; and moreover, as no other researches of like nature were being carried on within a radius of many thousand miles, special appliances had to be procured from abroad, and perhaps tested for a considerable time ere their unfitness stood revealed. Thus much time was continually being lost, and great *periodic gaps* occurred in the pursuance of the work.

There are also comparably great gaps of *totally uninvestigated tracts of country*, and even the areas that were visited have been practically skimmed over. Thus it has come about that much had to be done by delegation, through written instructions—a course which always fails to secure uniformity—for instance, in regard to collection of samples. Frequently failure to carry out these instructions to the letter has either

* It is in each case the surface layer of soil that is represented in the photograph.

hindered, or neutralised the value of, the subsequent laboratory work, or prevented its performance, more especially in sparsely populated parts of the country, where, through lack of conveyance, months have at times elapsed before fresh samples could be procured.

The *directions* in which investigation was made also show omissions that will be patent on glancing through these pages. Some of these defects will, it is hoped, be supplied in the near future; others must of necessity remain defects until contingencies enable one to widen the scope of investigation. Amongst the latter, unfortunately, has to be classed one of the most important studies that pertain to the soil, that is, the soil nitrogen, its exhaustion and replenishment.

And yet, however beset with difficulties and obstacles the work has hitherto been, the writer thinks that—thanks to the assistance of those who have, from time to time, been members of his staff, and whom, first one and then another, he charged with the details of the work—these records will show the existence of solid reason for initiating this undertaking, and that the investigation has not been wholly void of fruit must also be apparent. The connection between the composition of the soil and the ravages of bone disease in stock has not been fully traced out, but it is at least remarkable that these diseases find the greatest foothold in just those areas where lime and phosphates are deficient in the soil. In connection herewith the question has been put, why, if the sandstones of the Table Mountain and allied series are so poor in the plant food constituents named, "lamziekte" does not make its appearance in the south-west, but is confined to the districts further east? One answer obviously is that, in the more easterly districts, the rocks in which these constituents are deficient stretch uninterruptedly over vast extents of country, while in the west they are sufficiently diversified by granite and the rocks of the Bokkeveld series.

The confirmatory testimony given, in many cases, during the course of these investigations, by practical farmers, has shown that, presuming certain necessary data, correct deductions as to the probable fertility of a soil are capable of being made from analytical results. It would be idle to assert that discrepancies do not occur, but in the present state of enquiry one must needs meet with seeming anomalies: there is a plain necescity for pushing investigation very much further. The best means of determining the proportions of plant food constituents in the soil have to a certain extent been studied, and the methods finally adopted appear, judging from the confirmatory evidence just spoken of, to be the most suited to the country's circumstances. To transfer hither, unmodified, and without enquiry, European or American methods of treatment, or standards of interpretation, would scarcely have been wise.

Regarding the irrigation schemes which must continue to bulk largely in the country's future agricultural development, it has been shown how needful it is previously to enquire into the condition of the soil, and here not only the alkali deposits themselves need investigation, but equally so the physical condition of the soil. The important problems of differentiating soil types, and of classifying the Colony's soils from a laboratory standpoint—an investigation which has proved so useful in America—still remain to be grappled, and it is the writer's increasing view that just at this point a thorough study, and, if possible, a mapping out, of the mechanical condition of the soil should go conjointly with, if indeed not actually precede, enquiry into the quantities of plant food present. In connection with a scheme like this an adequate knowledge of the distribution of indigenous plants and of their soil relation is also most necessary. Such a scheme, the writer trusts, will ere long be put into practical operation. How frequently barrenness may be caused by other factors than the lack of plant food in the soil has been shown more than once in these pages, so that there is no need to labour the matter further; and in many cases where there is no question of barrenness at all, the difference of texture in soils suited, say, to the cultivation of potatoes, and soils of a more clayey nature, has exercised a controlling influence upon the class of farming to be practised; such differences of texture in the soil profile may be actually mapped out, and would afford a means of incalculable benefit. It has, for instance, been seen that to a certain extent geological influences perform an important part in this connection (see p. 195) and, placing this over against what has been referred to above regarding the mapping out of soil types, it becomes evident that an interesting and most valuable phase of the subject invites closer study. Hitherto the study of the soil's physical condition has extended little beyond the mechanical analyses of more or less typical soils of three broad classes, namely, the grain soils of the south-western districts, the fruit and general farm soils of the Worcester-Robertson area, and the deposited silts of the Orange River, all of which have been dealt with under the head of "Physical composition of soils." A far wider application of this branch of investigation should now be embarked upon.

From a chemical point of view the richness of the soils where the Bokkeveld series and the Karroo system prevail has been shown, not to mention the chemical value of the river silts, the products of the erosion that is going on elsewhere; and the efforts to retain and utilise these latter also deserve extended application as a matter of economic importance.

In these and other respects, briefly and inadequately touched upon hitherto, and in many more as yet untouched, which need not be specially mentioned here, but will occur at once to anyone reading the foregoing records and acquainted with the state of agricultural science to-day, the practical value of a soil survey to this vast and fertile country is immense, and all the more is it important at this juncture, when a general re-awakening to the need of agricultural development is manifesting itself, and when it is beginning to be more thoroughly realised how great are the capacities of this sub-continent for such development, and for taking full advantage of the magnificent climate wherewith it has been endowed.

I must not conclude without some words of acknowledgement of the services of those gentlemen who, as members of my staff, have from time to time individually undertaken many of the analyses which have enabled me to compile this record. Although most of the work detailed under the heads of "Alkalinity" and "Physical composition" was carried out by myself in person, of the analyses enumerated in Part III. opportunity was not afforded me, for the reasons already explained, of performing more than about eighty. My especial acknowledgments are due to Mr. A. Simons, B.A., who performed over 400 analyses. The services of the late Mr. J. C. Watermeyer, and of Messrs. J. Muller, B.A., and St. C. O. Sinclair, M.A., who undertook some 60 analyses each, are also entitled to special recognition here. Without the valued aid of these and the other members—past and present—of the laboratory staff, this compilation could not, for lack of material, have been undertaken. My thanks are also due to my brother, Mr. J. W. Juritz, for his ready assistance in drawing the maps with which this record has been illustrated.

INDEX.

(N.B.—Names of **farms have not,** as a rule, been included in this Index).

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