THE SOILS OF THE WELLINGTON - MALMESBURY AREA

by

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CONTENTS

A B S T R A C T

The fifteen soil series encountered in the survey of the area covered by the 1:50,000 topographical sheet, Wellington 3318DB are described. The morphological and chemical features as well as distribution and agricultural potential ~~is~~ are discussed. The genesis of the soils and their place in the 7th Approximation is given. The shortcomings of the 7th Approximation encountered are discussed.

Within the area, parent material was found to be the major soil forming factor. Differences in parent material resulted in oxisols occuring in an area dominated by argids. Argids are the climatically zonal soils on argillaceous rocks.

INTRODUCTION

Soil systematics is in its infancy in South Africa. While a Map of the zonal soils of South Africa was published in 1941, (van der Merwe) until recently little systematic work has been done. Since 1957 when the survey of soils in the Tugela Basin began, new impetus has been given soil systematics in South Africa.

The only systematic soil survey to have been done in the Western Cape prior to this one; was by Slabber, (1945) who produced a series map at 1 : 125,000 of an area of about 2,500 sq. miles in extent, to the north of the area studied in this survey.

To implement the Berg river development plan, the need for soil maps as an index of agricultural potential was felt. The Department of Agricultural Technical Services was asked in 1963 to do a soil survey of the catchment area - an area to the extent of some 2,000 sq. miles.

The Soils Research Institute had, at the time, started on its programme of siting "key areas" and studying the soils in these areas selected throughout the Republic. By surveying selected key areas maximum knowledge of the soils would be gained in a minimum time. The knowledge gained in these areas would be put to use to produce soil maps at 1 : 250,000 covering the whole Republic. With this project in mind, it was decided to choose key areas in the Berg river catchment basin and study the soils in them, with a view to later mapping at 1 : 250,000.

During a reconnaissance trip through the Western Province, taking note of variations in soils, physiography, geology and climate; three key areas were chosen, viz. at Wellington, at Piquetberg and at Darling. Together with an area in the Eerste river catchment basin, probably at Stellenbosch, sufficient knowledge of the soils would be gained to map the soils of the whole Western Province.

Since 1945, when Slabber surveyed the area, the language of the pedologist has widened considerably and more properties of soils are used as differentiating characteristics. With his larger vocabulary the soil systematist today can more accurately define soils. Munsell soil color charts (1954) and the terminology of the United States Department of Agriculture (1951 as modified 1960 and 1962) are internationally used as everyday tools of the pedologist. It has been thus necessary to redefine the soil series described by Slabber in modern terms.

Since it is the lowest category in the classification system of soils, which can, in practice, be mapped at 1 : 50,000; the series/...

the series map isthe most useful soil map to produce at this scale. From the series map single factor maps for engineers, agriculturalists and regional planners may be produced. To avoid unnecessary duplication of work therefore systematic soil surveys are far more useful than single factor maps, eg. break maps, shrinkage ratio maps or land capability maps; from the series map all of these can be produced but a series map could seldom be produced by combining all single factor maps normally produced.

A soil systematist looks upon soils as natural, vital bodies, not as a medium for plants, nor as the weathered crust of the earth. To an agronomist or a geologist it may appear at times that like bodies are separated and unlike bodies grouped into one soil series. The nature of the soil below the plough layer is of most significance to the series classification of a soil. Differences in nature of the plough layer are used to differentiate a series into phases. Differences between series are genetic; differences in soil behaviour, unrelated to genesis, differentiate between phases not series. Normally plant behaviour differs in different series, this alone, however is not differentiating between series. The origin of soil forming materials is of interest to the pedologist in evaluating a soil. Origin of materials does not differentiate between similar soils however.

CHAPTER I : SURVEY PROCEDURE

The survey of the Wellington key area began with a short reconnaissance survey to become familiar with the area, the soils, and their distribution. Use in this study of the soils, was made of road-cutting and donga exposures, as well as auger borings.

Knowing what soils could be expected and where to expect them, some two hundred test pits were sited, dug, described and sampled. These profiles were sited selectively throughout the area bearing in mind that all variations in "soil types" must be seen, and that for the purpose of classification into series, at the very least five profiles in separate individuals must be studied. While siting profiles, notice was taken of geological, vegetative and physiographic, as well as soil features. Accessability also governed pit siting for reasons of expedience and economy. Pits were therefore sited along the many roads which dissect the area. Profiles were described using the terminology of the United Sates Department of Agriculture[1)] (1951 as modified 1962). Each horizon of the solum was sampled for pH and resistance determinations on the saturated soil paste.

Having completed the study of the soil profiles, a preliminary series classification was prepared sorting the profile descriptions into groups of soils as like in morphological and chemical (pH and resistance) characteristics as possible. Care was taken not to separate pedons belonging to similar individuals as recognised in the field. The grouping of apparently dissimilar pedons into Swartland series is an example. The Swartland individual shows a great variability especially in colour in its substituent pedons.

Mention was made above, of the need for replication in profile descriptions. Because the series classification aims at the grouping of similar soil individuals, and because the individual itself cannot be fully studied but must be studied by means of a single or a few pedons; the more pedons of a soil series described the closer would the grouping of similar soil individuals into a series be to the truth. A soil individual is a definate entity with real boundaries, the series is however a man-made grouping of similar individuals with man-made limits imposed. As the number of pedons

described/.....

1) Hereafter U.S.D.A.

described tends to the number of pedons in all similar soil individuals, so the series definition tends to the soil individual characteristics.

Having compiled the classification, it was checked in the field to ensure that it was a workable classification. The limits set were checked to see if they included those pedons they were intended to include to the exclusion of pedons of dissimilar individuals. It was checked to verify that the series classified could actually be identified as such in the field. Where necessary, new criteria were established or new limits set.

Type profiles which conformed as closely as possible to the central concept of the series were selected, thoroughly and carefully described, and sampled for analysis to typify the chemical characteristics of the series. Of all newly defined series two type profiles were sampled and described.

Using the series classification as a foundation, a map legend was prepared and mapping of the soils commenced. The soils were mapped onto aerial photographs at approximately 1 : 25,000 scale. Two sets of photographs were made available by Trigonometrical Survey; one set covering only the western half was flown in 1960, the other set covering the whole area, in 1955. The latter set was rather indistinct. Stereoscopic interpolation - especially the demarcation of bottomlands - was accomplished using a pocket stereoscope.

Identification of the soils was made using a pick, a shovel a crowbar and an auger. Due to the preponderance of stone lines; the dryness of the soils, especially in the wheatlands; and the hard-setting A horizon of Swartland, it was almost only in the bottomlands that identification by auger alone could be used. The Thompson, a Rhodesian designed auger, proved the most useful. A 4 ft. Edelman auger was used in wet soils and a 7 ft. one in the moist deep sands.

It was during the process of mapping the soils that most concerning them was learnt. This knowledge is put down in this thesis. The soil map is in itself proof of the classification. That the soils differentiated and classified in terms of physical and chemical characteristics can be identified and defined in terms of space in the landscape, is proof of the validity of the classification.

THE SOIL MAP

Soils were encountered which did not fit into the legend comfortably. As was explained earlier it is not practicable to examine a whole soil individual, rather this individual is sampled by means of pedons whose properties are taken to represent the individual. Depending on the site of the pedons studied therefore, different interpretations as to the nature of the whole individual may result. Where soils did not fit into the legend, they were either grouped with the surrounding soils or mapped as that soil which they closest resembled.

Soil individuals have definite boundaries, but where two soils bound on each other they normally grade into each other via soils with affinities with both. Depending on the surveyor's concept of each soil individual the boundaries between two soils will thus differ.

From the scale of the soil map (1 : 50,000) it can be worked out that the smallest circular area which can be printed, without producing a map so intricate as to detract from its merit, is approximately 20 morgen in size. It is therefore to be expected that small areas of soils may have been "incorrectly" mapped. Where the area of the inclusions of foreign soils within an individual exceeds about 20%, use has been made of soil associations. The soil map produced is not intended for direct use in farm planning nor for any land use recommendations at the farm level. For regional or divisional planning the scale is perfect.

In essence the soil map can be said to be the concept of the position and nature of the soils as proposed by the surveyor. If the interpretations of the surveyor do not vary by more than 20% from the true facts the soil map is considered an acceptable interpretation. The impossible has been attempted in this survey - to produce a map which does not vary from the truth.

The soil map will be useful in land use recommendations only if interpreted in conjunction with the text. The map shows what soils are dominantly present. From the definitions in the text the separate soils can be identified and mapped at smaller scales. What must also be emphasised is that while soil boundaries may be pinpointed to within a few yards in the field, on the map a pencil line represents 30 yards. The map shows what to expect but the soil must nevertheless be identified before it can be stated that this soil is 'so and so' a series.

CHAPTER II : THE AREA SURVEYED

The area covered by this survey is in extent about 250 sq. miles as covered by the 1 : 50,000 topographical map "Wellington 3318DB" compiled and drawn by the Trigonometrical Survey Office (1942 reprinted by the Government Printer 1951). Paarl and a part of Wellington lie in the south-eastern corner. Hermon is just north of the north-eastern corner and Malmesbury of the north-western corner.

The area is well dissected by roads, of which about a quarter have tarred surfaces; the remainder having good gravel surfaces. The main electrified Cape Town-Johannesburg railway line traverses the eastern quarter of the area.

Almost all of the arable land is under cultivation. Vines, and to a minor extent, fruit, are grown around the two mountains Paarlberg and Paardeberg. Table grapes for markets overseas are grown north and east of Paarl mountain and west of Paarde mountain. For the rest vines are mainly for wine grape production. The major part of the cultivated land is cropped to a wheat-lupin-fallowland rotation. The lupins and the wheat stubble are grazed to sheep.

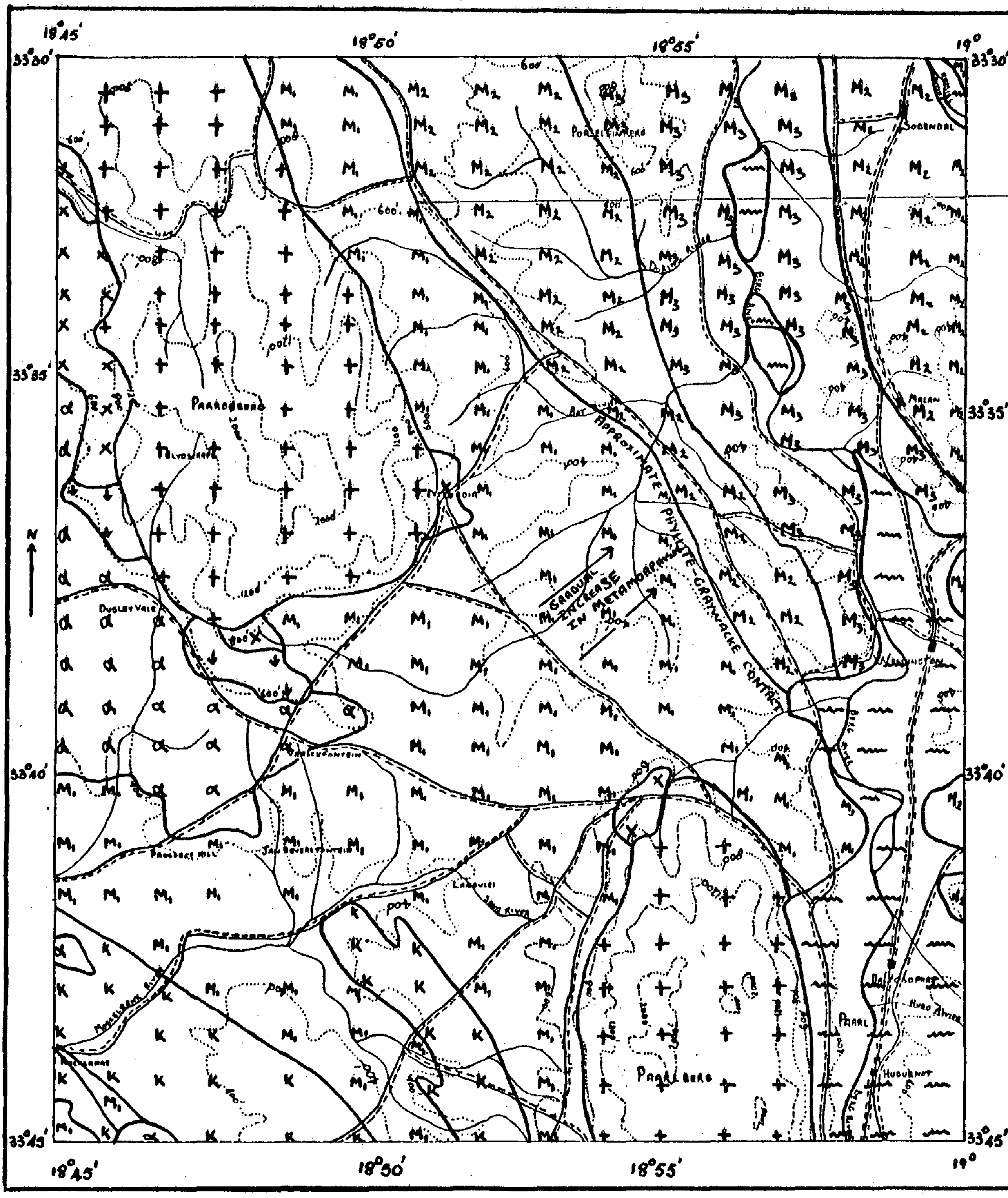
GEOLOGY

No detailed geological map covering the whole area is yet available. The accompanying geological map (Map 1) was compiled from a map in press covering about half the area, produced by the Department of Geological Survey (1964); a map of the area Koringberg-Malmesbury-Wellington produced by the University of Stellenbosch; and for the area east of Paardeberg - Klein Botriviersvlei - Caledons Gift and north of the Caledons Gift - Klipheuwel road from field observations of the writer.

The greater part of the area is covered by rocks of the Malmesbury formation. Next of importance in terms of extent are the granites intrusive in the Malmesbury beds, and lastly there occur small areas where the Klipheuwel beds are exposed.

The rocks of the Malmesbury formation are mainly fine grained graywacks and phyllites. Narrow bands of shales and conglomerates occur mainly in the south. Minor dolerite intrusions are to be found in the east. Contact metamorphism has taken place to a minor extent around the granites producing hornfels east of Paarlberg. Regional metamorphism is exhibited by the gradual transition from graywackes in the east to phyllites and schists in

MAP 1: Simplified Geological Map of the Survey Area



Approximate Scale 1:150,000

MAP LEGEND

- Granites
- Malmesbury shales & graywackes
- Malmesbury graywackes, shales and phyllites
- Malmesbury phyllites and schists
- Klipheuwel sandstones & conglomerates
- Coarse sand overlying laterite on Malmesbury graywackes & shales
- Fine sand of aedian origin
- Preweathered granite
- Terrace gravels clay and alluvium
- Railway lines
- Major roads
- ··200'···· Elevation in feet
- Major drainage lines

the west. Sericite-chlorite schists occur east of the Berg river.

The granites are chiefly biotite granites. According to Scholtz (1946) Paarlberg is chiefly composed of porphyritic and coarse even-grained granites. Paardeberg is mainly a medium to fine grained granite in the south and coarse and porphyritic in the north. Du Toit (1939) states that Paardeberg is chiefly a coarse biotite granite with porphyritic orthoclase crystals with some finer grained varieties and coarse pegmatites. Paarl mountain is generally a medium grained biotite variety, he states.

The Klipheuwel beds are chiefly sandstones and conglomerates with very minor shale bands. They are harder than rocks of Malmesbury formation (other than the schists) and contain very much less salt.

Isolated thin mantles of Tertiary terrestrial deposits as well as Quaternary gravels occur throughout the area.

VEGETATION

The map of Acocks (1953) divides the area into Coastal Rhenosterbosveld to the east and coastal macchia to the west.

The Rhenosterbosveld occurs on the heavy soils derived from Malmesbury sediments. Of the natural vegetation, which Acocks judges to be dense and thorny with Olea Africana and Sideroxylan inerme dominant no relicts were observed. In fact even of the invading Rhenosterbosveld little remains. In this unit Elytropappus rhinocerotus the rhenosterbos is dominant occuring together with other sclerophyllous shrubs such as Eriocepalus umbellatus, Asparagus stipulaceous and Exomis axyrioides.

Although more than 120 indigenous grass species occur, they are nowhere widespread; Themeda triandra, Erharta spp., Aristida diffusa, Eragrostis capensis, E. curvula, Briza spp., Danthonia spp., Brachiaria Serrata, Avena spp. and Sporobolis capense being amongst the commonest occuring.

On the sandy soils to the south and west various Fynbos types occur in Acocks' coastal macchia. Sedge like Restiaceae, Rhus spp. and Elytropappus glandulosus are among the dominant plants. The scattered Proteaceae including Protea spp., Leucospermum spp. and rarely Serruria spp. together with Erica spp., Bulbinella spp., Lachanalea spp., Ixia spp and Gladiolus spp. to name but a few, colour the the sandy country prettily in the wet winter months. Unfortunately what areas are not under cultivation are being invaded by the Australian acacias A. saligna and A. cyclopis

On the higher lying Paarl and Paarde mountains the vegetation is more or less similar to that on the sandy soils but for the absence of the acacias and with the emphasis on Proteaceae rather than Fynbos. Grasses which are sparse in the sandy macchia veld are equally sparse in the mountains. While the annuals Briza spp. are commonest on the sand, in the mountains Themeda triandra, being absent on the sand, is common.

CLIMATE (All climatic data from tables issued by the Weather Bureau Department of Transport)

The climate is of a Mediterranean type with cool moist winters and hot dry summers. Frost and snow are rare. Frost does occur but is never very heavy. Rainfall is normally in the form of light drizzles although heavy downpours are by no means absent. At Wingfield (Lat. 33° 54' Long. 18° 32') during the years 1938 to 1950 the maximum rainfall recorded over a 15 minute period was 16.0 mm. for a 1 hr. period 28.2 mm and for a 24 hr. period 61.7mm. During the same period only 10% of the total rainfall occurred with and intensity greater than 1.3 mm during a 15 minute period and only 2.6% with an intensity greater than 2.5 mm over a 15 minute period.

Table 1 shows the normal annual distribution of rainfall in Wellington, Paarl and Malmesbury.

TABLE 1: The annual distribution of rainfall normo for three weather stations in mm.

	Wellington	Paarl	Malmesbury
January	19.6	21.6	9.4
February	21.8	19.1	12.9
March	26.2	21.6	14.7
April	59.7	65.5	31.7
May	106.2	122.9	59.4
June	126.0	155.5	81.5
July	105.2	137.2	71.9
August	94.5	126.7	57.4
September	72.6	87.4	46.0
October	45.5	53.3	23.6
November	37.1	38.9	17.8
December	20.1	19.6	10.2
TOTAL	735.3	869.3	436.5

There is a considerable variation in rainfall within the area depending amongst other factors on aspect, on height and

distance/......

distance from high lying areas. Rainfall on Paarl and Paarde mountains is higher on western than on eastern slopes. With distance away from these mountains rainfall decreases rapidly. In the narrow kloofs in Paardeberg such as Modderkloof, Blydschap and Langkloof, rainfall is considerably higher than on the pediment slopes around the mountain at the same level. In some years rainfall reaches over 1270 mm (50 inches) in the kloofs whereas on the pediments it is rarely over 762 mm (30 inches). The effect of distance from high lying areas is admirably shown by the figures for Malmesbury and Paarl. Paarl is on the east of Paarl mountain which at its highest point is nearly 2,000 ft. above Paarl whereas the country around Malmesbury has no major promontories. Although Malmesbury has a higher elevation than Paarl its rainfall is much lower (Table 1). Perhaps the influence of aspect here too plays a part since at Paardeberg the northern slopes are drier than the southern slopes.

It appears as shown in Fig. 1 that rainfall generally is higher the greater the elevation. The effect of distance from high lying areas however must superimpose itself on the pure elevation effect.

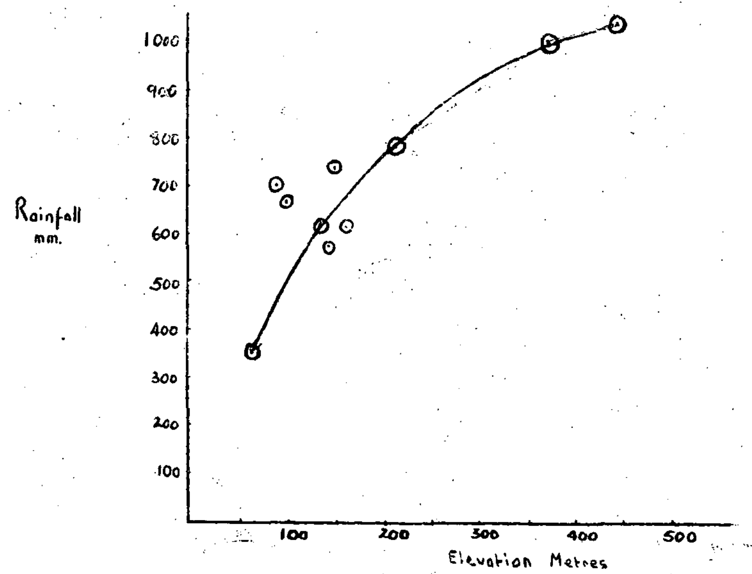


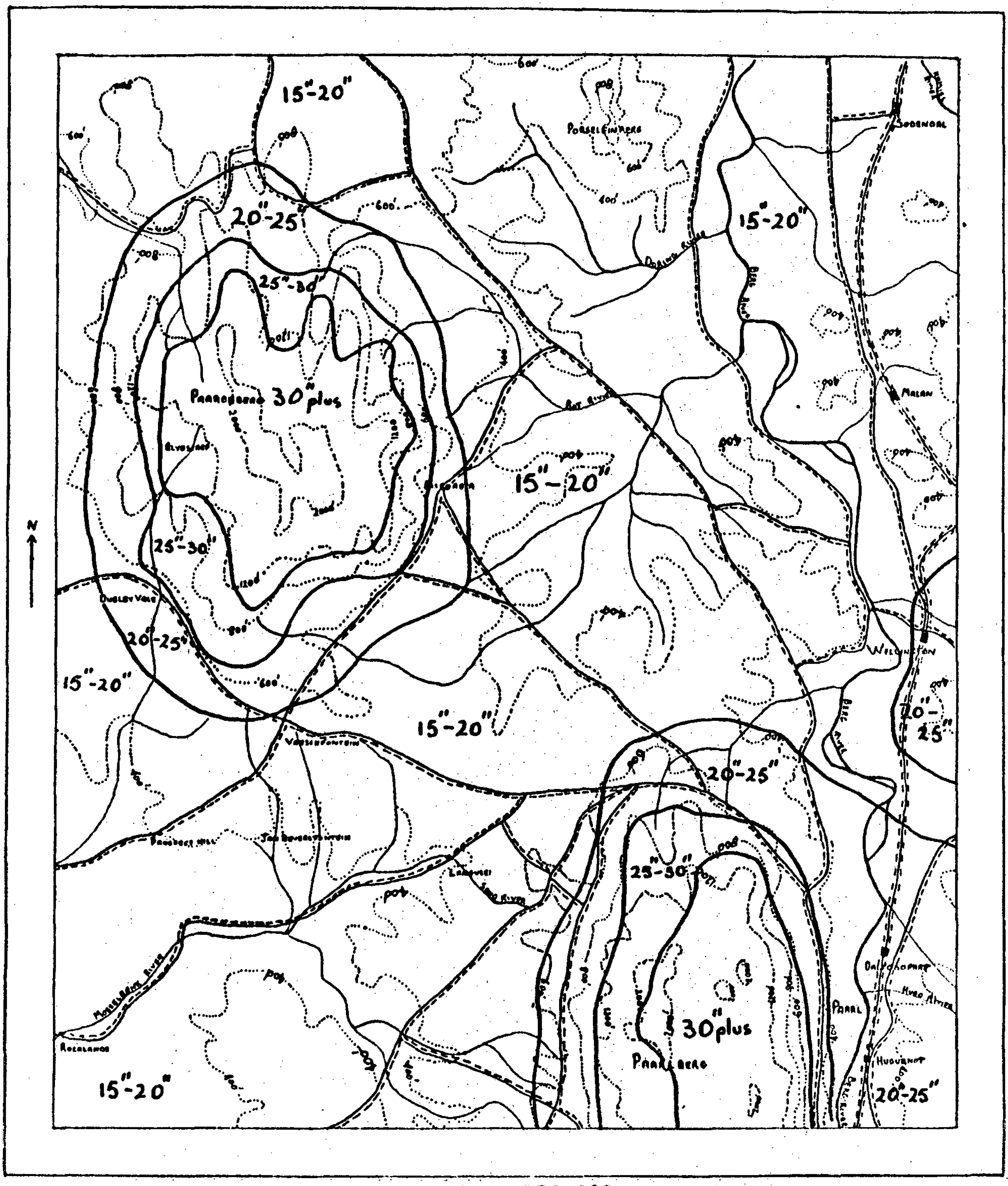
Fig. 1 - The relationship between elevation and rainfall.

Figure 2 a map showing distribution of rainfall in the area was compiled from figures of farmers. It is schematical and is not intended for any purpose but to show the relative distribution of rainfall, i.e. areas of higher and lower rainfall.

As can be seen from tables 2 and 3 below the hottest months of the year are between October and March and the coldest

between/......

FIG. 2 - Schematic map showing approximate rainfall distribution in inches



Approximate Scale 1:150,000

MAP LEGEND

15"-20"	381mm-508mm		Railway lines
20"-25"	508mm-645mm		Major roads
25"-30"	645mm-762mm	···400···	Elevation in feet
30" plus	762mm plus		Major drainage lines

between April and September. Although no figures are available to prove it, the drier areas are expected to be warmer than the areas around the mountains (Wellington is hotter than Paarl).

The relative humidity figures in table 3 show that the area generally has a low humidity. Only during the months May to September is it greater than 44% with a maximum during the months May, June and July of between 55% and 60%.

No frost or hail was recorded at Wellington for the year 1958 (shown in table 3). Mist occured in March, April and May (totalling 19 days during which it occured).

Table 2 - The monthly variation in temperature for the year 1958 at Paarl.

	Mean max. temp. °C	Mean min. temp. °C	Mean temp. °C	Dev. from mean °C	Highest max. temp. °C	Lowest min. temp. °C
January	30.2	16.9	23.5	0.6	37.0	10.9
February	26.8	14.6	20.7	-2.8	37.1	10.0
March	27.6	13.7	20.7	-1.4	33.5	9.5
April	23.3	11.0	17.1	-0.4	34.4	6.7
May	18.5	8.1	13.3	-1.2	27.2	2.0
June	17.7	4.7	11.2	-1.1	25.5	-0.5
July	19.0	5.7	12.3	1.2	25.0	2.8
August	19.1	5.9	12.5	0.0	26.9	1.2
September	19.2	9.6	14.4	-0.1	25.0	3.1
October	22.8	11.1	16.9	0.0	34.4	5.8
November	24.6	12.3	18.5	-0.8	32.2	8.2
December	30.6	16.7	23.7	2.6	40.0	9.6
Average 1958	23.3	10.9	17.1	-0.3	40.0	-0.5

Table 3 - Mean diurnal temperatures and relative humidities for 1958 at Wellington

	Mean dry bulb temp. °C		Mean rel. humidity °C		Average temp. °C (Mean - dev. from mean)
	08 hrs.	14 hrs.	08 hrs.	14 hrs.	
January	21.9	31.1	62	33	24.1
February	18.0	27.4	78	42	24.4
March	16.8	27.9	81	43	23.1
April	13.8	23.9	86	44	18.5
May	10.3	18.3	90	60	15.3
June	6.9	17.3	-	56	12.9
July	7.7	18.7	87	55	11.5
August	8.9	19.5	85	45	12.5
September	12.0	19.3	79	51	14.9
October	15.4	23.0	65	39	17.7
November	16.9	25.0	78	41	20.5
December	22.8	32.2	59	35	21.9
Mean	14.3	23.6	-	45	18.1

GEOMORPHOLOGY

The area is drained by the Berg river and its tributaries except in the south east where the Mosselbank, a tributary of the Diep river is found. The landscape is largely a young one, being gently undulating with the crests of the undulations in the same plane. This fact, as well as the extensive but isolated laterite relicts, suggests that the area is a dissected peneplain.

It is generally accepted (Du Toit, 1939; King, 1951; Krige, 1927) that during the Tertiary era the Western Cape was planed by a shallow sea. Somewhere about the early and middle Miocene emergence of the coastline began, resulting in the formation of a succession of marine and riverine terraces.

The oldest erosion surface found in the area, represented by the laterised preweathered granite between 650 ft. and 800 ft. is probably equivalent to King's "Victoria Falls" cycle (King, 1951). The minor plateau above Boesmansfontein at about 700 ft. to 770 ft. is also representative of this surface. Although Krige has found thin veneers of marine sediments elsewhere on this surface, no relicts were found in this area. It is believed that they have been

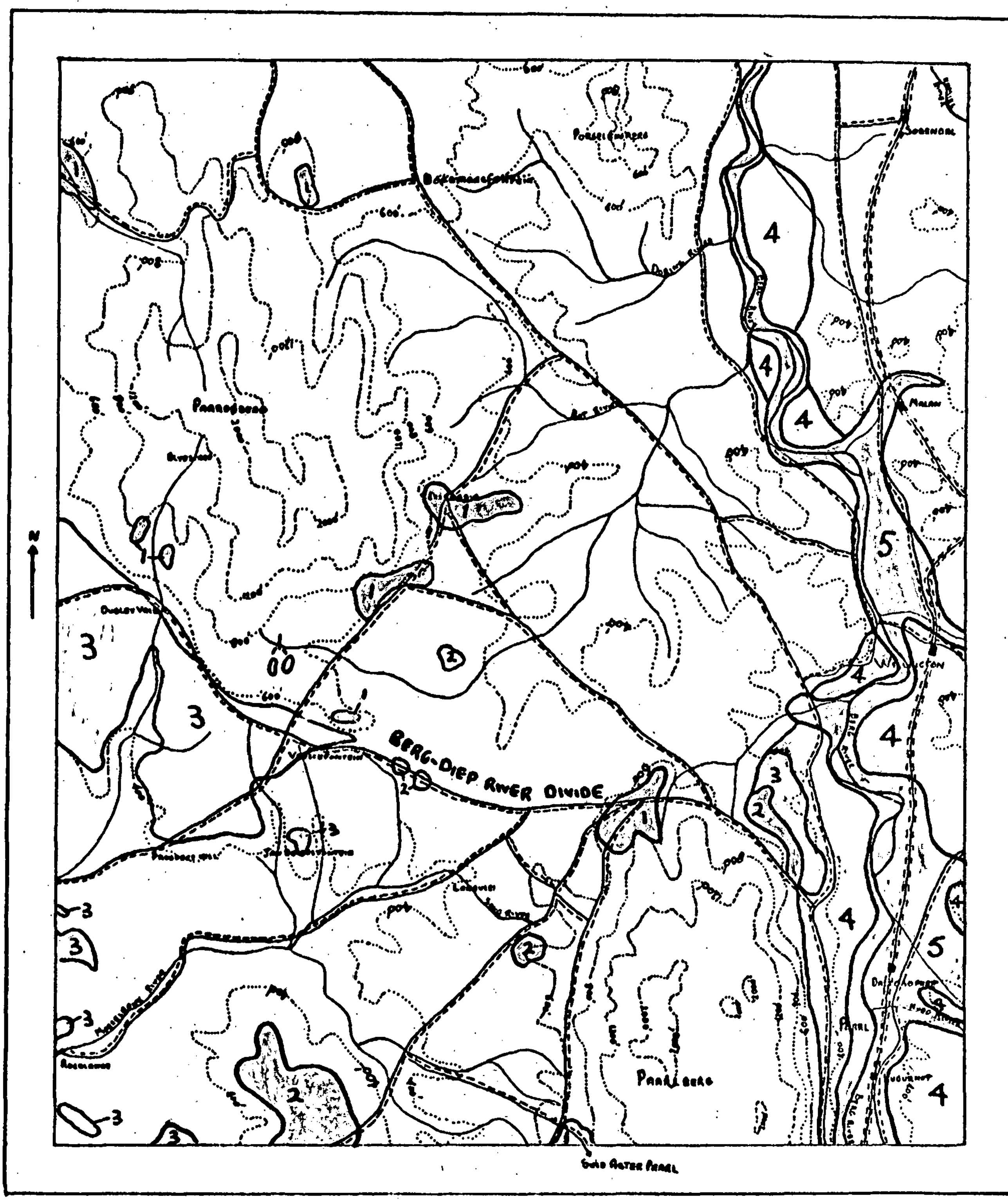
removed/......

removed by riverine cycles concurrently with the lowering of sea level. It is interesting to note that while preweathering occurred in the granites none occurred in the schists and phyllites. Alternatively if it did, all traces thereof have been removed. This surface was not recognised by Krige (1927) who correlated the next lowest level (530 ft. to 560 ft.) with the Kentani-De Vlugt- Upper Pet-Berg stage at 2,500 ft. on the basis of greater emergence in the north east than south west. The writer suggest the higher level - that of the laterised preweathered granite which at its highest may reach 1,000 ft. - represents the Kentani plateau and that the lower (530 ft. to 560 ft.) represents the Bredasdorp - Riversdale marine Tertiaries.

The 530 ft. to 560 ft. surface is the most extensive in the Western Cape. The extent and near uniformity in height of this terrace would point to it being marine in origin. It can be seen at Pools siding at 536 ft., in the Franshoek valley, and surrounding Stellenbosch. Most of the marine gravels have been removed by riverine action, the surface is today covered with a veneer of laterites, and where intact, of sand and laterite. In the area studied during this survey, the surface has been eroded away so that only laterites and occassionally terrace gravels are found as remnants; mainly in the southern half of the area. Here it would appear that the landscape is older and the drainage younger than to the north. Where previously the Berg river, or some other river with a provenance in the Table mountain sandstones, flowed south of Paarl Mountain and the east of Paarl Mountain, this area is now drained by the Mosselbank river. The Mosselbank has, as yet, not as completely removed traces of the 560 ft. Tertiary surface as have the tributaries of the Berg. This could be due to catchment of headwaters of the Diep Riverby the Berg.

With the emergence of the area, river action has cut down into the plain lowering it and forming Minor new riverine plains. Two definite terraces, viz. the 20 ft. and 50 ft. terraces of the recent period are easily recognisable. Those higher up do not seem to represent any specific terrace levels, except for one at approximately 400 to 450 ft., i.e. 150 ft. above the present river level. Other than these, there would seem to be no definite resting stages in the riverine cycle during the Pleistocene. Rather riverine action continued to cut down the landscape leaving gravel remnants at odd levels - a bevelling action, not forming definite terraces.

MAP 2: Physiographic features and location of major Tertiary and Pleistocene remnants



Approximate scale 1:150,000

MAP LEGEND

1	Miocene surface = preweathered granite		Major drainage lines
2	Pools siding pediplain = laterite at 500 ft. plus	200	Elevation in feet
3	Paardeberg pediplain = laterite at 450 ft.		Railway lines
4	60 ft. Berg river terrace = Terrace boulders		Major roads
5	20 ft. terrace + recent deposits = Terrace clays and boulders and alluvium		

South of Paardeberg at the divide between the Mosselbank and Berg river catchment areas, there is a minor pediplain at 450 ft. Here a deposit of coarse sand varying in thickness overlies laterite on Malmesbury shales. Away from Paardeberg, laterite with associated terrace gravels is found at this level. Explaining the origin of the sand poses a problem; there are no terrace gravels in it, nor does the laterite contain any of the terrace gravels found at this level; the sand does not thicken towards the granites so it cannot be a normal pediment and is too angular to have been transported over any great distance. It would seem (see Katarra series) that the sand was deposited on a flat river cut surface to be locally planed flat by wind action.

The 60 ft river terrace (60 ft. above river level) is composed of river gravels and sand. It is quite extensive but rarely thick. As stated above, between the 60 ft. and 150 ft. terraces a number of minor terraces are to be found. These seldom have "twins" on the opposite side of the valley and do not represent true terraces. The 20 ft. terrace seems to consist of more than one terrace. Normally the variation in height from one to the other is less than five feet. The upper one is of boulders and sand similar to the materials on the 60 ft. terrace and the lower one of clays and boulders.

Rock type has affected physiography to the extent that the soft shales and sandstones have been planed down whereas the hard granites and sericite schists not. The phyllites of the Malmesbury formation generally form undulations with longer periods than the graywackes. The Klipheuwel sandstones form a flatter landscape than the rocks of the Malmesbury formation.

CHAPTER III : THE SOIL SERIES DEFINED

Fifteen soil series have been described in this study. Not all of the soils seen fit into one of the series definitions. As explained earlier, the series is defined in terms of a modal individual as sampled by means of the pedon.

Apart from anomolous soils which were encountered once and not subsequently, there do occur variants of some of the defined series which were seen a number of times; but of which not sufficient individuals were seen soas to validate series definition.

One such soil is the felspathic variant of Discordia, represented by profile 334 of which only three individuals were seen. This soil would possibly fall into the same series as the "Paarl profile", described and analysed by van der Merwe and Weber (1963). Another such soil which is an intergrade between Discordia and Windmeul was only found north of Paardeberg near Doornfontein. This soil has been described as a heavy variant of Windmeul series-profile.

The problem of soil classification is to group similar entities, not to separate dissimilar entities. No two pedons are exactly the same. For obvious reasons to classify soils on the basis of pedons is thus not practical. If from the over three hundred pedons described in this study a classification was attempted by separating dissimilar pedons then over three hundred units would appear in the system. What the systematist attempts is to group soils into groups as like as possible in all morphological and chemical characteristics which have a bearing on their genesis.

The most important characteristic of the solum in classifying it is the number and position of the designated horizons i.e. an A_1, AC, C profile is vastly different from an A_1, A_2, B_2, C profile. Next in order of importance is the nature of the B- is it oxic, argillic or what? Is the B a colour B or a textural B or a structural B? Obviously many combinations of the various properties of B horizons are possible. Two soils with B horizons which differ in any important characteristics must be separated - a prismatic B with free salts and a pH over 7 separates a soil with an identical B but for the lack of free salts and a pH less than 6. The nature of the A as a differentiating characteristic is diagnostic far below the level of classification at which the B is diagnostic. Of the A horizons the A_2 is the most important since it is genetically the horizon which has lost some substituents to the B. Of the

properties of/......

properties of of the A_1/Ap only those important to soil genesis are used as differentiating criteria at the series level, eg. accumulation of organic matter. Factors such as stoniness and texture which are important to land use and plant growth are diagnostic at a lower level than the series unless they have a bearing on soil genesis. Obviously a soil with a sandy loam Ap would not fall into the same series as one with a sandy clay Ap. Generally such soils would be separated by some other factor but in a case where the solum below was similar the use of texture of the Ap would have to be invoked as a differentiating criteria. The nature of the C is often used as a differentiating characteristic. It's level of differentiation varies from instance to instance. Thus if the characteristic is wetness it would be invoked just after the B, if it were texture it would come after the A.

No hard and fast rules can be made as to what limits in differentia are to be used to separate series, only general rules can be followed. At the expense of being labelled repetive, the writer once again reiterates that in classifying soils the systematist classifies living things; part of the landscape. It is soil individuals which are classified into series, the limits set in series definitions must be an approximation of the limits of those properties actually occurring in the individual. If, for example, the individual has a base saturation of between 30% and 60% in the B then the series definition imposes these limits even though 40% saturation is the boundary between orders (U.S.D.A. 1960). The procedure in classification is then firstly to study what is to be classified - the soil individual - see what it's limits are, not to set limits and then to look for individuals falling within those limits as would be the case if arbitrary limits between series were defined.

The fifteen series which are described on the following pages have been classified applying the sentiments expressed above.

SWARTLAND SERIES

The most widespread of the soils of the area, Swartland has a distinctive if somewhat variable morphology. Profiles 49 and 31 are representative of Swartland series.

Site

Swartland is found on the gently undulating terrain which resulted from dissection of the Mio-Pliocene marine terrace. No definite differentiation between members on the upper slopes and those on the lower slopes appears to exist.

Parent Material

Swartland is restricted to areas where parent material was Malmesbury sedimentary rocks and to those rocks which have undergone little metamorphosis; phyllites and schists do not form the parent material of Swartland.

The upper part of the parent material normally has undergone colluviation and often includes materials relict of the ancient pediplain as well as terrace gravels of the rivers dissecting this plain.

Morphology

Typically Swartland has a grey brown gravelly sandy laom Ap, on a stone line designated B_1, with a clear transition to a yellow brown prismatic B_{2t} with strong dark clay skins, the B_{2t} has a gradual transition to a C of weathered graywacke with clay skins and perhaps weak soil structure.

Profiles 31 and 49 (see pages 16a and 16b) are given as representatives of Swartland series

The A in profile 31 is typical of Swartland, it has an Alfisol type hard-setting, massive A.

Colours of the B and C are geogenic, mottling not indicative of wetness is common. Individuals include pedons with colours varying from white to red.

Carbonates inherited from the parent material are sometimes found as nodules in Swartland. The carbonates in profile 31 are presumed amorphous as no nodules were identified in the pedon described.

Swartland members often have a blocky rather than prismatic structure.

Chemical properties

Profile 31, a shallow phase of Swartland has a higher pH and exchangeable sodium throughout the profile than has profile 49 an example of the deep phase. In both profiles pH and exchangeable sodium are highest in the B where accumulation of sodium and of magnesium has taken place.

The presence of alkaline earth carbonates interfered with the determination of calcium and magnesium in theB. The general trend appears to be for exchangeable calcium percentage to decrease with depth and for exchangeable magnesium to increase with depth.

Base saturation/....

PROFILE No. :	31 Swartland Series
LOCATION:	Lat. 33° 41' Long. 18° 53' on farm Caledonsgift
SITE :	Mid Slope gently undulating 1% slope
ELEVATION :	500 ft.
PARENT MATERIAL:	Malmesbury graywacke

Horizon	Depth	
A_1 Ochric	0-10	7.5YR$^4/_4$ Brown to dark brown (7.5 YR$^6/_4$ lt.Br.Dry) gravelly clay loam; very hard, apedal to weak blocky; frequent polished iron shot and fine small angular to sub-angular quartz; clear transition.
II B_{21t} natric	10-24	5YR$^4/_8$ Yellowish-red (5YR$^4/_8$ Y.R. dry) gravelly clay; very hard, moderate medium prismatic breaking to strong medium blocky; prominent 5YR$^4/_4$ reddish brown clay skins; occasional iron shot, occasional small graywacke, occasional small angular quartz; gradual transition.
III B_3	24-37	5YR$^4/_3$ Reddish-brown and 5YR$^5/_4$ reddish-brown prominent clay skins with 7.5YR$^8/_6$ reddish-yellow ped. interiors, clay loam; very hard, weak blocky; abundant 10YR$^5/_6$ brownish yellow weathering graywacke, rare small angular quartz; gradual transition.
III C	37-60	10YR$^6/_6$ Brownish-yellow loam to clay loam; with 5YR$^4/_4$ reddish-brown prominent clay skins down fissures and laminal planes, rock structure tending in places to weak blocky.

Lab. No.	B7435	B7436	B7437	B7438
Depth inches	0-10	10-24	24-37	37-60
Horizon	A_1	II B_{21t}	III B_3	III C
Particle size distribution %				
Gravel separate 2mm	19.7	23.7	2.2	1.4
C sand 2 -.5 mm.	12.3	7.3	4.5	6.8
M sand .5 - .2 mm.	4.6	2.7	5.3	5.7
f.sand .2 - .02 mm.	31.7	23.5	36.2	35.6
Silt .02 -.002 mm.	22.5	12.7	25.7	25.2
Clay .002 mm.	28.4	50.2	27,7	27.0
Extractable cations meq./100 gm.				
Na	1.35	1.99	1.01	0.79
K	0.50	0.61	0.29	0.25
Ca	3.22	$CaCO_3$	$MgCO_3$	2.54
Mg	2.55	present	present	3.37
C.EC.	5.92	6.77	5.27	4.72
Base sat. %	111.8	100 +	100 +	147.03
$CaCO_3$ eq	0.0	4.2	$MgCO_3$ present	0.0
pH 1:1 H_2O	8.0	8.95	8.9	8.55
Ohms R 60°F	588.3	449.5	777.0	710.4
Organic Matter				
% Carbon	0.55	0.17	0.08	0.08
% Nitrogen	0.08	0.04	0.03	0.02
C:N	6.8	4.25	2.67	4.0
Saturation extract soluble cations meq./100 gm.				
Na	-	0.10	-	-
K	-	0.01	-	-
Ca	-	0.07	-	-
Mg	-	0.02	-	-
EC10^3 cm. 25°C	-	4.85	-	-
Exchangeable cations expressed as % of total exchangeable bases				
Na	17.71	19.05	19.16	11.38
K	8.44	11.96	5.49	3.45
Ca	54.39	$CaCO_3$	$MgCO_3$	36.59
Mg	43.07	present	present	48.55
Base sat. %	111.8	100 +	100 +	147.03
Clay minerals				
C.E.C./100 gm. clay	20.8	13.5	19.0	17.5
Identified minerals	Kaol.v.v.s Ill.v.s Felspar T.	Kaol.v.v.s Ill. S.	Kaol.v.v.s Ill. S.	Kaol.v.v.s Ill. S.

PROFILE No.:	49 Swartland series
LOCATION:	Lat. 33°40' Long. 18°52' on farm Langerug (Hoër Landbouskool Boland)
SITE:	Mid slope gently undulating 2% slope
ELEVATION:	500 ft.
PARENT MATERIAL	Malmesbury graywacke

Horizon	Depth inches	
A_1 Ochric	0-11	10YR4/3 brown to dark-brown (10YR6/3 p.Br.dry) gravelly fine sandy clay loam; hard, apedal; frequent small, sub-angular quartz stones and fine iron shot; clear transition
IIB_{1t}	11-21	10YR6/6 brownish-yellow (10YR6/6 Br.Y.Dry) gravelly clay; slightly hard and loose, very weak fine blocky, weakly coherent mass of abundant small sub-angular quartz stone and iron shot; with distinct clay skins; forming a stone line; clear transition.
$IIIB_{21t}$ argillic	21-29	10YR5/8 Yellowish-brown (10YR5/8 Y.Br.Dry) clay; prominent thin 10YR4/3 (Moist) brown to dark-brown clay skins; very hard, strong fine blocky tending to weak medium prismatic; occasional fine diffuse 2.5YR4/8 (Moist) red mottles; occasional iron shot; gradual transition
$IIIB_{22t}$ natric	29-34	7.5YR5/6 Strong brown (10YR5/6 str.Br.Dry) clay; prominent 10YR4/2 (Moist) dark grey brown clay skins; common fine distinct 10R4/6 (Moist) red mottles; very hard, strong medium blocky tending to weak fine prismatic; occasional fine slightly weathered graywacke; gradual to clear transition
$IIIB_3$	34-39	7.5YR5/6 Strong brown (10YR5/8 Y.Br.Dry) silty clay; with prominent thick 7.5R4/4 (Moist) brown to dark brown clay skins; hard, weak blocky, abundant slightly weathered graywacke with purple, red and strong brown colours; gradual transition.
II C	39-60	Weathered laminated graywacke with thick 7.4YR4/4 (Moist) brown to dark brown and 10YR4/2 (Moist) dark grey brown clay skins along laminal planes.

Lab. No.	B7371	B7372	B7373	B7374	B7375	B7376
Depth inches	0-11	11-21	21-29	29-34	34-39	39-60
Horizon	A_1	IIB_{1t}	$IIIB_{21t}$	$IIIB_{22t}$	$IIIB_3$	IIIC
Particle size distribution %						
Gravel separate 2mm.	29.7	68.3	6.7	11.6	6.6	3.5
C.sand 2-.5mm	14.1	13.5	4.2	8.5	12.2	9.9
M.sand .5-.2mm.	9,3	2.6	1.6	3.0	3.8	3.6
F.sand .2-.02mm.	35.7	7.9	5.0	9.1	16.8	20.7
Silt .02-.002mm.	17.4	6.7	10.1	19.8	26.6	39.7
Clay .002mm.	24.1	70.2	80.0	58.2	42.0	28.9
Extractable cation meq./100 gm.						
Na	0.24	0.55	0.22	0.73	0.68	0.61
K	0.24	0.53	0.56	0.36	0.30	0.21
Ca	3.42			6.04	5.16	3.49
Mg	1.18	$MgCO_3$		6.72	5.78	4.89
C.E.C.	5.33	present		11.64	10.01	7.56
Base sat. %	95.3	100	100	119.0	110.0	121.7
$CaCO_3$ eq.	0.0	$MgCO_3$ present		0.0	0.0	0.0
pH 1:1 H_2O	6.5	8.1	8.1	8.0	8.03	8.0
Ohms R 60°F	1475.5	411.0	432.0	516.3	579.7	527.9
Organic matter						
% Carbon	0.53	0.32	0.15	0.09	0.09	0.04
% Nitrogen	0.07	0.08	0.05	0.05	0.05	0.06
C : N	7.5	4.0	3.0	1.8	1.8	.66
Saturation extract soluble cations meq./100 gm.						
Na		0.42	0.38			
K		0.01	0.01			
Ca		0.20	0.15			
Mg		0.17	0.09			
$EC10^3$/cm.25°C		3.73	2.03			
Exchangeable cations expressed as % of total exchangeable bases						
Na	4.5	1.32		5.27	5.7	8.07
K	4.5	5.29	4.79	2.59	2.51	2.70
Ca	64.16			43.61	43.28	46.16
Mg	22.13			48.51	48.48	64.68
Base sat. %	95.3	100	100	119.0	119.0	121.69
Clay minerals						
C.E.C./100 gm. Clay	22.11	13.98	14.32	20.0	26.15	
Minerals identified		Kaol.vvs Ill.MS	Kaol.vvs Ill.MW	Kaol.vvs Ill.MS	Kaol.vvs Ill.S.	Kaol.vvs Ill.S.
SiO_2% clay		38.98	38.22	39.10	39.24	40.20
R_2O_3% clay		43.48	43.84	42.20	42.00	41.76
SiO_2:R_2O_3 clay		0.896	0.871	0.926	0.954	0.962
SiO_2% soil		50.24	43.42	49.46	53.90	55.08
R_2O_3 % soil		34.32	39.80	35.36	32.72	33.68
SiO_2:R_2O_3 soil		1.463	1.090	1.398	1.647	1.635
Free Fe_2O_3%		4.30	5.13	5.09	5.36	5.51

PROFILE No.: 53

LOCATION: Lat. 33°40' Long. 18° 51' on the farm Knollefontein

SITE : Upper mid slope 1 - 2% slope near outer edge Paardeberg pediplain

ELEVATION: 550 ft.

PARENT MATERIAL: Malmesbury Graywacke

Horizon	Depth	
A	0-7	10YR4/3 Brown (10YR6/3 p. Br. Dry) loamy fine sand; very hard, apedal; frequent fine iron shot; gradual to clear transition.
B_{1t}	7-13	10YR4/2.5 Brown (10YR6/3 p.Br.Dry) fine sandy loam; slightly firm, apedal; frequent fine iron shot; clear transition
	13-14	A weakly formed stone line of graywacke fragments small subangular quartz and laterite fragments, clear to abrupt transition.
II B_{22t}	14-26	7.5YR5/8 to 10YR5/8 Yellowish brown clay; prominent 10YR4/3 Brown to dark brown clay skins, many faint fine 5YR5/8 Yellowish red mottles, firm, extremely hard, moderate coarse prismatic breaking to coarse blocky, gradual transition.
II B_3	26-40	10YR7/8 Yellow to 10YR6/6 brownish yellow silty clay; prominent 10YR5/4, 5/6, 5/8 clay skins, few diffuse fine 5YR5/8 yellowish red mottles; slightly firm, extremely hard, moderate blocky tending to prismatic; abundant weathering graywacke fragments clear transition caused by a hard hand in the graywacke.
II C	40 plus	Weathering Malmesbury graywacke

Depth inches	0-7	7-13	13-26	26-40	40 +
Horizon	A	B_{1t}	IIB_{22t}	II B_3	II C
Extractable cations (NH_4Ac) meq./100 gm.					
Na	0.244	1.361	7.330	8.586	5.914 1,36
K	0.11	0.082	0.145	0.109	0.093
Ca	0.78	0.724	0.88	0.64	0.48 0,33
Mg	0.32	0.936	2.72	2.48	1.44 1,08
C.E.C.	2.413	5.368		4.455	2.998
pH	5.15	5.10	4.45	4.40	7.65
Ohms R60°F	1320	380	75	52	76
Saturation extract soluble cations meq/100 gm.					
Na	0.128	0.775	5.012	6.248	4.558
K	0.013	0.007	0.008	0.012	0.011
Ca	0.048	0.241	0.014	0.150	0.146
Mg	0.047	0.079	0.052	0.815	0.359
mmhos./cm. $x10^3$ 25°C	1.136	1.351	3.6363	4.255	7.407
Exchangeable cations as a percentage of total exchangeable bases					
Na	4.80	10.91		52.48	45.99
K	4.01	1.39		2.17	2.78
Ca	30.33	12.72		10.99	11.14
Mg	11.31	15.96		37.37	36.05
Base sat. %	60.26	57.80		100 +	100 +

Base saturation is high there being free salts throughout the profile in profile 31 and below the A in profile 49. pH of the B and C is pH 8 or higher.

Profile 53 is included in this discussion of Swartland as a chemically interesting pedon. This pedon is acid throughout the profile yet it has very low resistance in the B and C horizons. The accompanying analysis by van Niekerk[1] shows that this soil has a high concentration of water soluble sodium in the B and C. Exchangeable sodium is extremely high. Notwithstanding the fact that the soil is fully saturated in the B it is very acid. This anomaly can not be explained at present. More study on the exchange properties of the clay and of the types of acid involved are necessary. Semi-quantitative analysis show chloride and sulphate anions to be dominant.

Physical characteristics and land use

The B horizon is dense and very slowly permeable to water. The irrigable value of the soil varies from a B_2 to a C. Salinity is a definite hazard especially in the shallow phase.

Generally Swartland is used for wheat production. On the farm Eensaamheid on the Durbanville - Agter Paarl road, dryland lucerne is grown to advantage.

Occassionally the deep phase of Swartland - usually on the intergrade to Langvlei or to Katarra - wine grapes are grown.

Associated soils

Because of its wide occurrence, Swartland bounds at some place with one of nearly all the soil series in the area.

It is commonly associated with Langvlei series which occupies the flat bottomlands and with the acid variant of Langvlei which occupies the young colluvial valleys.

In a northerly direction, Swartland grades into Kanonkop. Intergrades to Kanonkop are represented in Swartland individuals by pedons with weak B horizons in which structure is too weak to fall within the definition of Swartland.

Where Swartland grades into Katarra, the soil has lower chromas throughout the solum than is normal to Swartland. Here the Ap has especially abnormally low chromas.

1 P.E. le R van Niekerk : Viticulture Institute, Stellenbosch: unpublished salinity survey of soils in the Western Cape.

Genesis and classification of Swartland

Swartland has invariably developed in materials with three major discontinuities. The lower material (below the stone line) has developed in situ from the weathering of the shales or graywackes and the upper two are gravelly drift materials from the shales and graywackes the gravel having become concentrated during the lowering of the landscape and removal of finer materials.

The high sodium, and perhaps magnesium, content of the parent material has caused the dispersion of clay in the A resulting in its illuviation into the B. Simultaneous leaching of sodium and magnesium has left the A relatively richer in potassium and calcium. The soil is not highly weathered, the clay minerals have been inherited directly from the parent sedimentary rocks being liberated largely by a process of physical weathering. Essentially the B is a cambic horizon in which illuvial clay has accummulated to such an extent that it is morphologically and chemically a natric B.

In order to classify this soil in the 7th approximation system, moisture tension studies on the soil in situ are needed. Its classification depending on whether it is dry for at least seven months of the year or moist for more than 5 months would be into Argids (dry) or Ustalfs (moist). Ustalfs are defined as being usually moist, with periods in excess of 3 months being dry. Argids have a dry period in excess of 7 months.

From objective observations it seems that the cultivated Swartland is dry under a wheat crop for 7 months whereas the B of the fallow ploughed Swartland is dry only for 3 or 4 months. (The A is dry for 7 months.) This is a problem inherent in the classification system, viz. that the same pedon may change its order depending on its use. Swartland is a Natrargid under wheat, but a Natrustalf when fallow ploughed.

Under virgin conditions (rarely encountered) Swartland is probably a Ustalfic Natrargid.

Swartland series definition

A_1/Ap finer than loamy coarse sand excluding gravel fraction.

A_3/B_1 chromas greater than 2 and values greater than 3 abrupt transition to

B_{21t} Structure stronger than weak blocky, tending to prismatic. More than 20% clay. Resistance less than 250 Base saturation greater than 100% Exchangeable (Na + Mg) greater than Exchangeable Ca.
Colour variable but with clay coatings at least 1 unit darker than the matrix. Gradual transition to a C with rock structure usually via a B_3

ZWARTFONTEIN SERIES

Zwartfontein is found only in the area between the Berg river and the Paarl-Malmesbury road. Profiles 191 and 195 are representative.

Site

Limited to steep mountain slopes; Zwartfontein grades into Kanonkop where the slope is less steep and into Porseleinberg (Slabber, 1945) in the narrow colluvial valleys.

Parent material

Zwartfontein is typically formed from Sericite/Chlorite schists. As the parent racks become less schistose, so Zwartfontein grades into Kanonkop. In Zwartfontein's parent material, little colluviation has taken place.

During metamorphism of the Malmesbury formation rocks recrystallisation took place; the free salts, characteristic of the unchanged sediments, were used in the formation of secondary silicate minerals. The parent material of Zwartfontein is thus not as salty as that of Zwartland.

Morphology

Horizon differentiation in Zwartfontein is weak, the soil often has shallow rock outcrops at places. Profile 191 is an example of the central concept of Zwartfontein. It is shallower than profile 195 in which an appreciable amount of colluviation has taken place. Profile 195 tends towards the intergrade between Zwartfontein and Porseleinberg.

Typically Zwartfontein has a reddish brown gravelly fine sandy loam Ap with frequent large quartz and shist fragments. The Ap has a gradual transition to a weakly developed B; a weak blocky, red gravelly sandy loam overlying the schist.

The solum is rarely deeper than 30 inches, often it is shallower than 15 inches. An Ap 7 inches deep normally includes small areas where solum is mixed with bedrock.

Chemical properties

The solum is acid throughout, pH increasing with depth from about pH5 in the Ap to about pH 6.5 in the lower B. Base saturation increases with depth from about 60% in the Ap to over 80% in the B_2 and to saturation in the C.

Exchangeable sodium and magnesium increase with depth, exchangeable magnesium percentage being over 50% in the lower B. Exchangeable calcium and potassium percentages decrease with depth. In Zwartfontein, like in Kanonkop, exchangeable potassium is high in the A being higher here than the exchangeable sodium percentage. Calcium is the dominant cation in the A; magnesium is dominant in the B.

PROFILE No. : 191 Zwartfontein series

LOCATION : Lat. 33°31' Long. 18°54' on farm Porselein-berg

SITE : Steeply sloping mountain slope 15% slope

ELEVATION : 650 ft.

PARENT MATERIAL : Sericite schist

Horizon	Depth inches	
Ap Ochric	0-7	5YR 4/6 yellowish red (5YR 5/6 Y.R.Dry) gravelly fine sandy loam; soft, Apedal; abundant sub-angular to angular medium and small quartz, frequent angular platy schist fragments; gradual transition.
B_{2t} + C	7-26	5 YR 4/6 yellowish red (5YR 6/6 R.Y.Dry) gravelly fine sandy loam; apedal to weak blocky, weakly coherent mass of assorted angular schist and rare angular quartz; moderately developed clay skins present; gradual transition.
R	26 plus	Sericite schist which in places approaches to within 12 inches of the surface.

Lab. No.	B7428	B7429
Depth inches	0-7	7-26
Horizon	Ap	B_{2t}+C
Particle size distribution %		
Gravel separate 2mm.	38.6	33.1
C. sand 2-.5 mm.	18.4	24.7
M. sand .5-.2 mm.	7.9	8.5
F. sand .2 - .02 mm.	40.7	34.6
Silt .02 - .002 mm.	18.5	17.5
Clay .002 mm.	14.2	14.9
	32,7	32,4

Extractable cations meq./100 gm.		
Na	0.12	0.16
K	0.43	0.25
Ca	1.76	1.38
Mg	0.68	3.29
C.E.C.	4.53	5.97
Base Sat.%	66.0	85.09
$CaCO_3$ eq.	0.0	0.0
pH 1:1 H_2O	5.2	6.6
Ohms R60°F	1509	1554
		76.0
Organic matter		
% Carbon	0.35	0.17
% Nitrogen	0.06	0.05
C:N C:N	5.83	3.4
Extractable cations expressed as % of total exchangeable bases		
Na	2.65	2.68
K	9.49	4.18
Ca	38.5	23.11
Mg	15.01	55.10
Base sat. %	66.0	85.09
Clay minerals		
C.E.C./100 gm. Clay	24.48	40.06
Identified minerals	Kaol.I M.	Kaol. Med
	Ill. v.s.	Ill v.s.
	Mont. M.W.	Mont. M.W.
Free Fe_2O_3 %	6.50	3.95

PROFILE No.: 195 Zwartfontein series

LOCATION : Lat. 33°31' Long.18°59' on the farm Porseleinberg.

SITE: Lower slope weakly pedimented 3% slope

ELEVATION : 550 ft.

PARENT MATERIAL : Sericite schist

Horizon	Depth inches	
Ap Ochric	0-8	5YR$^4/_4$ reddish brown (7.5YR$^6/_4$ lt.Br.Dry) gravelly fine sandy loam; loose, apedal; abundant sub-angular quartz gravel; gradual transition.
B_{2t}	8-17	5YR$^5/_4$ reddish brown (7.5YR$^6/_4$ lt.Br.Dry) gravelly fine sandy loam; hard, apedal to weak blocky; frequent medium angular to sub-angular quartz stones forming a weak stone line at the transition to the lower horizon; weak clay skins present; clear transition.
II B_3 (IIC_1)	17-32	5YR$^5/_4$ reddish brown (7.5YR$^6/_4$lt.Br.Dry) stony sandy clay loam; hard, apedal to weak blocky; moderately developed 5YR$^4/_6$ yellowish red clay skins on the shist; abundant platy schist and rare angular quartz stone; gradual transition.
II C (IIR)	32-38	Slightly weathered schist with 5YR$^4/_6$ yellowish red clay skins.
IIR	38 plus	Hard schist (bed rock)

Lab. No.	B7430	B7431	B7432
Deptch inches	0-8	8-17	17-32
Horizon	Ap	B_{2t}	II B_3
Particle size distribution %			
Gravel separate 2 mm.	20.8	20.5	0
Coarse sand 2- .5mm.	15.0	14.0	27.7
Medium sand .5-.2 mm.	7.2	6.7	7.7
Fine Sand .2 - .02mm.	51.1	45.9	28.7
Silt .02-.002mm.	14.4	15.8	14.5
Clay .002mm.	10.9	17.9	21.7
	25,3	33,7	36,2
Extractable cations meq./100gm			
Na	0.12	0.32	0.59
K	0.20	0.12	0.18
Ca	1.93	2.19	1.85
Mg	0.33	1.10	5.20
C.E.C.	4.11	4.13	6.34
Base sat. %	62.77	91.54	123.34
$CaCO_3$ eq.	0.0	0.0	0.0
pH 1:1 H_2O	5.15	5.9	6.35
Ohms R 60°F	2086	888	666
Organic matter			
% Carbon	0.40	0.27	0.13
% Nitrogen	0.05	0.05	0.04
C:N	8.0	5.4	3.25
Exchangeable cations expressed as % of total exchangeable bases			
Na	2.91	6.76	7.54
K	4.86	2.53	2.30
Ca	46.95	58.90	23.65
Mg	8.02	23.25	66.49
Base sat. %	62.77	91.54	123.34
Clay minerals			
C.E.C./100gm. Clay	37.7	26.42	29.21
Identified minerals		Kaol.Med Ill.v.v.s. M.L. MW. Felspar VW	Kaol.v.s. Ill.v.v.s. M.L.M Felspar VW
Free Fe_2O_3 %	1.92	2.32	4.38

Carbon percentages and C : N ratios are low throughout the profile, decreasing with depth.

Genesis and classification

Only rudimentary soil development has taken place. Clay minerals have formed by the alteration of micaceous minerals, sodium and magnesium have been leached from the A to the B and C to a slight extent. Weak clay illuviation into the B has taken place Liberation of iron oxides during weathering of the micaceous minerals (sericite and chlorite) has given the soil its red colour. Comparing the profiles of Zwartfontein and Kanonkop, it can be seen that there is a direct relationship (in these freely drained soils) between free Fe_2O_3% and hue - the higher the Fe_2O_3%, the redder the hue.

In profile 195 there would appear to be an argillic B horizon from the mechanical analyses. The amount of clay skins seen in the field however does not reflect the 70% increase in clay from the A to the B, this difference is therefore attributed to a lithological discontinuity. Soils with argillic horizons do not fall within the definition of Zwartfontein.

The very young stage of weathering of Zwartfontein is shown by the presence of felspars in the clay fraction of profile 195. Mixed layer minerals and montmorillonite were also found in the B and C of Zwartfontein. For felspars to exist as clay sized particles, intensity of chemical weathering must be very low, or the material very young. Both of these possibilities exist in Zwartfontein - the steep slopes result in active colluviation keeping the solum in a youthful stage and, as throughout the low rainfall area, weathering is mainly physical.

Zwartfontein is a ruptic lithic-orthic orthustent.

Physical characteristics and land use

The soil is shallow, stony and usually steep. It has a "C" irrigable value as defined by the Soils Research Institute.

Zwartfontein is used for wheat production. The soil is inherently fertile and yields are quite fair.

Associated soils

Within Zwartfontein areas, there occur deep ravines up to 20 ft in depth cut into colluvium. These colluvial deposits are narrow, nowhere wider than 25 yds. They appear to correspond with Porseleinberg series of Slabber (1945). The similarity is given weight by the fact that the mountain Porseleinberg is also the type site of Zwartfontein. Because of the variability encountered, and the limited extent of these colluvial deposits, they have been left undefined. Normally they are red (5YR), sandy clay loam, weak fine blocky, hard soils with rare dolerite boulders (dolerites intrusive in the schists occur in the mountain Porseleinberg).

As slope flattens out, Zwartfontein grades into Kanonkop. Usually the change in slope is accompanied by a decrease in schistoscity of the underlying rock. In areas transitional between Zwartfontein and Kanonkop a complex of Zwartfontein and Kanonkop occurs.

Soils resembling Zwartfontein were found in Swartland individuals but not vice versa.

Zwartfontein series definition

Ap	less than 20% clay and more than 20% silt plus clay Colours of hue redder than 7.5YR
(II)B_{2t}	less than 30% clay and more than 30% silt plus clay Colours of hue redder than 7.5YR no darker than overlying A. Structure no stronger than weak blocky. Clay minerals are kaolin and micaceous (illitic or mixed layer) minerals. Not an Argillic B. pH less than 7
C	Weathering rock

The B is discontinuous in between 5% and 20% of the pedons in the individual.

KANONKOP SERIES

Kanonkop is fairly widely distributed in the northern and eastern part of the area. It was first described by Slabber (1945) Profiles 173 and 199 are representative of Kanonkop.

Site

Found on gently undulating topography, Kanonkop is limited to convex 'upland' sites. The slopes towards the bottom-lands are generally steep while the tops of the undulations are fairly broad and flat. No difference between Kanonkop members on upper and on lower slopes was noticed.

Parent materials

Parent material is a weakly colluviated coarse textured rubble overlying the phyllites of the Malmesbury formation. Often the rubble has been strongly influenced by terrace materials. Generally Kanonkop is limited to areas where the rocks are more metamorphosed than those from which Swartland has formed. Kanonkop-like soils are found on young land surfaces underlain by weakly metamorphosed rocks, which, on older surfaces, might have given rise to Swartland.

Morphology

Typically horizon differentiation is weak. A strong brown gravelly loamy sand overlies a thin yellowish red, weak blocky sandy clay loam B_2 which overlies weathering rock. Normally the solum is less than 24 inches deep.

The B horizon is often discontinuous with the Ap directly overlying weathering rock. Profile 173 is an example of a shallow member with a weakly developed B_2 horizon, and profile 199 of a deep member with a well developed (for Kanonkop) B_2 horizon.

Chemical properties

Profile 199 has a surprisingly low base saturation below the Ap. It is cultivated and fertilised which probably explains the higher saturation of the Ap. Below the Ap, in the B and the C, base saturation is less than 30% increasing with depth. Profile 173 is not cultivated and shows an increase in base saturation from 49% to 68% from the A to the B horizon.

The higher rainfall, nature of parent material (173 is felspathic) better drained site and possibly leaching during the more recent river action probably account for the low base saturation of profile 199. Of all these factors, parent material is probably the most important. The absence of felspars and presence of haematite in the lower B and the C of profile 199 point to the low base

PROFILE No. :	173 Kanonkop series
LOCATION :	Lat. $33^{o}31'$ Long. 18^{o} 55' on farm Zwartfontein.
SITE:	Mid slope gently undulating bevelled upper Berg river terrace 3% slope
ELEVATION:	360 ft.
PARENT MATERIAL	Malmesbury schist/phyllite

Horizon	Depth inches	
A_1 Ochric	0-8	10YR$^4/_4$ dark yellowish brown (10YR$^6/_4$ lt.Y.Br. Dry) gravelly loamy fine sand; soft, apedal; frequent sub-angular quartz gravel; gradual transition
B_{21t} argillic	8-15	7.5YR$^4/_4$ brown to dark brown (10YR$^6/_4$lt.Y.Br.Dry) gravelly fine sandy loam; soft to slightly hard apedal; abundant sub-angular quartz gravel and small stones, occasional angular phyllite fragments; gradual transition.
IIR+IIC	15plus	Partly weathered and unweathered phyllite

Lab. No.	B7433	B7434
Depth inches	0-8	8-15
Horizon	A_1	B_{21t}
Particle size distribution %		
C.sand 2 - .5 mm.	14.1	15.0
M.sand .5 - .2 mm.	8.4	8.6
F.sand .2 - .02 mm.	58.2	49.3
Silt .02 - .002 mm.	11.1	14.6
Clay .002 mm.	9.5	14.9
Extractable cations Meq./100 gm.		
Na	0.08	0.14
K	0.28	0.24
Ca	0.61	1.22
Mg	0.17	0.42
C.E.C.	2.32	2.96
Base. Sat. %	49.14	68.24
$CaCO_3$ eq.	0.0	0.0
pH 1:1 H_2O	5.5	5.5
Ohms R60^{o}F	2664.0	2386.5
Organic Matter		
% Carbon	0.26	0.15
% Nitrogen	0.05	0.04
C:N C:N	5.2	3.75
Exchangeable cations expressed as % of total exchangeable bases		
Na	3.45	4.73
K	12.06	8.1
Ca	26.29	41.21
Mg	7.32	14.18
Base. sat. %	49.14	68.24
Clay minerals		
C.E.C./100 gm. clay	24.2	19.86
Identified minerals		Kaol. v.s M.L. M.W. Felspar V.W.
Free Fe_2O_3	1.42	2.23

PROFILE No.: 199 Kanonkop series

LOCATION: Lat. 33°36' Long. 18°59' on farm Soetendal

SITE: Mid slope gently undulating bevelled 60 ft. Berg river terrace 3% slope

ELEVATION: 370 ft.

PARENT MATERIAL: Malmesbury phyllite with a terrace boulder plus colluvium mantle.

Horizon	Depth inches	
Ap Ochric	0-7	7.5YR 5/8 strong brown (10YR 6/4 lt.Y.Br.Dry) gravelly loamy sand; soft to slightly hard; apedal; abundant sub-angular and angular quartz gravel and small stones; occasional terrace boulders of round Table Mountain sandstone; gradual transition.
B_{21t} (A_3)	7-20	7.5YR 5/6 strong brown (10YR 6/5 Br.Y.Dry) gravelly sandy clay loam; a slightly loose mass of abundant sub-angular and angular quartz gravel and small stones, occasional phyllite fragments forming a structureless stone line; clear transition.
IIB_{22t} (IIB_{2t}) argillic	20-28	5YR 5/8 yellowish red clay; frequent faint fine 2.5YR 4/8 red mottles; soft to slightly hard, weak fine blocky, frequent fine platy phyllite fragments and angular quartz gravel; gradual to clear transition.
IIC+IIR	29-48+	2.5YR 4/8 red and 10YR 6/8 brownish yellow clay loam; rock structure well evident; moderately developed clay skins especially in the brownish yellow laminae which are more strongly weathered than the red.

Lab. No.	B7424	B7425	B7426	B7427
Depth inches	0-7	7-20	20-28	28-48
Horizon	Ap	A_3	IIB_{2t}	IIC+IIR
Gravel separate 2 mm.	43.8	53.9	13.4	11.3
C. sand 2-.5 mm.	35.2	31.1	24.1	20.5
M. sand .5-.2 mm.	13.8	9.0	7.1	6.5
F. sand .2-.02 mm.	36.6	25.0	16.2	17.2
Silt .02-.002 mm.	4.7	13.4	12.4	18.4
Clay .002 mm.	10.5	20.8	40.8	38.9
Extractable cations meq./100 gm.				
Na	0.06	0.06	0.06	0.13
K	0.21	0.20	0.18	0.16
Ca	0.57	0.39	0.41	0.15
Mg	0.28	0.10	0.61	0.41
C.E.C	2.09	4.18	5.19	6.52
Base sat. %	53.59	17.95	24.27	28.37
$CaCO_3$ eq.	0.0	0.0	0.0	0.0
pH 1:1 H_2O	5.85	5.0	5.0	5.0
Ohms R 60°F	4273.5	5217.0	4495.5	3274.5
Organic matter				
% Carbon	0.39	0.29	0.22	0.13
% Nitrogen	0.05	0.05	0.05	0.04
C : N	7.8	5.8	4.4	3.25
Exchangeable cations expressed as % of total exchangeable bases				
Na	2.87	1.65	1.16	7.03
K	10.04	4.78	3.46	2.45
Ca	27.27	9.33	7.89	2.30
Mg	13.39	2.39	11.75	21.62
Base sat. %	53.59	17.94	24.27	28.37
Clay Minerals				
C.E.C./100 gm. Clay	19.9	20.09	12.7	16.76
Identified minerals		Kaol.V.V.S. Ill. S.	Kaol.v.v.s Ill. S Haem.v.w.	Kaol.v.v.s. Ill. M Haem.v.w.
Free Fe_2O_3	1.72	4.62	5.63	6.42

releasing more acid nature of the phyllite from which profile 199 was formed.

Kanonkop is always acid. Free salts are absent in the solum. Base saturation below the Ap increases with depth. Exchangeable magnesium and sodium tend to increase with depth and calcium to decrease. The A of the shallow profile 173 shows a leaching of exchangeable calcium as well as sodium and magnesium. Exchangeable potassium percentage is high being over 10% for both profiles.

Carbon percentage is low as are the C : N ratios. C : N ratios decrease from 5.2 in the A of profile 173 to below A with depth.

Genesis and classification

Soil formation has proceeded sufficiently far to form a weakly structured argillic horizon. Clay movement has been chiefly mechanical. A stronger grade of structure has not formed because of the gravelly nature of the solum - the high ratio of gravel to fine separates. Leaching vertically as well as laterally of sodium and magnesium salts to accumulate in lower lying areas (and slightly in theB) has taken place.

Kanonkop is a haplargid not orthic but possibly an (undefined) dystric haplargid.

Physical characteristics and land use

Infiltrometer studies could not be made on Kanonkop due to its stoniness. The shallowness of the solum in most members renders it a C irrigable soil, with greater depth it varies to a B_2 value (Soils Research Institute). Kanonkop is mainly used for wheat production. The deep members, especially along the Berg River, are used for wine grape production.

Kanonkop is basically a fertile soil, it does not have the saline problems of Swartland. It does tend to be somewhat drier than Swartland. In wet years it can be expected to produce better wheat crops than Swartland. X

Associated soils and mapping

In areas where the rocks are strongly metamorphosed and the topography steep, Kanonkop grades into Zwartfontein. In such areas complexes of Kanonkop with Zwartfontein are found. Generally speaking, Zwartfontein is dominant on the steep slopes and Kanonkop on the shallow slopes. These areas of the Zwartfontein-Kanonkop complex occur mainly east of the Berg river and west of the Malmesbury-Paarl road.

In areas where the rocks are metamorphosed but not highly schistose, Kanonkop occurs as a complex of litholic soils, Kanonkop with a weakly structured B, Kanonkop with a strongly structured B, and Swartland. The Kanonkop variant with the strongly structured B at times resembles Swartland but has no free salts in the B. It is inseparable from the normal Kanonkop being part of the soil individual. Swartland is found in this area on the lower slopes where the landscape is less convex than where Kanonkop occurs.

In areas of Swartland there occur pedons which have weakly formed B horizons in complex association with Swartland as stated above. Normally these soils are too salty to be identified as Kanonkop.

There occur areas where Swartland has been truncated by river action to be covered by a mantle of coarse material. These soils resemble Kanonkop but are saline. (eg. at Boland Landbouskool)

The bottomlands in Kanonkop areas are weakly formed, they are not as alkaline as those in areas of Swartland and have a greater incidence of young alluvium in them.

<u>Kanonkop series definition</u>

A_1/Ap	More than 10% silt and clay. Less than 20% clay. Hues no redder than 7.5YR gradual transition to
B_{2t}	Structure no stronger than weak blocky. Chromas and values are greater than 3. pH less than 6.5 base saturation less than 80%. Exchangeable (na + Mg)% is less than 35%
C+R	The B_2 overlies and tongues weakly into the weathering rock laminae pH of the C is less than 6.5

SWELLENGIFT SERIES

Only encountered in the south western part of the area, Swellengift is fairly widespread where it occurs. Profiles 39 and 21 are representative examples.

Site

Swellengift is found on very gently undulating, gradual sloping slopes which are weakly pedimented. The topography on which it is found is generally less convex than that associated with Swartland. Rock outcrops, as well as silcrete and laterite caps on the higher levels, are common.

Parent material

Swellengift is limited to areas of Klipheuwel sandstones and conglomerates. The rocks of the Klipheuwel formation tend to be of a coarser texture than those of the Malmesbury formation in the area studied. They also have much less (if any) free salts than rocks of the Malmesbury formation which tend to be quite salty at times.

Relicts of the Pleistocene and Tertiary surfaces, i.e. laterites and silcretes as well as the terrace gravels and artifacts of recent age are commonly found in the soil. These have, however, not contributed anything to soil development remaining unweathered.

Morphology

Swellengift has a distinct horizon differentiation. A grey brown loamy coarse sand overlies, with a clear transition, a gravelly loamy coarse sand forming a stone line of terrace stones, artifacts, laterite fragments and quartz. This horizon has an abrupt transition to a dark coloured clay B_2. The dark colours are due to clay skins on ped surfaces, the ped interiors have light coloured gley colours - low chromas with prominent red mottles. The B is usually medium prismatic. At times the B is weakly developed and almost discontinuous. Profile 21 is an example of a pedon with a weakly developed B, profile 39 of one with a well developed B.

Chemical properties

pH is on the acid side, the soil tending to become more acid with depth. Base saturation is fairly high but the soil is not saturated with bases. Profile 39 is cultivated and has been limed so that the calcium figures and the base saturation figures for the A horizons are higher than for the virgin profile 21. In profile 21 base saturation is lowest in the A_2 being more or less constant below the A_2. Calcium is the dominant exchangeable basic cation in the A horizons, decreasing with depth so that in the B magnesium is the dominant basic cation. Exchangeable sodium percentage is highest in the B_2, but nowhere does

PROFILE No.: 39 Swellengift Series

LOCATION: Lat. 33° 44' Long. 18° 49' on farm Karnemelksvlei

SITE: Upper slope bevelled Miocene marine terrace 0-1% slope

ELEVATION: 320 ft.

PARENT MATERIAL: Klipheuwel sandstone + river terrace (Table Mountain sandstone) gravels

Horizon	Depth inches	
A_p Ochric	0-9	10YR 4/2 dark grey brown gravelly loamy coarse sand; soft, apedal; frequent sub-angular to round small quartz, occasional round terrace stones and early stone age artifacts; gradual transition
A_2	9-14	10YR 5/2 grey brown (10YR 6/2 lt.br.Gr.Dry) gravelly loamy coarse sand; soft, apedal; frequent sub-angular quartz; abrupt transition to clear transition
II A_3	14-22	10YR 5/2 grey brown (10YR 6/2 lt.Br.Gr.Dry) very gravelly loamy coarse sand; apedal, weakly coherent mass of abundant sub-angular quartz, frequent laterite fragments, and occasional rounded terrace stones forming a stone line; abrupt transition
$IIIB_{2gt}$ Argillic	22-32	10YR 3/2 very dark grey brown prominent thick clay skins; mottled 7.5YR 5/8 red, 10R 3/6 dark red and 2.5Y 6/2 light brownish grey clay; extremely hard, strong fine and medium prismatic breaking to moderate medium blocky; abrupt transition to clear transition in places
III C_t (IV C)	32-42	10YR 5/6 yellow brown sandy loam; many fine distinct 5Y 8/1 white mottles; hard to very hard, apedal to weak rock structure; occasional thick prominent 10YR 3/1 very dark grey clay skins down fissures, root holes, etc.

Lab. No.	B7449	B7450	B7451	B7452
Depth inches	0-14	14-22	22-32	32-42
Horizon	A	IIA_3	$IIIB_{2t}$	IIIC
Particle size distribution %				
Gravel separate 2mm.	26.0	82.1	16.7	6.3
C.sand 2-.5mm.	51.2	46.4	15.5	34.4
M.sand .5-.2mm.	13.3	14.6	8.4	14.1
F.sand .2-.02mm.	26.9	25.6	8.3	21.2
Silt .02-.002mm.	4.9	4.7	5.6	15.9
Clay .002mm.	5.1	9.4	63.5	16.3
Extractable cations meq./100 gm.				
Na	0.06	0.06	0.41	0.15
K	0.10	0.13	0.14	0.10
Ca	0.58	0.54	1.27	0.32
Mg	0.09	0.22	2.55	0.95
C.E.C.	1.03	1.34	6.92	2.60
Base sat. %	80.58	70.89	63.15	58.46
$CaCO_3$ eq.	0.0	0.0	0.0	0.0
pH 1:1 H_2O	5.65	5.8	5.0	5.4
Ohms R60°F	3140.3	4558.5	1316.9	2532.5
Organic matter				
% Carbon	0.20	0.22	0.26	0.08
% Nitrogen	0.03	0.03	0.06	0.01
C:N	6.7	7.3	4.3	8.0
Extractable cations expressed as % of total exchangeable bases				
Na	5.8	4.48	5.92	5.77
K	9.7	9.70	2.02	3.84
Ca	56.31	40.29	18.35	12.30
Mg	8.73	16.42	36.84	36.53
Base sat. %	80.58	70.89	63.15	58.46
Clay minerals				
C.E.C./100 gm. Clay	20.19	14.25	10.89	15.95
Minerals identified			Kaol.vvs Ill.med.	Kaol.vvs Ill.v.s.
Free Fe_2O_3 %	0.51	2.21	2.69	1.45

PROFILE No.: 21 Swellengift series
LOCATION : Lat. 33° 43' Long. 18° 51' on farm Agterdam
SITE : Gently undulating, upper slope 1% slope
ELEVATION : 420 ft.
PARENT MATERIAL : Klipheuwel sandstone

Horizon	Depth inches	
A_1 Ochric	0-6	10YR$^5/_2$ Grey-brown (10YR$^6/_1$ Gr.Dry) loamy sand; soft, apedal; occasional sub-angular quartz gravel; gradual transition
A_2	6-15	10YR$^6/_2$ light brownish grey (10YR$^7/_1$ lt.Gr.Dry) gravelly loamy sand; soft, apedal; frequent small sub-angular quartz, clear transition.
IIB_{21gt} (IIB_{1t}) Argillic	15-24	10YR$^5/_{1.5}$grey to grey brown (N$^8/_0$white dry) gravelly sandy loam; apedal to weak blocky; a weakly coherent mass of sub-angular quartz gravel and small stones, occasional Table Mountain Sandstone terrace stones and occasional laterite fragments forming a stone line; clear transition
$IIIB_{22gt}$	24-30	2.5Y$^6/_2$ light-brownish grey sandy clay loam; many prominent medium to coarse 5YR$^5/_8$ yellow red mottles; common moderately developed 10YR$^5/_1$ grey clay skins; extremely hard, apedal, to weak medium prismatic and moderate medium prismatic in places; gradual to clear wavy transition
IIIC	30-40	5YR$^6/_6$ reddish yellow (5YR$^7/_4$pink Dry) sandy loam; hard, apedal; weak rock structure with thick prominent 10YR$^4/_1$ dark grey clay skins. Individual sand grains have separate colours.

Lab. No.	B7443	B7445	B7446	B7447	B7448
Depth inches	0-6	6-15	15-24	24-36	30-40
Horizon	A_1	A_2	IIB_{21t}	$IIIB_{22t}$	III C
Particle dize distribution %					
Gravel separate 2 mm.	11.2	23.0	66.1	2.0	1.0
C.sand 2-.5 mm.	33.8	34.3	31.7	22.4	24.9
M.sand .5-.2mm.	25.7	24.4	17.1	18.1	23.3
F.sand .2-.02mm.	30.0	27.2	22.3	19.2	24.3
Silt .02-.002mm.	5.9	8.7	12.5	14.4	17.6
Clay .002mm.	5.1	5.5	16.0	25.7	10.1

Extractable cations meq./100 gm.					
Na	0.06	0.04	0.21	0.44	0.17
K	0.14	0.07	0.17	0.17	0.07
Ca	0.29	0.12	0.17	0.25	0.11
Mg	0.18	0.14	0.64	1.75	0.89
C.E.C.	1.11	.87	2.08	4.55	2.14
Base sat. %	60.4	42.5	57.2	57.4	57.9
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	6.0	6.1	5.65	5.3	5.6
Ohms R60°F	3545.8	7091.0	228.6	1316.9	2532.5
Organic matter					
% Carbon	0.32	0.08	0.15	0.09	0.03
% Nitrogen	0.03	0.01	0.03	0.02	0.01
C : N	10.66	8.0	5.0	4.5	3.0
Extractable cations expressed as % of total exchangeable bases					
Na	5.41	4.60	10.1	9.7	7.94
K	12.61	8.04	8.17	3.73	3.27
Ca	26.12	13.79	8.17	5.49	5.14
Mg	16.22	16.09	30.72	38.46	41.59
Base.sat. %	60.4	42.5	57.2	57.4	57.9
Clay minerals					
C.E.C./100 gm. clay	21.76	15.8	13.0	17.1	21.19
Identified minerals			Kaol.vvs Ill.vvs	Kaol.vvs Ill.vvs	Kaol.vvs Ill.vvs M.L. Med
Free Fe_2O_3 %	0.11	0.14	0.21	0.35	0.20

it reach 15%, nor does (Exch. Na + Exch. Mg) exceed 50% of the exchange capacity. Profile 39 is slightly more base saturated than profile 21 so that, while hydrogen exceeds magnesium on the exchange complex in profile 21, in profile 39 magnesium is dominant.

Exchangeable potassium is surprisingly high in the horizons which contain drift material (in the upper gravelly horizons.)

The organic matter figures show a bimodel accumulation, in the A_1 and in the B. C/N ratios are low (10.66 or less) decreasing with depth.

Genesis and classification

In the absence of high sodium and magnesium contents the clays in the soil are flocculated. The movement of clay from the A into the B sufficient to produce a diagnostic argillic horizon has therefore probably been chiefly mechanical - probably as clay-humus complexes.

From the extractable cation % figures for the virgin profile 21 it can be seen that the A_2 is leached of bases, there is no definite accumulation in the B, however, the base saturation percentage being constant in the B and C. Leaching, chiefly of calcium, in the A_2 would appear to be in a lateral direction by ground waters moving over the B through the A. The A horizon as a whole would appear to have lost magnesium with a resultant relative accumulation of calcium and potassium compared with the B and C horizons. Since there is a discontinuity between the A and the B and since no accumulation in the B appears to have taken place this can be attributed only either to lateral leaching of the A or to the nature of the discontinuous materials themselves. The fact that the bottomlands in areas of Swellengift areas - Rocklands series, are accumulating salts of magnesium and sodium and to a certain extent of calcium bears out the hypothesis of lateral leaching. Leaching in Swellengift is, hypothesised as vertical within the A, and lateral above the B within the overlying A.

According to the 7th approximation classification system, Swellengift is an orthic albaqualf.

Physical properties and land use

The B horizon is very slowly permeable. According to standards used by the Soils Research Institute, the irrigable value of this soil is normally B_2 to C.

Swellengift occurs in areas where the other dominant soil is Swartland. Swartland has a shallower rooting zone and is saline, X it is not as wet in winter as Swellengift and is thus more adapted to to wheat production than Swellengift which is the better soil for vines. Swellengift's peak wet period occurs when the vines are dormant, the coarser textured A horizons dry out during the summer growth period enabling vines to grow fairly reasonably.

Associated soils and mapping

Commonly Swellengift occurs in association with a litholic sandy soil with which rock outcrops are associated. These outcrops vary from small isolated outcrops to kopjes and hills.

Where Swellengift bounded on Swartland, the two were normally easily distinguished from each other. Use in mapping could often be made of the less convex topography associated with Swellengift. At Agterdam however Swellengift was found to resemble Swartland very closely, the only morphological difference being a clear transition from the B to the C in the case of Swellengift.

Bottomland positions in Swellengift areas are occupied by Rocklands in well defined flat to slightly concave areas. Bottomland positions were found occupied by a soil resembling Swellengift where the bottomland was ill-defined.

Swellengift series definition

A_1/Ap texture no coarser than loamy coarse sand and no finer than coarse sandy loam. Chromas less than 3 and values greater than 3.

A_2 as coarse as the A_1 or coarser. Chromas less than 3 and values at least one unit greater than that of the A_1. An abrupt transition to the B_2

B_{2t} Either twice as much clay as the A_2 or 20% more clay than the A_2 Chromas 2 or less. Peds coated with clay skins with darker colours than the matrix. Structure stronger than weak blocky-normally it is prismatic. pH less than 7, base saturation less than 70% but more than 50% Transition to the C clearer than gradual.

C Less than half the percent clay of the B or 20% less clay than the B. pH less than 7

PAARDEBERG SERIES

Paardeberg is found to a limited extent on the slopes of Paardeberg mountain and to a lesser extent on Paarl mountain. Profile 161A is representative of Paardeberg series.

Site

Paardeberg is found on the upper slopes of steeply sloping pediments. It normally occurs close to rock outcrops.

Parent Material

This soil formed in a coarse granitic colluvium overlying weathering granite.

Morphology

A brown coarse sand about 20 inches thick abruptly overlies weathering granite. The transition between the coarse material and the saprolite is wavy to weakly tonguing. A weak B_2 horizon occurs in the tongues and at the transition. The C (weathering rock) has felspars, micas and original granite structure still evident in it. This C often tongues into and around granite rock with an abrupt transition to the rock.

Chemical characteristics

The soil is acid. Base saturation is below 80% in profile 161A. Hydrogen is the dominant cation in the A, and magnesium in the B and C. The A and especially the A_3 appears to have lost some magnesium and sodium (in comparison with the C) with a resultant relative gain in calcium and potassium.

As for most soils in the area carbon percentages and C:N ratios are low.

The high C.E.C./100 gm. clay in the A horizons is probably strongly influenced by organic matter content. Clay minerals in the A are expected to be illite and kaolinite.

Genesis and classification

Paardeberg is found on a steep topography. It is highly erodible so that the materials have not been able to remain in situ long enough for more than rudimentary soil development to take place. What weathering has taken place below the A is mainly mechanical, the granite is only weakly weathered.

The A has been slightly leached, weak eluviation of clay from the A has occurred but not enough to form an argillic horizon. The B_{2t} is normally discontinuous only occurring in the tongues into

PROFILE No. : 161A Paardeberg series
LOCATION : Lat. 33° 32' Long. 18° 48' on farm Langkloof
SITE : Upper slope weakly formed granite pediment 5% slope
ELEVATION : 800 ft.
PARENT MATERIAL : Granite

Horizon	Depth inches	
Ap Ochric	0-7	10YR$^4/_3$ brown to dark brown (10YR$^6/_3$ p.Br.Dry) coarse sand; soft apedal; occasional large granite stones; gradual transition
A_3	7-17	10YR$^5/_4$ yellowish brown (10YR$^6/_3$ p.Br.Dry) loamy coarse sand; soft to slightly hard; occasional large granite stones; abrupt tonguing transition.
IIB_{21t} + IIC	17-44	10YR$^5/_6$ yellowish brown (10YR$^6/_3$ p.Br.Dry) gravelly coarse sandy clay loam tongues into weathered granite; hard, apedal porous; granite still has rock structure; 10YR$^5/_8$ yellowish brown coatings of clay occur around some crystal pseudomorphs, micas have weathered to give 2.5YR$^4/_8$ red colours to the weathered felspars; abrupt transition
II R	44 plus	Granite rock

Lab. No.	B7421	B7422	B7423
Depth inches	0-7	7-17	17-44
Horizon	Ap	A_3	IIB_{21t}+IIC
Particle size distribution %			
gravel separate 2mm.	9.5	10.6	24.4
coarse sand 2-.5mm.	33.4	36.9	41.4
medium sand .5-.2mm.	15.5	13.7	9.4
fine sand .2-.02mm.	34.1	29.2	15.1
Silt .02-.002mm.	6.5	8.8	3.9
Clay .002mm.	7.5	12.3	30.8
Extractable cations meq./100 gm.			
Na	0.13	0.08	0.26
K	0.23	0.17	0.21
Ca	0.72	0.57	0.98
Mg	0.30	0.28	2.75
C.E.C.	2.75	3.04	5.27
Base sat. %	50.18	36.18	79.69
$CaCO_3$ eq.	0.0	0.0	0.0
pH 1:1 H_2O	5.1	4.9	5.6
R 60°F Ohms	2064	5494	2775
Organic matter			
% Carbon	0.43	0.25	0.11
% Nitrogen	0.05	0.03	0.03
C : N	8.6	8.33	3.67
Extractable cations expressed as % of total extractable bases			
Na	4.73	2.63	4.93
K	8.36	5.59	3.98
Ca	26.18	18.75	18.59
Mg	10.90	9.21	52.18
Base sat. %	50.18	36.18	79.69
Clay minerals			
C.E.C./100 gm.clay	36.7	24.7	17.1

in the C. In Paardeberg the tongues are usually of a B horizon formed in the C material, not in A_2 - like material which has entered fissures in the underlying material as is the case in Windmeul.

Where crotavinas occur, clay illuviation into the cratavinas is marked in Paardeberg series. Weathering in the C has produced clays and liberated some iron oxides, structure is still that of granite however so a cambic horizon can not be recognised.

Paardeberg is an orthic psammustent.

Physical characteristics and land use

Paardeberg is normally too steep to be irrigated other than by overhead irrigation, it is highly erodible and has a low water holding capacity. It seldom varies from a B_2 irrigable value as defined by the Soils Research Institute. Paardeberg is mainly used for wheat production, it is also used for wine grape production north of Paardeberg mountain mainly under dryland conditions.

Erosion of this soil appears to take place by slipping of the soil mass over the rock, as well as by normal transportation of the sand particles by water. When the soil becomes saturated with water there is in the sandy materials no cohesion between the particles and they flow easily as a mass together with the water. Due to the nature of the underlying rock formations, water dams up in the soil to form wet patches in the rainy season. Sooner or later the forces holding the soil in place give way and the soil in the wet patch slides downslope over the rock forming a slip scar which progresses to form a donga.

Contouring the landscape does not alleviate the slipping of the soil mass, it does however prevent the topsoil eroding away to a certain extent. The contour furrows have to be periodically opened, for they fill in with the coarse sand, dam up the water and so hasten erosion.

Associated soils

Paardeberg normally is associated with rock outcrops and litholic sandy soils. It often occurs as a complex of deep and shallow soils especially on the steeper topographies where old ravines have been filled in with the coarse surface materials.

Occasionally Paardeberg is found associated with a heavier soil resembling Windmeul but with abundant felspars visible in the "pre-weathered" horizon.

The bottomlands in Paardeberg areas are usually not very well developed they contain organic alluvia, alluvium and Botriver series.

Paardeberg series definition

Paardeberg has an A_1/Ap - A_3 - Band C - R profile or an A_1/Ap - AC - C - R profile.

A_1/Ap less than 20% clay, less than 10% silt. More than 5% felspars in the coarse sand fraction. Less than 40% fine sand.

A_3/AC no finer than limits set on the A_1. Chromas 3 or greater values greater than 4. More than 5% felspars in sand and gravel fraction an abrupt wavy or tonguing transition to the C. A discontinuous B is permitted in the tongues. Base saturation less than 50%

C More than 20% clay. pH less than 6.5 chromas 3 or more values greater than 4. No structure other than that of rock, felspars or their pseudomorphs are visible to the naked eye.

Abrupt transition to Rock

NB Only one profile was analysed so that this definition must be regarded as tentative only.

DISCORDIA SERIES

Nowhere very extensive it is found mainly north of Paarl mountain and east of Paardeberg, between elevations of 655 ft and 720 ft. Profiles 112 and 119 are representative.

Site

It is found on gently sloping bevelled Miocene land surfaces generally above 655 ft in elevation.

Parent material

Discordia has formed from vesicular laterite and laterised pre-weathered granite thought to be relicts of a Miocene land surface.

The thickness of the laterite is not known. In a quarry south of Paarl mountain at Vrymansfontein a vesicular laterite with horizontal pores and vertical tongues of gravel and softer material similar to that described by Prescott and Pendleton (1952) is at least 12 ft. thick. Judging by the slope and the extent of the laterite up-slope if the laterite were formed in a flat area it must have been of considerable depth. Because of the isolated occurence and bevelling of this surface it is difficult to determine exactly whether more than one level is involved. At Dun Darach two benches appear to be present - at 655 ft. and between 710 and 730 ft. Dissection and redeposition of colluvium can not be ruled out as the cause of the lower level. Only by mapping areas further apart can the nature of this surface be accurately described.

Morphology

While horizon differentiation is not marked, Discordia has a distinctive morphology. Typically it has a dark brown (7.5YR or redder) sandy loam Ap with a gradual to clear transition to a yellowish red, friable, apedal porous sandy clay loam B_2. The soil becomes gravelly with depth and tongues into laterised pre-weathered granite material. Profile 112 represents the coarse textured phase and 119 the fine textured phase of Discordia.

Chemical characteristics

These soils are acid. Base saturation increases with depth. The high base saturation, high exchangeable calcium and low magnesium as well as high pH of profile 119 would indicate it has been limed and fertilized quite heavily. (cf. the more or less constant exchangeable K% and the low C:N ratio of the upper 18 inches, compared with the C). Exchangeable calcium % decreases with depth and Mg% increases with depth showing the typical leaching pattern of all soils in this area

PROFILE No. : 112 Discordia series

LOCATION : Lat. 33° 36' Long. 18° 51' on farm Discordia

SITE : Mid slope laterised granite pedislope 3% slope

ELEVATION : 685 ft.

PARENT MATERIAL : Laterised granite

Horizon	Depth inches	
Ap Ochric	0–9	7.5YR 4/3 dark brown (7.5YR 6/4 lt.br.Dry) loamy sand slightly hard apedal; rare iron concretions; clear transition
B_{21t} (IIB_{21t}) cambic (oxic)	9–20	5YR 4/8 yellowish red (5YR 6/8 Y.R.Dry) sandy clay loam; soft, apedal-porous; weak clay skins evident rare laterite fragments; gradual transition
B_{22t} ($IIIB_{22t}$) cambic	20–28	5YR 4/8 yellowish red (5YR 6/8 Y.R.Dry) sandy clay loam; soft apedal-porous; rare laterite fragments; abrupt transition
IIC_1 ($IIIC_1$)	28–72	7.5YR 5/8 strong brown (7.5YR 6/8 Str.Br.Dry) gravelly sandy clay loam; soft, apedal-porous; loose mass of rounded to sub-angular laterite fragments and occasional small and gravel size angular quartz; clear transition.
IIC_2 ($IIIC_1$)	72–82	7.5 YR 5/8 strong brown gravelly sandy clay loam; many medium distinct 2.5YR 7/6 yellow mottles; friable, apedal-porous, abundant angular to sub-angular quartz gravel, occasional iron shot, occasional fine distinct 5R 2/4 very dusky red soft iron concretions.

Lab. No.	B7398	B7399	B7400	B7401	B7402
Depth inches	0–9	9–20	20–28	28–72	72–82
Horizon	Ap	B_{21t}	B_{22t}	IIC	IIC_2
Particle size distribution					
Gravel separate 2 mm.	8.3	8.2	13.6	56.2	20.4
C.sand 2–.5 mm.	40.0	33.6	34.0	38.9	36.9
M.sand .5–.2mm.	15.2	14.1	11.1	10.2	10.2
f.sand .2–.02mm.	33.7	24.3	34.0	21.3	20.3
Silt .02–.002mm.	0.9	0.4	4.2	6.2	4.4
Clay .002mm.	10.6	30.5	30.0	27.2	31.7
Extractable cations me.q./100 gm.					
Na	0.07	0.04	0.06	0.09	0.31
K	0.14	0.15	0.13	0.13	0.14
Ca	0.76	0.84	0.95	0.25	0.13
Mg	0.04	0.51	0.64	1.22	1.00
C.E.C.	2.49	3.39	3.24	3.21	2.41
Base sat. %	40.56	45.42	54.93	52.64	65.56
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	5.3	5.2	5.3	5.6	5.23
Ohms R 60°F	2941.5	4273.5	3385.5	3940.5	2497.5
Organic Matter					
% Carbon	0.42	0.25	0.26	0.20	0.15
% Nitrogen	0.03	0.02	0.02	0.02	0.02
C:N	14.0	12.25	13.0	10.0	7.5
Exchangeable cations expressed as % of total exchangeable bases					
Na	2.81	1.18	1.86	2.80	12.86
K	5.62	4.42	4.01	4.04	5.80
Ca	30.52	24.77	29.32	7.78	5.39
Mg	1.60	15.04	19.75	38.00	41.49
Base sat. %	40.56	45.42	54.93	52.64	65.56
Clay Minerals					
C.E.C./100 gm. clay	23.49	11.11	10.8	11.8	7.6
Identified minerals	Kaol.v.s.	Kaol.v.s.	Kaol.v.s.	Kaol.v.s.	Kaol.v.s.
Free Fe_2O_3%	0.82	1.80	1.74	3.34	2.60

PROFILE No. :	119 Discordia series
LOCATION :	Lat. 33°35' Long. 18° 51' on farm Groot Vondeling
SITE :	Mid slope laterised granite pedislope 3% slope
ELEVATION :	685 ft.
PARENT MATERIAL	Laterised granite

Horizon	Depth inches	
Ap Ochric	0-9	5YR$^4/_4$ reddish brown (7.5YR$^5/_4$ Br. to dk.Br. Dry) sandy clay loam; friable, apedal-porous; occasional laterite nodules, rare sub-angular quartz gravel; gradual to clear transition
B_{21t} cambic (oxic)	9-18	5YR$^4/_6$ yellowish red (5YR$^5/_8$ Y.R. Dry) gravelly sandy clay loam to sandy clay; a weakly coherent mass of laterite fragments; apedal-porous; weak clay skins in ground mass and around the concretions; gradual transition.
B_{22}+C_1 (B_{22} + IIC_1) Oxic	18-44	5YR$^4/_8$ yellowish red (5YR$^5/_8$ Y.R.Dry) sandy clay loam to gravelly sandy clay loam; a weakly coherent mass of laterite fragments in an apedal-porous matrix; tonguing into and around a mottled 5YR$^5/_8$ yellowish red, 10R$^4/_8$ red, 7.5R$^6/_4$ pale red and 2.5Y$^8/_2$ white sandy loam, which is an extremely hard strongly fissured breaking to fine blocky laterised granite; clear transition
IIC_2 ($IIIC_2$)	44-60	5YR$^4/_8$ yellowish red (5YR$^5/_8$ Y.R.Dry) clay; few medium to large distinct 2.5YR$^4/_6$ red mottles; soft, weak fine blocky to apedal porous, occasional fine soft iron concretions/hard iron-clay rich nodules, rare fine angular quartz gravel.

Lab. No.	B7403	B7404	B7405	B7406	B7407
Depth inches	0-9	9-18	18-44	18-44	44-60
Horizon	Ap	B_{21t}	B_{22t}	$C_1(IIC_1)$	$IIC_2(IIIC_2)$
Particle size distribution %					
Gravel sep. 2mm.	6.4	19.8	12.4	1.2	9.5
C.sand 2-.5mm.	29.8	30.0	34.6	36.4	23.6
M.sand .5-.2mm.	10.7	9.2	11.1	15.6	6.4
F.sand .2-.02mm.	30.0	24.3	23.1	28.0	17.5
Silt .02-.002mm.	4.6	4.2	5.6	4.5	5.6
Clay .002mm.	27.4	34.5	28.6	19.0	50.0
Extractable cations meq./100 gm.					
Na	0.14	0.10	0.08	0.08	0.06
K	0.25	0.27	0.14	0.14	0.12
Ca	4.46	3.69	0.68	0.85	0.43
Mg	0.24	0.23	1.58	1.52	1.46
C.E.C.	4.44	5.26	3.92	3.42	3.01
Base sat. %	114.6	81.6	63.2	76.0	68.8
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	7.25	6.7	6.0	5.7	5.9
Ohms R60°F	1176.0	2553.0	2830.5	2719.5	3108.0
Organic matter					
% Carbon	0.53	0.53	0.23	0.27	0.21
% Nitrogen	0.04	0.04	0.02	0.01	0.02
C:N	13.25	13.25	11.5	27.0	10.5
Exchangeable cations expressed as % of total exchangeable bases					
Na	2.75	1.9	2.04	2.34	1.99
K	4.91	5.13	3.57	4.09	3.98
Ca	87.62	70.15	17.34	25.14	14.28
Mg	4.71	4.37	40.3	44.44	48.5
Base sat. %	114.6	81.6	63.2	76.0	68.8
Clay minerals					
C.E.C./100gm. clay	16.2	15.24	13.7	18.0	6.0
Identified minerals	Kaol.med	Kaol.v.s	Kaol.s.	Kaol.M.S.	Kaol.v.s.
SiO_2% clay			35.61	36.32	
R_2O_3% clay			45.52	45.84	
$SiO_2:R_2O_3$ clay			.782	.792	
SiO_2% soil			51.08	36.28	
R_2O_3% soil			50.52	35.16	
$SiO_2:R_2O_3$ soil			1.407	1.436	
Free Fe_2O_3 %	1.70	2.26	4.43	3.06	3.97

Carbon percentage is higher than in other representative soils in the area studied. The C:N ratios in the B and C are higher than those encountered in most other soils showing the material to be not as highly decomposed. The Ap of profile 119 would be mollic but for the high value ($5YR^{4}/_{4}$) and the low carbon % of .53 as against .58 as required for a mollic epipedan.

The free iron oxide percentages are considerably lower than was expected. They are sufficient to designate the 18"-44" horizons in profile 119 oxic but are too low to define any horizon in profile 112 oxic on the basis of clay:Fe_2O_3 ratio alone. Since in all other respects the B_{21t} horizons in both profiles appear oxic it would seem that free Al_2O_3 must be high.

With an SiO_2:R_2O_3 ratios considerably below 1 the B_{22} and C_1 of profile 119 can be seen to be highly weathered, that the B_{22} is ferralitic or oxic can not be doubted.

Genesis and classification

From such highly weathered sesquioxide rich materials as those from which Discordia has formed, only an oxisol could form. That an oxisol has developed from granitic materials in the area, is the result of a geological rather than pedological process.

The material from which Discordia is formed was weathered in the Miocene, laterised to quite extensive depths and subsequently exposed to weathering forces. Weathering subsequent to exposure, has liberated sesquioxides as well as the clay which was bound into the laterite, to form the soil. Base saturation of the parent material probably was low, subsequent leaching has lowered it further moving especially sodium and magnesium out of the upper solum to accumulate in the C. The sesquioxides liberated by weathering stabilise the clay forming clay-iron bridges resulting in the porous microaggregate structure peculiar to oxisols, and in the absence of strong clay movement.

It should perhaps be explained that while the parent material of Discordia dates back to the Miocene there is no reason to expect that the soil itself has been in situ longer than other soils in similar positions, e.g. Paardeberg and Windmeul, i.e. that while Discordia is called an "old soil", this refers to its weathering stage and not to the length of time it has existed as a soil.

Discordia is an idox if the B is oxic as is thought to be the case. Since the C is as weathered as the B it is also oxic and Discordia is then deep enough to qualify as an orthic haplidox.

Physical characteristics and land use

Oxisols have some of the most desirable physical characteristics of all soils. They are permeable, porous and have a reasonably high water holding capacity. Moreover most of the water retained is available to plant growth. Discordia does have a C which at times impedes water penetration and it is sometimes shallow and stony. Generally it has however an A_2 irrigable value as defined by the Soils Research Institute.

Discordia is invariably used for grape production either trellised or not.

Associated soils and mapping

Discordia is associated geographically with Katarra and Paardeberg and sometimes in complex association with Windmeul. It normally occurs in topographically well defined areas as caps on the hillocks around the granites or on the old pediment slopes in the granitic areas. Its red hues easily distinguish it from surrounding soils.

Discordia is often associated with organic rich dark termite mounds or "heuweltjies".

Discordia series definition

A_1/Ap Hues redder than 10YR and chromas at least one unit darker than the underlying B. Between 10% and 35% (silt + clay) %

B_2 Hues 7.5YR or redder with values between 4 and 6 and chromas between 4 and 8 inclusive. More than 20% clay. Friable when moist structure no coarser than fine blocky - defined as apedal with common to many visible fines pores. No prominent clay skins.

C laterite or laterised granite with basic values and chromas of 4 or greater.

KATARRA SERIES

Katarra series (Slabber,1945) occurs extensively south of Paardeberg. Elsewhere it is of limited occurrence, usually being found in areas transitional between granites and shales. Katarra has a distinctive morphology represented by profiles 74 and 76.

Site

Katarra is typically found on flat land-surfaces often relicts of Pleistocene land-surfaces, as at the minor pediplain south of Paardeberg. Seldom is it found with a slope steeper than 3% ✗

Parent material

Katarra members studied, have always been formed in binary materials, invariably in coarse sands overlying Malmesbury sedimentary rocks. The sand has, in all cases, been presumed granitic because Katarra is only found downslope from granites. The depth of sand varies from 1 ft. to over 7 ft. In the pediplain south of Paardeberg the modal depth is about 3 ft.

The pediplain mentioned above, occurs at an average height of 450 ft. It is a flat plain stretching continuously from Paardeberg to Prospect Hill, a distance of almost 5 miles, with a drop of 50 ft. from Dagbreek to Prospect Hill, which represents a slope of 0.4%. A remnant found north of Rocklands at about 370 ft. represents a slope of 0.3% from Dagbreek.

Associated with this plane are found silcretes and laterites as well as terrace gravels eg. at Trig.beacon 181 near Jan Beversfontein at 451 ft. No terrace gravels nor silcretes were found in profiles of Katarra.

It appears that the pediplain has formed by the deposition of sand onto a flat surface. This surface is probably a remnant of Pleistocene age, it would appear to be river-cut. From remnants of the laterites associated with this pediplain the surface seems to have a slope with a vector southwards as well as one westwards. This is in corroboration of the writer's theory of the capture of the headwaters of the Mosselbank by the Berg river, i.e. during the Pleistocene a river rising in Franschoek, flowed south of Paarl mountain, turning north-west towards Paardeberg to deposit gravels of Table mountain sandstone found extensively at 500 ft. at Karnemelksvlei and at 450 ft. at Agterdam. The vector in slope of the surface westwards, is explicable in terms of earlier marine planation but the vector southwards not.

It is difficult to explain the mode of deposition of the sand mantle on the flat surface. At one time it was probably of near uniform depth with small promontories of sedimentary rocks jutting out of it, for the sand is thinnest in lower lying areas, becomes thicker with rise in height, to disappear with further increase in height. No obvious sorting of materials has occured, the sand close to Paardeberg is no coarser than that 3 miles away. Contrary to what would be expected with a process of pedimentation the sand is no thicker close to the granites that it is 3 miles away. The sand is angular and has thus not been transported far; moreover as pointed out previously the fact that Katarra, with this type of sand, is only found around the granites, predisposes the writer to suggest the granites in the immediate proximity as the provenance.

There are two possible modes of deposition of this sand; a process of pedimentation with local redistribution of materials by wind, this would have resulted in a greater degree of sorting of materials than is found; or a local riverine terrace formation similar to that envisaged for the deposition of the fine sands (Ofazi series) in young alluvial positions. The action must necessarily have been local, as witness the uniformity of materials - the absence of finer materials and of terrace gravels in the sand itself.

The sand has remained in situ for two reasons. Firstly it is in a position almost at the divide between the Mosselbank-Diep and the Berg river catchment areas so that river incision is expected to be behind the stage reached elsewhere. There must have been a considerable time lag in river incision while the Mosselbank and Diep rivers adjusted themselves to their lowered carrying capacity after capture of their former headwaters by the Berg river. Secondly in rapidly draining, flat lying materials such as these, drainage is lateral through the sand over the heavier materials, so that erosion is reduced to the retreat of the sand mantle at the edges, rather than by incision and removal by stream action. The steepness of the valley at Jan Beversfontein bears this out; Swartland has eroded away, the stream has cut deeply into the shales, but the sand mantle remains more or less intact on top of the hill because the sands drain as a whole and little accumulation of drainage water into valleys occurs as in the heavier materials

Morphology

Katarra has a very striking morphology. Typically it is a brown coarse sand, often appearing slightly reddish on the surface with uniform chromas and values. The sand overlies a layer of laterite concretions or a massive flat iron-pan. This abruptly overlies a prismatic clay prominently mottled red, yellow, and grey; often with soft iron concretions in it. The colour of the ped surfaces changes from a dark red (or yellow-brown) to a light grey with depth; ped interiors are more or less uniform mottled red and yellowish brown.

PROFILE No.	74 Katarra series
LOCATION	Lat. 33°41' Long. 18°47' on farm Kromrivier
SITE :	Gently sloping pediplain of granite sand on Miocene marine cut surface 0-1% slope
ELEVATION :	420 ft.
PARENT MATERIAL :	Granitic sand on Malmesbury shale

Horizon	Depth inches	
Ap Ochric	0-9	10YR 4/3 brown to dark brown sand; loose, apedal; occasional laterite fragments; gradual transition
A_2 (+Ap_2)	9-16	10YR 5/3 brown (10YR 6/2 lt.br.gr.Dry) gravelly sand; loose, apedal; frequent laterite fragments, gradual to clear transition
IIA_3 (+Ap_3)	16-30	10YR 5/3 brown (10YR 6/2 lt.Br.Gr.Dry) very gravelly loamy sand; weakly coherent mass of laterite slabs to fine laterite gravel and abundant fine angular to sub-angular quartz gravel. One laterite slab dug out measures 6'x6'x3ft, is massive non vesicular; abrupt transition
$IIIB_{21t(g)}$ argillic	30-40	5Y 8/1 white and 5Y 7/2 light grey clay. Ped interiors are 10R 4/6 red to 2.5YR 4/8 red and 5YR 4/8 yellowish red surrounded first by 10YR 6/8 brownish yellow and then the grey of ped surfaces. The grey does extend into the peds, it gives the impression of being of very old orientated clays. Prominent clay skins on ped surfaces from 10YR 6/3 pale brown to 10YR 4/1 dark grey. Very firm, moderate medium prismatic tending to keep prismatic form on breaking, also breaking to moderate medium blocky; gradual transition
$IIIB_{3t(g)}$	40-54	10YR 8/1 white sandy clay; many large prominent vertical 10R 4/6 red to 2.5YR 4/8 red and 10YR 6/8 brownish yellow in ped interiors; prominent 10YR 4/1 dark grey clay skins along vertical fissures ped surfaces, etc; very hard, apedal, tending to weak prismatic; gradual transition
IIIC(g)	54-69	10YR 7/1 light grey sandy clay; many large vertical prominent 10YR 6/8 brownish yellow mottles, diffusely mottled 2.5YR 4/8 red; prominent 10YR 5/1 grey and 10YR 4/1 dark grey clay skins down fissures; very hard, apedal.

Lab. No.	B7465	B7466	B7467	B7468	B7469	B7470
Depth inches	0-9	9-16	16-30	30-40	40-54	54-69
Horizon	Ap	A_2	IIA_3	$IIIB_{21t}$	$IIIB_{3t}$	III C
Particle size distribution %						
Gravel separate 2mm.	11.8	17.6	60.8	3.0	3.4	0.7
C.sand 2-.5mm.	52.6	52.6	42.9	16.8 37,8	27.1 42,2	21.9 32,8
m.sand .5-.2mm.	12.1	12.9	14.5	7.6	13.0	11.8
f.sand .2-.02mm.	29.3	29.9	35.8	13.0	18.8	23.0
Silt .02-.002mm.	1.2	1.7	2.7	2.4	2.0	2.3
Clay .002mm.	4.8	4.3	6.2	60.5	40.9	41.2
Extractable cations meq./100 gm.						
Na	0.02	0.0	0.03 (0.10)	0.45	0.49	0.81
K	0.04	0.04	0.06 (0.05)	0.15	0.07	0.05
Ca	0.46	0.21	0.33 (0.60)	2.05	1.07	0.71
Mg	0.05	0.06	0.31 (0.14)	4.73	3.21	3.12
C.E.C.	0.95	0.46	0.79 (0.64)	8.04	4.94	4.84
Base sat. %	60.0	67.39	92.39	91.79	97.97	96.9
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	5.9	6.2	6.8	6.4	6.4	6.4
Ohms R60°F	6078.0	10,000.0	6585.0	912.0	1033.0	760.0
Organic matter						
% Carbon	0.25	0.07	0.08	0.17	0.07	0.05
% Nitrogen	0.02	0.005	0.009	0.03	0.01	0.006
C : N	12.5	14	9.0	5.7	7.0	8.3
Extractable cations expressed as % of total exchangeable bases						
Na	2.1	0.0	3.79	5.59	9.91	16.73
K	4.2	8.69	7.59	1.86	1.41	1.03
Ca	48.42	45.65	41.77	25.49	21.65	14.66
Mg	5.26	13.04	39.24	58.83	64.97	64.46
Base sat. %	60.0	67.39	92.39	91.79	97.97	96.9
Clay materials						
C.E.C./100 gm. clay	19.79	10.69	12.74	13.28	12.07	11.74
Identified minerals				Kaol vvs	Kaol.vvs Ill.M.W. Mont.M.W.	Kaol.vvs
SiO_2 clay	42.26	46.96	45.02	40.28	42.90	42.56
R_2O_3 clay	35.92	34.96	37.52	40.80	39.76	39.28
SiO_2:R_2O_3 clay	1.176	1.343	1.199	.987	1.078	1.083
SiO_2 soil	96.10	92.68	96.46	64.17	78.14	76.97
R_2O_3 soil	1.92	2.08	3.28	26.00	16.68	15.92
SiO_2:R_2O_3 soil	50.520	46.961	29.408	2,468	4,684	4,834
Free Fe_2O_3	0.43	0.26	0.54	2.00	0.86	0.46

PROFILE No.:	76 Katarra series
LOCATION:	Lat. 33°40' Long. 18°47' on farm Dagbreek
SITE:	Gently sloping pediplain of granitic drift on Miocene cut surface 1% slope
ELEVATION:	470 ft.
PARENT MATERIAL:	Granitic sand on Malmesbury shale

Horizon	Depth inches	
Ap Ochric	0-10	5YR $^{4}/_{4}$ red-brown (7.5YR $^{6}/_{4}$ lt.Br.Dry) sand; loose, apedal; occasional laterite fragments; gradual transition.
A_2	10-21	7.5YR $^{4}/_{4}$ brown (7.5YR $^{6}/_{4}$ lt.Br.Dry) sand; loose apedal; few clay lamellae; occasional laterite fragments; clear transition.
II A_2	21-38	7.5YR $^{4}/_{4}$ brown (7.5YR $^{6}/_{4}$ lt.Br.Dry) gravelly sand; loose, apedal mass of laterite fragments and nodules; abrupt transition
$IIIB_{21t}$ argillic	38-42	7.5R $^{3}/_{8}$ dark red gravelly clay, with prominent 2.5YR $^{3}/_{6}$ dark red clay skins in upper 2", going to 5YR $^{5}/_{6}$ yellowish red to 7.5YR $^{6}/_{2}$ pinkish grey and finally at the transition to 5Y $^{7}/_{1}$ light grey. Firm, moderate medium prismatic breaking to fine blocky; frequent iron concretions; gradual transition.
$IIIB_{22t(g)}$ ($IIIB_3$)	42-55	7.5R $^{3}/_{8}$ dark red clay; prominent thick 5Y $^{7}/_{1}$ light grey clay skins; firm, moderate fine prismatic breaking to fine blocky; frequent iron concretions; gradual to clear transition
$IIIB_{3(g)}$ (IIIC)	55-70	Strongly mottled 7.5R $^{3}/_{8}$ dark red, 5YR $^{4}/_{8}$ yellowish red and 10YR $^{6}/_{8}$ yellow brown with prominent thick 5Y $^{7}/_{2}$ light grey clay skins giving impression of a light grey mottled red and yellow brown horizon; firm, weak medium prismatic breaking to coarse blocky; frequent iron concretions in the dark red mottles.

Lab. No.	B7471	B7472	B7473	B7474	B7475	B7476
Depth inches	0-10	10-21	21-38	38-42	42-55	55-70
Horizon	Ap	A_2	IIA_2	$IIIB_{21t}$	$IIIB_{222t}$	$IIIB_3$
Particle size distribution %						
Gravel separate 2 mm.	8.8	12.2	80.2	25.7	15.6	6.2
C.sand 2-.5 mm.	44.0	42.8	48.9	19.4	10.9	5.9
M.sand .5-.2 mm.	15.6	17.0	16.9	5.6	3.7	3.0
F.sand .2-.02 mm.	34.4	35.6	26.4	8.2(8.8)	11.2	17.2
Silt .02-.002 mm.	1.6	1.6	1.3	9.8(5.2)	8.4	10.9
Clay .002 mm.	5.3	4.5	7.6	55.8(59.8)	67.4	72.4
				65,6 65,0	75,8	83,3
Exchangeable cations meq./100 gm.						
Na	0.06	0.00	0.02	0.42	1.61	1.29
K	0.09	0.05	0.07	0.19	0.10	0.16
Ca	0.75	0.30	0.43	1.65	0.64	0.45
Mg	0.07	0.003	0.17	2.67	5.19	6.51
C.E.C.	1.24	0.56	1.09	8.07	10.69	12.91
Base sat. %	78.22	63.03	63.30	61.09	70.53	65.14
$CaCO_3$ eq.	0.0	0.2	0.3	0.0	0.0	0.0
pH 1:1 H_2O	6.3	6.3	6.6	5.1	4.3	4.0
Ohms R 60°F	3242	4924	3780	767	444	308
Organic matter						
% Carbon	0.37	0.13	0.14	0.58(0.61)	0.19(0.17)	0.13(0.13)
% Nitrogen	0.03	0.01	0.02	0.05(0.06)	0.03(0.03)	0.01(0.03)
C : N	12.3	13.0	7.0	11.6(10)	6.3 (5.7)	13.0(4.3)
Saturation extract soluble cations meq./100 gm.						
Na						1.43
K						0.0
Ca						0.14
Mg						0.03
$EC10^3$/cm.25°C						2.88
Extractable cations expressed as % of total extractable bases						
Na	4.84	0.00	1.83	5.20	15.06	
K	7.25	8.92	6.42	2.35	0.93	
Ca	60.48	53.57	39.44	20.44	5.98	
Mg	5.64	0.53	15.59	33.09	48.55	
Base sat. %	78.22	63.03	63.30	61.09	70.53	65.14
Clay minerals						
C.E.C./100 gm. clay	23.39	12.44	14.34	13.49	15.86	17.83
Identified minerals				Kaol.v.s	Kaol.vvs Ill.M.W.	Kaol.vvs Ill.M.W.
SiO_2 % clay	37.34	38.58	40.08	37.43	43.94	43.36
R_2O % clay	40.40	40.96	42.88	43.76	39.44	39.44
$SiO_2:R_2O_3$ clay	0.921	0.941	0.934	0.855	1.114	1.099
SiO_2 % soil	93.46	95.90	93.60	51.39	42.40	44.66
R_2O % soil	3.44	1.96	4.48	35.00	41.08	38.28
$SiO_2:R_2O_3$ soil	27.168	48.928	20.892	1.468	1.032	1.166
Free Fe_2O_3 %	0.92	0.56	1.24	10.30	6.75	5.76

The thickness of the light grey coatings on the ped surfaces increases with depth, so that deeper in the B, the horizon is dominantly grey. The transition from B toC is gradual. Only rarely is rock structure encountered in the C since the underlying rocks (in the type area) are mainly mudstones without strong rock structure, and since they are deeply weathered/altered.

The iron pan encountered in Katarra resembles a sandstone. It is dense, massive and extremely hard. Nowhere was it found continuous over large areas. It is supposed, by the local inhabitants, to occur in strips. This could not be verified in the survey.

Rarely, as in profile 76, clay lamellae are found in the sandy horizons.

Chemical properties

The soil is acid throughout the solum. Base saturation is over 60% but nowhere is the solum fully saturated. Base saturation is more or less constant with depth or as in the case of profile 74 increases from the A to the B. This is probably the more normal case. Profile 76 with carbonates in the A_2 has obviously been limed heavily. Exchangeable calcium percentages decrease with depth, probably due to liming of the surface horizons. Magnesium and sodium increase with depth. The sodium accumulation peak is below that of magnesium. Either in the lower B or in the C exchangeable sodium percentages exceed 15%

Carbon percentage in profile 76 shows a marked accumulation peak in the B_{21t} (0.37% in the Ap, 0.13% in the A_2 and 0.58% in the B_{21t}). The absolute accumulation in the B_{21t} of profile 74 is not as marked but nevertheless constitutes a 100% increase over the content of the A_2. The peaks of carbon accumulation are accompanied by peaks in free iron percent and by the lowest $SiO_2:R_2O_3$ ratios in the clay fraction. A distinct tendency towards podsolisation (formation of a spodic B) is present as is evident in most of the soils in the area tending to form argillic horizons (sols lessives).

Genesis and classification

Chemically Katarra shows tendencies towards the formation of a spodic B horizon. The structure of the B, and the presence of oriented clays however, causes its designation to be argillic.

Elucidating the genesis of the soil poses some interesting problems. Laterite encountered in the soil is always indurated, soft plinthite in the sandy materials was not found. The laterite is at present releasing iron oxides which accumulate in the B (c.f. red clay skins in profile 76). Ped surfaces show gley colours, the interiors do not. The ped interiors have reddest hues colour becoming yellower and bluer towards the ped surface (except in the upper B of profile 76 to be discussed later). Reduction of iron to give gley colours is thus active in the lower B and in the C. If the gley were, like the laterite, a relict of a past pluvial (wet period - probably not more than of application to this pediplain) then ped exteriors would be oxidised as in the upper B_2 of profile 76.

It appears that soil formation in Katarra is actively taking place in a paleosol. Prior to the lowering of the water table in Katarra areas the water table fluctuated above the clay forming plinthite in the sand. With lowering of the water table and probably removal of some of the sand mantle to make it thinner, the plinthite hardened, then began weathering with further recession of the water table. The writer does not believe that the laterite belongs to a pluvial period in the Pleistocene but that recession of the water table took place concurrently with dissection of the landscape. Instead of water accumulating over the clay it now drains laterally over it. Although no examples were found of it, it is reasonable to expect that in the Katarra landscape plinthite is still forming at places.

Comparisons between profile 76 and 74 show the absence of red clay skins in profile 74 and that gley colours are present higher up in the B_2 than in profile 76. The landscape in which profile 76 occurs is in a more advanced stage of dissection than that of profile 74. Profile 74 has not reached the same stage of recession of the water table that 76 has. Fluctuations of the water table in profile 76 take place within the B causing the active formation of iron concretions. A large proportion of this iron is probably illuvial from the weathering of the laterite in the A.

In the discussion concerning water table above, it must be realised that no permanent water table exists in these soils. The lower B remains moist throughout the season; in winter a perched water table occurs above the B. What is meant is that the B in profile 74 is moist throughout while in 76 only the lower part is moist. Only in winter is there free water present in the solum. The A is dry for the major part of the season.

The shale-derived materials have been in situ longer than most members of Swartland which have been exposed to erosion after the Pleistocene. In Katarra leaching of the shale-derived clay has removed all the free salts normally expected in the Malmesbury formation shales and weathering has destroyed rock structure to a greater depth than is encountered in Swartland.

Katarra series is an albaqualfic typustalf; the deep members are crypto albaqualfic typustalfs grading into orthic quarzopsamments with greater depth (See: "Some problems in classification", Chapter 4).

Physical characteristics and land use

The B is very slowly permeable and topography flat so that Katarra is not to be recommended for intensive irrigation. With extensive drainage systems the deep phase could be used. The shallow (less than 48 inches) members have B_2 irrigable values, the deeper ones from a poor B_1, to a fair B_1 (Soils Research Institute).

In the area surveyed, Katarra is used for vine, fruit and wheat production. Some fairly large areas are still virgin - apart from some bottomlands and Ofazi-Maputa complexes Katarra is the only soil extensively left virgin. This appears to be due to a geographical tendency of farming habits. Katarra is a very poor wheat soil so that in wheat areas it may be left uncultivated whereas in vine areas it would be among the first soils to be cultivated.

Associated soils

Where it occurs extensively, Katarra occupies a well defined landscape with sharp topographical changes at the boundaries to other soils. The coarse textured A of Katarra is normally deeper in higher lying areas (within the same landscape unit) than in lower lying areas.

With Katarra there are associated rare termitaria or heuweltjies of uniform texture (approximately sandy clay loam) with dark colours caused by admixture of organic material.

Often, near Paardeberg, a soil is encountered in isolated patches within the Katarra individual which has the A and B of Katarra, but with a layer of strong brown granite colluvium between the A and B. This material resembles that of the pre-weathered granite surface and is possibly related to that surface.

Katarra series definition

A_1/Ap	with less than 10% silt + clay
A_2	with chromas greater than 2 with less than 10% silt + clay fine sand % less than 40% and coarse sand % greater than 40%. An abrupt transition to the B_2
B_2	Prismatic structure moderate to strong fine to medium. More than 40% clay with gley colours within 10 inches of upper boundary with clay skins in the upper 10 inches with redder hues or higher chromas and values than below 10 inches. pH less than 7, base saturation between 60% and 100%. A gradual transition to C.

C structure other than that of rock, with gley colours, prominently mottled, pH less than 7 and base saturation less than 100%

WINDMEUL SERIES

Of fairly widespread occurrence in the granite areas, Windmeul occurs in two forms. Profile 13A is representative of the soft form and profile 149 of the hard form. The latter is more commonly encountered.

Site

Windmeul is found on moderately sloping relict Miocene landsurfaces at between 600 ft. and 800 ft. elevation.

Parent material

Windmeul has formed in binary materials. A coarse textured granitic drift overlies and often tongues into pre-weathered granite. This pre-weathered material has lost all resemblance to the parent rock. It is quite highly weathered - kaolin is the only clay mineral - but felspars are still present in the finer sand fractions. This pre-weathered material corresponds with the materials found in the C of Discordia and would on exposure to soil formation, probably give rise to Discordia.

Morphology

A dark grey brown coarse sandy loam Ap overlies a yellowish brown coarse sandy loam A_2 or A_3 with a clear transition to a yellowish brown gravelly coarse sandy clay loam B_{2t}. This horizon consists of round plinthite nodules which have hardened, weakly cemented by clay and iron/clay bridges. Often this material tongues into the horizon below. Where these tongues occur, a B_{2t} has been formed in them. The tongues vary in depth from about 12 inches to over 6 ft., being deepest in the hardened form of Windmeul.

The horizon below the B_{2t} (that which is often hardened in the pre-weathered granite) is brownish yellow vertically mottled with redder colours. It is a sandy clay either slightly hard moderate fine blocky, or hard to very hard weakly cemented "columnar". The columns do not represent true columnar structure, this is but one of the forms plinthite appears to take (as opposed to vesicular or massive or nodular). The columns are apedal to massive.

This pre-weathered granite horizon could be defined as a cambic B horizon yet since it is a relict this does not seem correct. Rather than cause confusion perhaps it would be better to regard it as a C horizon. (see Chapter 4). In not one instance was hard rock encountered in Windmeul, nor was any material with granitic structure or texture encountered in Windmeul.

There occurs south of Malmesbury near the farm Doornfontein, a variant of Windmeul in which the surface horizon is a sandy loam to

PROFILE No.: 13A Windmeul series

LOCATION : Lat. 33°41' Long. 18°54' on farm Olyvenboom

SITE : Lower mid slope granite pediment 2% slope

ELEVATION : 650 ft.

PARENT MATERIAL Granite colluvium (probably preweathered)

Horizon	Depth inches	
Ap Ochric	0-15	10YR$^{4}/_{2}$ dark grey brown (10YR$^{6}/_{2}$ lt.Br.Gr.Dry) gravelly loamy coarse sand; soft, apedal; rare laterite nodules; gradual transition
A_2	15-28	10YR$^{5}/_{4}$ yellowish brown (10YR$^{6}/_{3}$p.Br.Dry)gravelly coarse sand; soft to slightly hard, apedal; rare laterite nodules; clear transition
IIB_{21t} (IIA_3)	28-37	10YR$^{5}/_{4}$ yellowish brown (10YR$^{7}/_{3}$v.p.Br.Dry)very gravelly coarse sandy clay loam; slightly coherent mass of sub-angular laterite nodules, and fine quartz; apedal; abrupt transition
$IIIB_3$ ($IIIB_{21t}$) (Cambic)	37-44	10YR$^{5}/_{8}$ yellowish brown gravelly sandy clay; many large vertical distinct to faint 7.5YR$^{5}/_{8}$ strong brown, and many large distinct 10R$^{4}/_{8}$ red mottles; hard, weak blocky; gradual transition
IVC_{1t} (IVB_{22t}) (Cambic)	44-55	10YR$^{5}/_{8}$ yellowish brown sandy clay; few fine distinct 10R$^{4}/_{8}$ red mottles in places being large vertical; many large faint 7.5YR$^{5}/_{6}$ strong brown vertical mottles; hard, moderate fine blocky; occasional cratavina of 10YR$^{5}/_{4}$ yellowish brown sandy clay loam; frequent moderately developed 10YR$^{5}/_{4}$ clay skins; gradual transition
IVC_{2t} (IVB_{23t}) (Cambic)	55-63	10YR$^{6}/_{8}$ brownish yellow sandy clay; many faint large vertical 7.5YR$^{5}/_{8}$ strong brown and few distinct medium 10R$^{4}/_{6}$ red mottles; hard moderate to weak fine blocky, frequent 2.5Y$^{6}/_{2}$ light brownish grey clay skins; gradual transition
IVC_{3t} (IVB_3)	63-75	10YR$^{5.5}/_{8}$ yellowish brown sandy clay; many medium continuous reticulate 7.5R$^{4}/_{6}$ red and few faint medium 2.5Y$^{8}/_{2}$ white mottles; slightly hard weak blocky; occasional prominent 10YR$^{4}/_{2}$ dark greyish brown clay skins; gradual transition
VC_{4t} (VB_{32})	75-85	10YR$^{6}/_{8}$ brownish yellow sandy clay; many medium distinct to prominent 7.5R$^{4}/_{6}$ red large continuous reticulate weakly vertical, and few medium faint 2.5Y$^{8}/_{2}$ white mottles; slightly hard to hard, weak fine blocky to apedal; occasional prominent thick 10YR$^{3.5}/_{2}$ very dark grey-brown clay skins

Lab. No.	B7453	B7454	B7455	B7456	B7457	B7458	B7459
Depth inches	0-15	15-28	28-37	37-44	44-55	55-63	63-85
Horizon	Ap	A_2	IIB_{21t}	$IIIB_3$	IVC_{1t}	IVC_{2t}	$IVC_{3t}+IVC_{4t}$
Particle size distribution %							
Gravel separate 2 mm.	20.6	26.0	74.6	34.5	6.4	6.6	7.2
C.sand 2-.5mm.	63.0	66.0	48.7	38.2	22.8	20.4	22.2
M.sand .5-.2mm.	9.5	9.8	8.9	6.1	3.7	4.0	5.1
F.sand .2-.02mm.	17.2	14.9	15.2	3.6	9.7	11.6	10.7
Silt .02-.002mm.	2.5	1.8	5.0	11.9	20.0	24.6	19.7
Clay .002mm.	8.5	7.8	21.6	42.1	46.1	41.0	43.0
Extractable cations meq./100gm.							
Na	0.04	0.06	0.07	0.08	0.06	0.10	0.08
K	0.08	0.08	0.19	0.12	0.11	0.14	0.12
Ca	0.87	0.65	0.67	0.67	0.48	0.13	0.01
Mg	0.40	0.22	0.61	1.42	1.94	2.18	1.84
C.E.C.	1.51	0.88	2.01	2.51	2.94	2.63	2.73
Base sat. %	92.05	114.77	76.61	91.23	88.09	96.95	75.09
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	6.1	6.3	6.3	6.2	6.2	6.0	5.3
Ohms R 60°F	4559	5065	2735	2533	2026	1722	2026
Organic matter							
% Carbon	0.42	0.16	0.28	0.14	0.14	0.09	0.09
% Nitrogen	0.04	0.02	0.03	0.02	0.03	0.02	0.02
C : N	10.5	8	9.3	7	4.7	4.5	4.5
Extractable cations expressed as % of total extractable bases							
Na	2.64	5.94	3.48	3.18	2.04	3.80	2.93
K	5.29	7.92	9.45	4.78	3.74	5.32	4.39
Ca	57.61	64.35	33.33	26.69	16.32	4.94	0.36
Mg	26.49	21.78	30.34	56.57	65.98	82.88	67.39
Base sat. %	92.05	114.77	76.61	91.23	88.09	96.95	75.09
Clay minerals							
C.E.C./100 gm. clay	17.76	11.28	9.51	5.96	6.38	6.41	6.34
Identified minerals				Kaol. v.v.s	Kaol. v.v.s	Kaol. v.v.s	Kaol. v.v.s
Free Fe_2O_3	0.55	0.56	1.42	2.68	3.11	3.50	1.80

PROFILE No.:	149 Windmeul series
LOCATION :	Lat. 30°32' Long. 18°49' on farm Jakkalsfontein
SITE :	Mid slope to upper slope granite pediment 3% slope
ELEVATION :	900 ft.
PARENT MATERIAL	Granite and laterised granite drift (probably preweathered)

Horizon	Depth inches	
Ap Ochric	0-9	2.5Y$^4/_2$ dark grey brown (10YR$^6/_2$ lt. Br.Gr.Dry) coarse sand; soft, apedal; gradual transition.
IIA_3	9-18	10YR$^5/_4$ yellowish brown (10YR$^7/_2$ lt.Gr.Dry) loamy coarse sand; soft, apedal; rare laterite fragments, clear transition
IIIC + IIB_{21t} (Cambic)	18-28	7.5YR$^5/_6$ strong brown (7.5YR$^6/_6$R.Y.Dry) gravelly coarse sandy loam: strong clay/iron-clay bridges bind the laterite fragments together. The B exists as tongues of A_3-like material approximately sandy clay loam in texture. Laterite fragments are rounded 2.5YR$^4/_6$ red and 7.5YR$^5/_6$ strong brown, gradual transition
IIIC + IIB_{22t} (Cambic)	28-38	7.5YR$^5/_6$ strong brown (7.5YR$^6/_6$R.Y.Dry) gravelly sandy clay loam to sandy clay, very hard, weak blocky; tongues of B_2 material between the vertically laterised 2.5YR$^4/_6$ red drift and laterite nodules; moderately developed clay skins; gradual tonguing transition to abrupt where laterised crust occurs.
IVC + IIB_{23t} (Cambic)	38-72	7.5YR$^5/_6$ strong brown clay; hard, moderate fine blocky; moderately developed clay skins; the B exists as tongues in the 10YR$^5/_8$ yellow brown weakly cemented laterised granite drift with ¼" to 1" thick 2.5YR$^4/_6$ red films surrounding it, in places on indurated crust a few mm to ½" thick 7.5R$^2/_2$ very dusky red forms laminae around this material

Lab. No.	B7411	B7412	B7413	B7414	B7415
Depth inches	0-9	9-18	18-28	28-38	38-72
Horizon	A_p	IIA_3	IIB_{21t} IIIC	IIB_{22t} IIIC	IIB_{23t} IVC
Particle size distribution %					
Gravel separate 2 mm.	11.6	0	24.2	17.6	5.6
C.sand 2-.5mm.	52.9	49.5	43.0	26.5	17.8
M.sand .5-.2mm.	11.1	12.2	12.8	10.5	4.5
f.sand .2-.02mm.	26.2	25.7	25.2	24.2	9.2
Silt .02-.002mm.	4.3	5.1	8.0	5.3	7.4
Clay .002mm.	8.7	10.2	11.6	35.1	63.1
Extractable cations meq./100 gm.					
Na	0.05	0.04	0.08	0.12	0.18
K	0.05	0.09	0.31	0.23	0.18
Ca	0.53	0.39	0.95	0.70	0.42
Mg	0.03	0.00	1.26	2.27	2.83
C.E.C.	1.48	1.62	4.58	5.09	5.48
Base sat. %	33.78	32.10	56.76	65.22	65.87
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	5.1	5.0	5.6	5.5	5.6
Ohms R 60°F	3607.5	6493.5	4329	2997.0	2353.2
Organic matter					
% Carbon	0.33	0.21	0.25	0.27	0.30
% Nitrogen	0.03	0.01	0.03	0.04	0.01
C : N	11.0	21.0	8.34	6.75	30
Extractable cations expressed as % of total extractable bases					
Na	3.38	3.21	1.75	2.36	3.28
K	.33	5.55	6.76	4.51	3.28
Ca	35.8	24.07	20.74	13.75	7.66
Mg	2.02	0.0	27.51	44.59	51.64
Base sat. %	44.59	32.10	56.76	65.22	65.87
Clay minerals					
C.E.C./100 gm. clay	17.01	15.88	39.48	14.5	8.68
Identified minerals			Kaol.M.S.	Kaol.v.v.s	Kaol.v.v.s
Free Fe_2O_3		0.53	3.73	3.96	3.10
$SiO_2:R_2O_3$ clay			0.935	0.891	0.890
$SiO_2:R_2O_3$ soil		17.38	2.034	1.929	1.734

a sandy clay loam and which has hues of 7.5YR or greater in the surface. It appears to fall between Windmeul and Discordia, but has too high a felspar content in the finer sand fractions to be oxic. For this reason it is named here as a heavy variant of Windmeul rather than a felspathic variant of Discordia.

Chemical characteristics

Profile 13A is sited in an old vineyard, profile 149 in a wheatland. The high base saturation of the A_2 in profile 13A is ascribed to liming since the exchangeable calcium and magnesium figures are much higher in the A horizon, than should be expected.

On the whole profile 149 has much lower base saturation figures than 13A. Possibly the material is older in profile 149 - it's elevation is much higher.

Windmeul series soils are acid throughout the solum, base saturation is less than 100%, is more or less constant below the A or increases slightly with depth. Calcium or calcium + hydrogen are the dominant cations in the A horizons. Magnesium, increasing with depth is more or less equivalent with calcium in the B_{21t}. Below the B_{21t} magnesium is the dominant cation.

Carbon percentage of the A is about normal for soils in the area, the great depths to which it has moved is abnormal especially in profile 149 where there is only a 10% difference in Carbon % between the Ap and the IIB_{23t}+IVC at 38 to 72 inches.

A certain amount of movement of free iron appears to be indicated by the analysis.

The C.E.C./100 gm. clay for the 18-28 inch horizons in profile 149 of 39.48 meq. is high for kaolin, the clay % for these horizons by analysis is considerably lower than that estimated in the field.

Genesis and classification

Assessing the genesis of Windmeul is complicated not only by the presence of a number of lithological discontinuities in the parent material, but also by the fact that the material in the B position is part of an old land surface. This material is strongly and deeply weathered. The conditions under which it was weathered no longer pertain. It is thus not truly part of the solum as it has no genetic significance to present soil forming processes. Although the material is morphologically a cambic horizon it is genetically a C horizon relict of an ancient erosion cycle.

Since soil formation began to form Windmeul, very little of genetic significance has occurred. Clay has moved downwards to form a weak, often discontinuous B_{2t}. Leaching of magnesium appears to have taken place but the presence of such contrasting materials makes absolute elucidation difficult. Alternate wet and dry conditions have, at some time, caused the formation of slightly hard plinthite nodules above the major discontinuity. These conditions appear to no longer pertain (no nodules which had not irreversably hardened were encountered). At the present time strong oxidising conditions occur in the solum. Iron is locally dissolved within the "cambic B" and redeposited to harden on the surface of old cracks or crotavinas thereby producing the "columnar" structures often found in the slightly cemented form of Windmeul.

As can be seen from the minerological analysis of profile 149 below; the pre-weathered material is not quite weathered enough to be called oxic, except perhaps for the 50 inch to 72 inch horizon. The only clay minerals present however are kaolin. Granitic materials weathered under more recent cycles contain illite and vermiculite as well as kaolinite (v.d.Merwe & Weber) in the area studied. Upon mechanical break up accompanied by a slight chemical weathering, the pre-weathered materials are known to give riseto ferralitic soils. The writer feels thus that the limit set on felspar percentages in oxic materials is too low at 1%. 5% would perhaps be a better upper limit. (See Chapter 5.)

Table Minerological analysis of profile 149 (Single count analysis)

Light mineral analysis of the various sand fractions

Mesh size	35			60			70		
Depth inches	Qu	Fel	Sau	Qu	Fel	Sau	Qu	Fel	Sau
0-9							89.5	10.5	0
9-18	96.7	3.3	0	92.5	7.5				
18-28							92.6	6.5	0.9
28-38				87.0	6.5	6.5	87.1	1.7	11.2
38-50	98.0	2.0	0	98.7	1.3	0	95.5	3.0	1.5
50-72	100	0	0	100	0	0	98.9	1.1	0

Mesh size	140			270			Heavy mineral analysis of the 140-270 mesh fraction non magnetic/ magnetic ratio
Depth inches	Qu	Fel	Sau	Qu	Fel	Sau	
0-9	92.9	7.1	0	91.7	8.3	0	0.59
9-18	88.2	10.7	1.1	91.8	7.3	0.9	0.72
18-28	92.1	5.8	2.1	86.4	12.1	1.4	0.65
28-38	88.3	1.1	10.6	76.5	7.1	16.4	0.51
38-50	76.1	10.9	13.0	90.3	4.0	5.7	0.63
50-72	98.5	1.5	0	98.3	1.1	0.6	0.36

Qu. = Quartz
Fel.= Felspar
Sau.= Sausserite

35 mesh = 0.5 mm
60 mesh = 0.25 mm
70 mesh = 0.210 mm

140 mesh = 0.105 mm
270 mesh = 0.083 mm

Windmeul is probably a thapto oxic ustochrept.

Physical characteristics and land use

Windmeul is moderately well drained it has a B_1 irrigable value (Soils Research Institute designation)

It is mainly used for wine grape production. North of Paarl mountain table grapes are produced on Windmeul

Associated soils

Windmeul often occurs as a consociation of deep and shallow phases. The shallow phase is easly recognised by the presence of plinthite nodules in the Ap.

Rarely, Windmeul occurs as a complex together with Katarra, eg. North of Windmeul-Paardeberg Cellars. More often Windmeul occurs in the high lying areas with Katarra occurring at the transition to the Malmesbury sediments (Swartland series).

Windmeul series definition

A_1/Ap	with more than 50% coarse and medium sand
A_2/A_3	more than 50% coarse and medium sand chromas of 4 or more and values of 5 or more overlying
Cambic B	preweathered granite which has chromas of 4 or more and values of 5 or more which has no structure other than fine blocky. With no visible rock structure and no more than 1% felspars discernable to the naked eye. This material may be slightly cemented in which case the sûrface of the fissures present have redder colours than the matrix or if not cemented it is mottled with red colours.

FERNWOOD SERIES - CONCRETIONARY VARIANT

This soil is of limited occurrence. It is mainly found around Paardeberg. Profile 55 is representative. This soil has been defined in the Natal Sugar Belt by Beater.

Site

It is limited to sites in which laterally moving drainage water accumulates - chiefly bottomland sites. At times the deep sands south of Paardeberg mapped as a deep Katarra phase fall within the definition of Fernwood series

Parent Material

Granite sandy drift materials form the parent material of Fernwood.

Morphology

Typically Fernwood is a deep coarse sand, greyish brown to pale brown in colour. Rare members are found with clay lamellae, these are not diagnostic in this series which has an A-C profile. Typically where lamellae occur they occur deeper than 25" and the total thickness of lamellae is only a few millimetres. Profile 55 is abnormal in that concretion development is taking place in the C. More often concretions are hardened relicts. These iron concretions occur above the major discontinuity, this discontinuity occurs below 50 inches and is normally underlain by a gleyed coarse sandy clay.

Common to all members of this series are coarse textures and low chromas with high values to a depth of 50 inches, no B horizon, and no soft iron concretions shallower than 36 inches.

Chemical properties

pH is less than 6.5 throughout the profile and resistance greater than 3,000. Base saturation is greater than 80% to a depth of 53 inches. The lower base saturation in the 53 inches to 69 inches sample is due to the lateral leaching of the C_{4g} by groundwater moving over the gleyed sandy clay C_{5gt}.

In the coarse drift material (above 69 inches) calcium is the dominant cation. Magnesium is absent on the exchange complex in the Ap AC and C_1 and sodium absent in the AC and C_1. Since the granites contain sodic felspars and biotite these low sodium and magnesium contents point to a strong leaching of the material, the high base saturation and exchangeable calcium figures are mainly due to fertilization. Leaching of potassium from Ap to the C is shown by the analysis

PROFILE No.: 55 Fernwood series – concretionary variant

LOCATION : Lat. 33°40' Long. 18°49' on farm Varschfontein

SITE : Lower slope gently sloping pediplain

ELEVATION : 500 ft.

PARENT MATERIAL : Granite pediment

Horizon	Depth inches	
Ap Ochric	0-8	10YR4/2 dark greyish brown (10YR6/3 p.Br.Dry) coarse sand; loose, apedal; gradual transition.
AC	8-25	10YR5/4 yellowish brown (10YR7/2 lt.Gr.Dry) coarse sand; loose, apedal; gradual transition.
C_1	25-44	10YR7/3 very pale brown (10YR8/3 v.p.Br.Dry) coarse sand; loose, apedal; occasional iron concretions gradual transition.
C_2	44-53	10YR7/3 very pale brown (10YR8/3 v.p.Br.Dry) coarse sand; occasional large distinct 5YR4/8 yellowish red mottles which are a soft sandy clay loam; occasional iron concretions; loose, apedal; clear transition
C_{3CA}	53-59	10YR7/3 very pale brown gravelly coarse sand; abundant large iron nodules forming in places an almost continuous indurated laterite sheet, in other places being a loose mass. Below the concretions the horizon has common prominent 5YR4/8 yellowish red large diffuse mottles; clear transition.
C_{4g}	59-69	2.5Y7/2 light grey coarse sand; loose, apedal; abrupt transition
IIC_{3gt}	69-79	2.5Y7/2 light grey coarse sandy clay; common large prominent 5YR4/8 yellowish red, 7.5YR6/8 reddish yellow and 10R 3/4 dusky red mottles; with prominent 10R4.5/1 dark reddish grey clay skins; firm to very firm, apedal.

Lab. No.	B7377	B7378	B7379	B7380	B7381	B7382
Depth inches	0-8	8-25	25-44	44-53	53-69	69-79
Horizon	Ap	AC	C_1	C_2	C_3+C_{4g}	IIC_{5gt}
Particle size distribution mm.%						
Gravel separate 2mm.	0.0	0.0	0.0	7.8	2.2	3.5
C. sand 2-.5 mm.	65.8	48.0	50.5	45.2	51.9	37.0
M. sand .5-.2mm.	12.9	17.9	16.5	15.9	18.2	10.8
F. sand .2-.02mm.	18.7	31.2	30.8	28.3	26.3	6.0
Silt .02-.002mm.	2.2	2.5	2.0	6.6	3.5	2.4
Clay .002mm.	2.7	2.3	2.2	4.2	2.2	38.9
Extractable cations meq./100 gm.						
Na	0.03	0.00	0.0	0.35	0.05	0.36
K	0.02	0.02	0.03	0.05	0.07	0.09
Ca	0.48	0.40	0.21	1.26	0.36	0.67
Mg	0.00	0.00	0.0	0.27	0.19	1.87
C.E.C.	0.63	0.45	0.29	2.34	1.13	3.58
Base sat. %	84.12	93.3	82.75	82.47	59.29	83.51
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	6.0	6.2	6.1	5.9	6.1	5.0
Ohms R 60°F	3689	6324	10000	4215	4531	1054
Organic matter						
% Carbon	0.13	0.05	-	0.24	0.10	0.04
% Nitrogen	0.01	0.01	-	0.01	0.02	0.01
C : N	13	5	-	24.0	5.0	4.0
Extractable cations expressed as % of total exchangeable bases						
Na	4.16	0.0	0.0	14.95	4.42	10.05
K	3.17	4.44	10.34	2.13	6.19	2.51
Ca	76.19	88.88	72.41	53.84	31.85	18.71
Mg	0.0	0.0	0.0	11.53	16.81	52.23
Base sat. %	84.12	93.3	82.75	82.47	59.29	83.51
Clay minerals						
C.E.C./100 gm. Clay	23.3	19.6	13.2	55.7	51.3	9.2
Identified minerals						Kaol.v.s. Ill. tr.
Free Fe_2O_3 %	0.36	0.16	0.06			

The high sodium and magnesium in the C_2 is attributed to the upward movement of salts of these ions via fluctuating groundwaters, from the IIC_{5gt} as well as from external sources.

The organic matter analysis of profile 55 shows tendencies towards the formation of a spodic horizon in the C_2 horizon, even the wide C/N ratio and accumulation of iron together with organic matter point to this tendency, however the high C.E.C./100 gm clay in C_2 and (C_3+C_{4g}) disprove this. While the (C_3+C_{4g}) has a C/N ratio of 5.0 as is normal where illuvial organic matter is highly decomposed; in the C_2 it is 24. It seems more acceptable therefore that the high carbon % in the C_2 is due to the presence of decaying plant roots (probably of the grapevines) and not to a podsolisation process. The iron rich mottles in the C_2 have in either case been formed by the fluctuating water table bearing reduced iron and not by eluviation of an A_2.

D.T.A. analysis of the iron-clay rich nodules of the C_2 show endothermic peaks typical of a vermiculite type of clay, the presence of this mineral even if only in small proportions would explain the high cation exchange capacity of the clay

Genesis and classification

Fernwood, in the area surveyed has developed in materials sorted and leached by a combined colluvial and alluvial process. When deposited, the materials were already highly leached of most cations.

Subsequent to deposition leaching as reflected by the potassium figures and the low sodium and magnesium figures continued. Mechanical clay movement has taken place as evidence the presence of lamellae in some pedons. The inherent low clay content of the material limits the significance of any clay movement however. Above the C the only pedological process which has taken place to a significant extent is the accumulation of organic matter in the A and a weak illuviation of organic matter into the C.

The presence of a groundwater table moving over a dense material has resulted in the bleaching of the zone immediately above the material. The fluctuations of this water table has resulted in the deposition and subsequent oxidation of iron compounds in the C. These are in the process of being hardened during dry periods.

The water table has also enriched the horizon of iron accumulation with sodium and magnesium.

Profile 55 in which no lamellae were seen is probably an orthic quarzopsamment. Those soil individuals (which are rare) with lamellae present, are probably alfic quarzopsamments. Generally the coarse sands with lamellae have however chromas too high for Fernwood series. Mineral analysis are necessary to place the Psamments into great groups. The presence of 2:1 minerals in the C_2 of profile 55 might mean there are more than 5% weatherable minerals in which case it is an aquic orthopsamment.

Fernwood series of which profile 55 is a member was first described in the Natal Sugar Belt by Beater ( ). It has subsequently been defined by Loxton and MacVicar (1965).

Physical characteristics and land use

The soil is freely drained to depths greater than 50 inches. Somewhere in the vicinity of 50 inches a water table which rises in winter receding in summer to below the major discontinuity, occurs. The coarse texture and low water holding capacity of the soil make it a B_1 irrigation soil according to standards used by the Soils Research Institute. Where it has a marked water table it may approach a B_2 value.

This soil, drained, is used in the area only for grape production. It needs moderate fertilisation and liming (as shown by the low exchangeable magnesium figures dolomitic lime would be best).

Associated soils and mapping

Fernwood occurs associated with Katarra series in ill defined bottomland positions as well as in better defined bottomland positions in association with alluvium in areas of the Paardeberg-Windmeul series soils.

Fernwood series definition

An A_1-C profile in which silt and clay is less than 10% in the A_1 and C. Values are 5 or more and chromas 3 or less in the C and there is less than 40% fine sand with a ratio of coarse + medium to fine sand greater than 1.

The concretionary variant of which profile 55 is a member is defined as above with the proviso that the textures remain as coarse for at least 50 inches and that soft iron rich mottles are not found in the C horizon immediately underlying the A_1. Laterite is present only in a discontinuous form, not as massive pans and is not present to an extent more significant than an occasional concretion in the upper 36 inches.

OFAZI SERIES LIGHT TEXTURED PHASE

Four areas of this soil occur, south of Paardeberg, west of Paardeberg, east of Paarl mountain and at Sodendal. These areas occur as isolated deposits. Profiles 84 and 181 are representative of this series first described in Zululand by Hensley et al and defined by Loxton and Macvicar (1965).

Site

In the area surveyed Ofazi may occupy any site except wet positions. It has been found in broad bottomlands as well as well drained upland positions and on river terraces.

Parent material

The individual south of Paardeberg in which profile 84 is sited, must from reasons of site and surrounding rocks be of aedian origin. The member east of Paardeberg occurs on a flat surface with marked "ripple" marks the crests of which are about 25 yards apart and about 4 feet high on an average. This member extends discontinuously upslope. It would appear the material has been wind deposited, or if not at least to have been moved by wind to form the undulating microrelief. The member east of Paarl mountain occurs on a bevelled river terrace in Noorder Paarl, as old alluvium ($\pm$ 15 ft. terrace), and in association with terrace gravels on the 60 ft. terrace at Huguenot. The member at Sodendal would appear from site to be alluvium were it not for the absence of stratifications.

The origin of the sand poses a problem. By deductive processes it is postulated that it was first deposited on the 60 ft. terrace most probably by river action, although it is not impossible that the river deposited the gravels and wind the sand. There is no evidence to disprove the sand mixed with the terrace gravels to be of the same origin as them. Since the gravels are of Table Mountain sandstone it is presumed the sand is largely of the same origin. Subsequent erosion of this terrace surface as well as the river bringing in more from the provenance resulted in accumulation of the sand as alluvium. Wind scouring of the terrace surface at some time transported this material to redeposit it elsewhere, both in the bottomlands where Rocklands is today found, and where Ofazi is found. It is possible that the Ofazi in alluvial positions along the Berg river is wind deposited - as evidence lack of stratification and the uniformity of the material.

The parent material of Ofazi is locally wind transported sand of alluvial origin. More work would need to be done before this could be proved absolutely.

Morphology

A deep fine sand slightly darker in the surface horizon, and yellow below the surface. This sand is more or less uniform to usually over 6 ft. and is markedly absent of particles greater than 2 mm in diameter. Below 6 ft. a variety of materials can be expected usually with laterite forming above a water table. Profile 84 would appear to overly materials which are similar to those out of which Paardeberg series was formed while profile 181 overlies terrace boulders in which laterite is forming.

Chemical properties

Profile 181 is cultivated under a heavy grape production and fertilisation programme. This is reflected in its high pH and base saturation figures. Profile 84 at the roadside while slightly disturbed is not fertilised, the soil is acid and the base saturation of the A and AC are below 50%. Base saturation increases with depth from the A_1 to the C as do the exchangeable sodium and potassium percentages.

The cation exchange capacities of the clay decrease with depth more or less in relation to the decrease in organic matter (the AC of profile 181 is inconsistent; here the higher organic matter content is probably due to decaying vine cuttings or roots ploughed in.)

Genesis and classification

In coarse materials little horizon development can take place other than accumulation of organic matter and in colder climes perhaps the development of a spodic horizon. No clay lamellae have been seen in the light textured phase in the area studied. All that has happened of genetic significance is a slight leaching of cations and the accumulation of organic matter to form an A_1 horizon.

The classification of Ofazi is hindered by lack of moisture tension curves on a seasonal basis. If it is accepted that Ofazi light textured phase is a dry soil it is probably an oxic psammustent unless it has less than 95% quartz in the sand fraction in which case it is an orthic psammustent.

Physical characteristics and land use

The soils are rapidly permeable. Because of the low water retention capacity of the light textured phase however it has an irrigable value of only B_1, it is however a good B_1 soil (according to standards used by the Soils Research Institute). Where it occurs on well drained sites it may be irrigated intensively.

Ofazi is normally used for intensive grape production. At

PROFILE No.:	181 Ofazi series
LOCATION :	Lat. 33°42' Long. 18°57' on farm St.Peter's Rocke
SITE :	Gently sloping second terrace Berg River 1-2% slope
ELEVATION :	320 ft.
PARENT MATERIAL :	Aeolian sand on terrace material

Horizon	Depth inches	
Ap Ochric	0-20	10YR 6/4 light yellowish-brown fine sand;, loose apedal; abrupt wavy transition
AC	20-40	10YR 5/8 yellowish-brown fine sand; loose, apedal; gradual transition
C_1	40-67	10YR 7/6 to 2.5Y 7/8 yellowish fine sand; coarse, apedal; gradual transition.
IIC_2	67-88	10YR 8/8 to 2.5Y 8/8 yellow sand; loose, apedal; gradual transition
$IIIC_3$	88-100	2.5Y 8/4 pale yellow sand to gravelly sand; many large faint 10YR 6/8 brownish yellow and few large faint 2.5Y 8/2 white mottles; losse, apedal; clear transition.
IVC_4	100 +	10YR 8/6 yellow (2.5Y 8/4 p.Y.rubbed) gravelly coarse sand; abundant laterite fragments, quartz gravel and rounded Table Mountain sandstone terrace stoves; loose, apedal.

Lab. No.	B7460	B7461	B7462	B7463	B7464
Depth inches	0-20	20-40	40-67	67-88	88-100
Horizon	Ap	AC	C_1	IIC_2	$IIIC_3$
Particle size distribution %					
Gravel separate 2mm.	0.5	0.0	0.0	4.9	4.2
C.sand 2-.5mm.	17.7	19.9	11.4	37.3	37.6
M.sand .5-.2mm.	36.3	30.3	20.8	18.7	18.0
F.sand .2-.02mm.	42.9	45.9	66.1	37.4	34.1
Silt .02-.002mm.	0.2	0.2	0.4	1.2	1.4
Clay .002mm.	4.0	4.9	5.8	4.9	7.1
Extractable cations meq./100 gm.					
Na	0.03	0.02	0.06	0.02	0.03
K	0.08	0.09	0.12	0.08	0.13
Ca	1.09	0.83	0.53	0.26	0.21
Mg	0.16	0.21	0.17	0.11	0.19
C.E.C.	1.14	1.15	0.88	0.47	0.11 (0.71)
Base sat. %	119.29	83.47	81.81	100.0	78.87
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	7.0	7.2	7.0	7.0	6.6
Ohms R 60°F	3039	2735	2330	5056	3546
Organic matter					
% Carbon	0.15	0.23	0.11	0.05	0.04
% Nitrogen	0.02	0.02	0.02	0.01	0.01
C : N	7.5	11.5	5.5	5.0	4.0
Extractable cations expressed as % of total exchangeable bases					
Na	2.20	1.73	6.81	4.25	4.22
K	5.88	7.82	13.63	17.02	18.3
Ca	80.14	72.17	60.22	55.31	29.57
Mg	11.76	18.26	19.31	23.40	26.76
Base sat. %	119.29	83.47	81.81	100.00	78.87
Clay minerals					
C.E.C./100 gm. Clay	28.5	23.46	15.17	9.59	10.0

PROFILE No.:	**84 Ofazi series**
LOCATION :	**Lat. 33°39' Long. 18°46' on farm Graafwater**
SITE :	**Gently sloping granite pediment 1% slope**
ELEVATION :	**600 ft.**
PARENT MATERIAL	**Aeolian sand on granite**

Horizon	Depth inches	
A_1 Ochric	0–9	10YR 4/3 Brown to dark brown (10YR 5/3 Br.Dry) sand; loose, apedal; gradual transition.
AC	9–18	10YR 5/4 Yellowish-brown (10YR 6/4 Br.Y.Dry) fine sand; loose, apedal, gradual transition.
C_1	18–32	10YR 5.5/6 Yellowish-brown (10YR 7/6 Y.Dry) fine sand; soft to loose, apedal; gradual transition.
C_2	32–57	10YR 7/6 Yellow (10YR 8/6 Y.Dry) fine sand; soft, apedal, gradual transition
C_3	57–82	10YR 8/8 Yellow sand; loose, apedal; clear transition.
$IIIC_{ACH}$	82–88	10YR 8/6 Yellow gravelly coarse sand; loose, apedal; abundant hard laterite nodules; abrupt tonguing transition
$IIIC_{5t}$	88–100	10YR 6/8 Brownish-yellow sandy clay loam; many distinct coarse 2.5YR 5/8 red mottles, going to 2.5YR 8/2 white and N 8/0 white mottled many distinct coarse 10YR 6/8 brownish yellow and 2.5YR 4/8 red at 100"; firm, apedal; occasional distinct 10YR 6/8 brownish yellow clay skins; tongues of C_4 like material extend into this giving it patches of sandy loam in amongst the sandy clay and sandy clay loam matrix.

Lab. No.	B7383	B7384	B7385	B7386	B7387	B7388
Depth inches	0–9	9–18	18–32	32–57	57–82	88–100
Horizon	A1	AC	C_1	C_2	C_3	$IIIC_{5t}$
Particle size distribution %						
Gravel separate 2mm.	1.1	0.0	0.0	0.0	0.0	2.5
C.sand 2–.5mm.	24.6	17.0	19.2	23.9	28.8	22.7
M.sand .5–.2mm.	25.3	22.4	22.8	23.6	19.0	14.2
F.sand .2–.02mm.	47.1	58.3	55.6	49.6	50.4	25.9
Silt .02–.002mm.	1.4	2.4	2.1	1.3	0.8	2.0
Clay .002mm.	3.0	2.4	2.6	3.3	3.2	37.4
Extractable cations meq./100 gm.						
Na	0.03	0.03	0.03	0.03	0.03	0.08
K	0.05	0.04	0.04	0.04	0.04	0.12
Ca	0.41	0.32	0.20	0.12	0.11	0.46
Mg	0.0	0.00	0.10	0.05	0.06	1.13
C.E.C.	1.22	0.84	0.56	0.55	0.49	2.42
Base sat. %	40.16	46.42	66.07	43.63	48.97	73.96
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	5.5	6.1	6.3	6.5	6.6	5.8
Ohms R 60°F	4005.2	10000	8853.5	10000	8959.0	3583.0
Organic matter						
% Carbon	0.20	0.12	0.08	0.05	0.08	0.08
% Nitrogen	0.03	0.01	0.01	0.01	0.01	0.01
C : N	6.67	12.0	8.0	5.0	8.0	8.0
Exchangeable cations expressed as % of total exchangeable bases						
Na	2.46	3.57	5.35	5.45	6.12	3.31
K	4.09	4.76	7.14	7.27	8.16	4.95
Ca	33.60	38.09	35.71	21.81	22.41	19.80
Mg	0.0	0.0	17.85	9.09	12.24	46.69
Base sat. %	40.16	46.42	66.07	43.63	48.97	73.96
Clay minerals						
C.E.C./100 gm. clay	40.66	35.0	21.54	16.67	15.31	6.47
Clay minerals						Kaol.v.s.

Huguenot is an example of a wine grape vineyard producing 45 tons per morgen or 11 tons per 900 vines, under irrigation amounting to only 9" per annum (a total precipitation of about 35" per annum). In Noorder Paarl the soil is used for table grape production as well as wine grapes. At Sodendal where there is a lack of water for irrigation, vines are little better than those on Kanonkop series in the precincts.

Associated soils and mapping

Ofazi can be found associated with all the soils in the survey (geographically). When found in flat areas it is often in complex association with Maputa, the latter occupying the slightly more lower lying areas. On the 60ft. terrace level a complex association of these two with terrace gravels and fine sand occurs with various grades of stoniness from over 50% gravel to only rare gravels. At Huguenot the silt plus clay nearly reaches 10% in some members of Ofazi higher upslope becoming more sandy down slope.

West of Paardeberg there occur a number of terraces in an Ofazi individual. These terraces were found to have at their outer edges (down slope) a soil which resembled Misgund series (Prof.231)as well as highly organic soils. No acceptable explanation for these phenomena - the terraces as well as the high clay content of its tip can be advanced. Once theterrace is formed, or a clay rich bank formed the nature of the soil may be explained. Water dams up against the heavy textured soil and causes it to support a dense vegetation which decays to form peatlike accumulations. Because the tips of the terraces are perpendicular to slopedirection it was at first thought selective colluviation was a possible cause, this can however be discounted for as the surrounding soils are not colluvial but aeolian. More likely the solution lies in the nature of wind deposition, possibly augmented by lateral clay illuviation. More study of the phenomena is needed before a theory can be advanced. ~~Profile 231 is a description of a pedon in the tip of one of the smaller terraces.~~

Ofazi series definition

Ofazi has immediately below the A_1 or Ap a uniform colour with hues of 10YR and values 4 to 6 with chromas of 4-8. It has an A_1 - C profile with less than 20% silt + clay in the C and more than 40% fine sand.

The light textured phase described in this ~~soil~~ survey has less than 10% silt plus clay throughout the solum to a depth of at least 50 inches, it has increasing values and chromas below the A_1 (unless the horizon below the A_1 has a chroma of 6 or more and a value of 7 or more when this is not necessary) the value reaches at least 7 and chroma at least 6 within the solum above the first major discontinuity.

It may yet be found that this light textured phase should be relegated to the higher status of a new series. The two phases do not for example, occupy the same great group, have markedly different moisture holding capacities and thus probably different soil climates (yearly moisture tension curves).

MAPUTA SERIES

Maputa is limited in occurrence. It is found in bottomland wet positions in geographically associated with Ofazi and in complex association with Ofazi. Profile 83 is representative.

Site

It is found in positions which receive groundwater from higher lying soils, either in bottomlands or on lower slopes in areas of aeolian sand. Maputa is also found directly behind the clay banks in the terraces found associated with Ofazi west of Paardeberg (see Ofazi series).

Parent Material

Aeolian sand and alluvium as for Ofazi series forms Maputa in wet positions.

Morphology

Maputa is a deep, grey fine sand with a slightly darkened surface horizon. The sand is comparable with Ofazi in depth, usually over 6 ft. deep but has chromas less than 3 and is often mottled within 40 inches of the surface.

Chemical properties

The soil is acid and has a low base saturation. The exchange capacity of the AC is lower than what would be expected. This has resulted in the low C.E.C./100 gm. clay of 6.66 whereas the upper and lower horizons are over 18. Presuming 18 to be the correct value the C.E.C. becomes 0.6 meq./100 gm., the base saturation 31.67% and exchangeable calcium 28.67% - figures were in keeping with the morphology site and parent material of the soil. Exchangeable sodium and magnesium were either undetectable or very low in the upper 60 inches.

The C_1 appears to have A_2 properties chemically as well as morphologically and the C_2 to have B properties - it has accumulated sodium magnesium and potassium ions.

Carbon percentages as well as C:N ratios are low, even in the Ap.

Genesis and classification

An albic horizon would appear to be forming between 40 inches and 60 inches, the horizon below receiving the eluviated salts. This soil is cultivated however so the higher base status of the Ap and AC may be attributed to fertilisation rather than to the leaching of the 40-60 inch horizon resulting in its lower base status.

PROFILE No.:	83 Naputa series
LOCATION :	Lat. 33°37' Long. 18°46' on farm Uitkyk
SITE:	Lower pediment slope 3% slope
ELEVATION :	500 ft.
PARENT MATERIAL:	Aeolian sand on granitic material

Horizon	Depth inches	
Ap Ochric	0-23	10YR $^{5}/_{2}$ grey brown (10YR $^{6}/_{2}$ lt.Br.Gr.Dry) sand; loose, apedal; clear transition
AC	23-40	10YR $^{7}/_{2}$ light grey sand; rare fine 7.5YR $^{5}/_{8}$ strong brown mottles; loose, apedal; gradual transition.
C_1	40-60	10YR $^{8}/_{2}$ white sand; loose, apedal; gradual transition.
C_2	60-86	10YR $^{7}/_{3}$ very pale brown sand; common fine distinct 7.5YR $^{5}/_{8}$ strong brown mottles; loose, apedal; clear transition
IIC_3	86-100	2.5Y $^{7}/_{4}$ pale yellow sandy loam; many prominent large 7.5YR $^{5}/_{8}$ strong brown mottles, many distinct 5YR $^{5}/_{1}$ and $^{6}/_{1}$ grey large mottles along old root channels; few 5YR $^{5}/_{8}$ yellowish red root channels; friable, slightly sticky, apedal. This material continues to 150 inches plus, becoming more grey with depth.

Lab. No.	B7477	B7478	B7479	N7480	B7481
Depth inches	0-23	23-40	40-60	60-86	86-100
Horizon	Ap	AC	C_1	C_2	IIC_3
Particle size distribution					
Gravel separate 2mm.	0	0	0.4	0	1.1
C. sand 2-.5mm.	20.3	15.7	16.0	18.6	15.6
M. sand .5-.2mm.	27.5	26.4	27.9	27.4	26.9
F. sand .2-.02mm.	49.0	54.4	53.4	51.7	44.5
Silt .02-.002mm.	1.1	1.3	0.8	0.9	1.5
Clay .002mm.	3.8	3.3	2.3	2.4	12.1

Extractable cations meq./100 gm.					
Na	0.00	0.00	0.00	0.02	0.04
K	0.04	0.02	0.02	0.04	0.11
Ca	0.17	0.17	0.05	0.04	0.17
Mg	0.03	0.00	0.00	0.04	0.52
C.E.C.	0.72	0.22	0.42	0.24	1.33
Base sat. %	33.33	86.36	16.66	58.33	63.15
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	5.1	5.8	6.0	6.3	5.3
Ohms R 60°F	4268	9603	6402	5868	2988
Organic matter					
% Carbon	0.16	0.05	0.03		
% Nitrogen	0.02	0.01	0.01		
C:N	8.0	5.0	3.0		
Extractable cations expressed as % of total extractable bases					
Na	0.00	0.00	0.00	8.33	3.00
K	5.55	9.09	4.76	16.66	8.27
Ca	23.61	77.27	11.9	16.66	12.78
Mg	4.16	0.00	0.00	16.66	39.09
Base sat. %	33.33	86.36	16.66	58.33	63.15
Clay minerals					
C.E.C./100 gm.clay	18.94	6.66	18.26	10.0	10.99

Little organic matter accumulation has taken place. The lower chromas than Ofazi are caused by the wetter nature of the site the soil is found in, iron has been segregated and removed to the extent that colour of the soil is that of the primary sand grains.

Profile 83 is an Orthic Psammaquent.

Maputa was first described in Zululand by Hensley et al and defined by Loxton and Macvicar(1965).

Physical characteristics and land use

The soil is rapidly permeable but the site has impeded drainage. Maputa has a variable irrigable value depending on site, normally a B_2 or B_1, before being intensively irrigated it must be drained, especially where associated with clay-banks.

West of Paardeberg the Ofazi-Maputa-clay bank complex is used for wheat production. Wheat does very poorly on Maputa and very well on the clay bank. The Ofazi-Maputa complex in the lower lying area here is left virgin whereas above Huguenot on the 60 ft. terrace level wine grapes are grown. X

Associated soils and mapping

Seldom does Maputa occur to any extent alone, more normally it occupies less than 50% of the area demarcated as Ofazi - usually less than 20%

Maputa series definition

It has an A_1/Ap-C profile having less than 10% silt plus clay in the upper part of the C values of 5 or more and chromas of 3 or less in hues of 10YR (10YR$^4/_2$ permitted) pH values less than 6.5 with more than 40% fine sand and more find sand than medium plus coarse sand. (Loxton and Macvicar)

ROCKLANDS SERIES

Of limited occurrence mainly in the south western corner of the area studied, Rocklands is represented by profiles 210 and 85.

Site

Site is limited to more or less flat concave bottomland sites.

Parent material

From its site it would be expected that Rocklands had formed in alluvium, this is especially the case with profile 210. The silt figures are however remarkably low for alluvia especially since the rocks from both Klipheuwel and Malmesbury formations are quite high in silt content (see analysis Swellengift and Swartland series respectively). Profile 85 is situated in an area of aeolian sands. The peculiar particle size distribution in profile 85 is thought to be due to the admixture of aeolian sand with the alluvium. Since the distribution in profile 210 is essentially similar to profile 85 it is postulated that the material from which it was formed is a mixture of aeolian sand and alluvium. (By the term "aeolian sand" the writer includes both sands transported over large distances as well as locally wind sorted materials.)

A prerequisite for the formation of Rocklands is that such materials in which it is formed be fairly coarse textured (no heavier than sandy clay loam) and must contain or receive form external sources an adequate supply of bases, most often this is attained via salts in the water table.

Morphology

Profile 85 is shallower than the normal profile. A deep (about 36 inches) brown fine sand abruptly overlies a light brownish grey fine sandy clay loam extremely hard when dry, firm when moist and sticky when wet. This B_2 horizon is coarse prismatic mottled olive brown to reddish brown. The prism surfaces are usually darker coloured than the interiors and are often coated with a layer of fine sand which has fallen down the fissures from the A upon contraction (drying) of the B_2. The B shows evidences of wetness either as mottling or gley colours. The B overlies a gleyed C of sandy loam texture.

Chemical properties

The pH increases with depth from acid in the A to slightly alkaline in the B and C. This is reflected in the exchangeable cation figures. Base saturation percentage is lowest in the A_1/Ap, increasing slightly in the A_2 and then by more than 20% to an almost fully satura-

PROFILE No.:	210 Rocklands series
LOCATION :	Lat. 33°43' Long. 18°46' on farm Rocklands
SITE :	Bottomland
ELEVATION :	225 ft.
PARENT MATERIAL :	Alluvium Klipheuwel sandstone provenance

Horizon	Depth inches	
Ap Ochric	o-19	10YR5/4 yellowish brown (10YR7/2 lt.Gr.Dry) fine sand; soft to slightly hard, apedal; gradual transition.
A_2	19-39	10YR5/3 brown (10YR7/2 lt.Gr.Dry) fine sand; soft to slightly hard, apedal; abrupt wavy transition in places extending 18 inches into the next horizon.
$IIB_{2t(g)}$ natric	39-52	2.5Y6/2 light brownish grey to 2.5Y6/4 light yellowish brown and to 2.5Y7/6 yellow with depth, fine sandy loam; firm, weak very coarse prismatic; many distinct fine 5YR3/2 dark reddish brown mottles; frequent fine soft black iron-manganese concretions; gradual transition
IIB_3	52-62	10YR5/6 yellowish brown fine sandy loam; many faint medium 10YR5/4 yellowish brown mottles; firm, apedal; clear transition
$IIIC_{2g}$	62-82	2.5Y5/2 grayish brown fine sandy clay loam; many distinct fine 5YR4/8 yellowish red mottles; slightly firm, apedal to weak blocky; abrupt transition.
$IVC_{3(g)}$	82-96	10YR6/3 pale brown sand; common medium distinct 10YR5/8 yellowish brown, few medium to large faint 10YR6/2 light brownish grey mottles; soft, apedal.

Lab. No.	B7482	B7483	B7484	B7485	B7486
Depth inches	o-19	19-39	39-52	52-62	62-82
Horizon	Ap	A_2	IIB_{2t}	IIB_3	$IIIC_g$
Particle size distribution %					
Gravel separate 2mm.	0.	0.5	0	0	0
C. sand 2-.5mm.	4.6	4.6	4.3	1.5	1.0
M. sand .5-.2mm.	16.0	15.4	17.0	10.2	6.3
F. sand .2-.02mm.	73.0	73.8	57.6	68.4	63.3
Silt .02-.002mm.	2.8	3.6	5.4	4.1	10.1
Clay .002mm.	3.1	3.4	16.4	16.1	20.6
Extractable cations meq./100 gm.					
Na	0.04	0.04	0.47	0.43	0.79
K	0.07	0.04	0.14	0.12	0.12
Ca	0.18	0.22	2.15	1.78	2.02
Mg	0.10	0.04	3.16	6.01	3.83
C.E.C.	0.79	0.47	6.o2	5.64	6.37
Bas. sat. %	49.36	72.34	98.33	147.87	106.12
$CaCO_3$ eq.	0.0	C.0	0.0	0.3	0.0
pH 1:1 H_2O	5.6	6.5	6.9	7.0	7.2
Ohms R 60°F	2348	5335	7469	9603	9070
Organic matter					
% Carbon	0.14	0.04	0.04		
% Nitrogen	0.02	0.01	0.02		
C : N	7.0	4.0	2.0		
Exchangeable cations expressed as % of total exchangeable bases					
Na	5.06	8.51	7.80	5.15	11.68
K	8.86	8.51	2.32	1.43	1.77
Ca	22.78	46.80	35.71	21.34	29.88
Mg	12.65	8.51	52.49	72.06	56.65
Base sat. %	49.36	72.36	98.33	147.87	106.12
Clay minerals					
C.E.C./100 gm. clay	25.48	13.82	36.70	35.03	30.92
Minerals identified			Kaol.v.v.s. Ill.v.v.s. Mont.v.v.s.	Kaol.v.v.s. Ill.v.s. Mont.v.v.s.	Kaol.v.v.s. Ill. med. Mont.med.

PROFILE No.:	85 Rocklands series
LOCATION :	Lat. 33°39' Long. 18°48' on farm Toekoms
SITE :	Bottomland
ELEVATION :	550 ft.
PARENT MATERIAL:	Alluvium aeolian sand-tertiary sandstone provenance (possibly weak granite influence)

Horizon	Depth inches	
A_1 Ochric	0-9	10YR5/3 brown (10YR6/2 lt.Br.Gr.Dry) fine sand; frequent 5YR4/6 yellowish red "rusty" root holes; loose, apedal; gradual transition
A_2	9-20	7.5YR6/4 light brown (7.5YR8/4 Pink Dry) fine sand; abundant rusty root holes (5YR4/6 yellowish red) loose, apedal; occasional laterite fragments at the lower boundary; abrupt transition.
IIB_{2tg} natric	20-33	10YR6/2 light brownish grey fine sandy clay loam; frequent 7.5YR3/2 dark brown coatings on ped surfaces, also 7.5YR6/2 pinkish grey, 5GY5/1 greenish grey, 2.5Y6/2 light brownish grey and 2.5Y5/2 grayish brown; mottled many fine distinct 5Y4/4 olive, abundant fine distinct 7.5YR5/8 strong brown in upper four inches; extremely hard, moderate very coarse prismatic breaking to very coarse blocky; prominent 10YR2/2 very dark brown and 10YR5/1 gray clay skins; gradual to clear transition.
IIB_{3g}	33-48	2.5Y5/2 greyish brown ped surfaces 10YR7/2 light grey interiors; fine sandy loam; few distinct medium to many distinct fine (in the upper parts) 5Y5/4 olive and few diffuse 5GY6/1 greenish grey mottles; extremely hard, weak to moderate coarse blocky; occasional 5GY6/1 greenish grey clay skins, occasional 10YR3/3 dark brown clay-organic matter accumulations along old root channels; gradual transition.
IICg	48-63	10YR7/2 light grey fine sandy clay loam; many distinct medium 2.5Y5.5/6 olive yellow, few faint fine 5GY6/1 greenish grey to 5Y6/1 light grey to grey mottles; very firm, weak blocky tending to weak medium prismatic; occasional 5GY6/1 greenish grey clay skins down root channels.

Lab. No.	B7389	B7390	B7391	B7392	B7393
Depth inches	0-9	9-20	20-33	33-48	48-63
Horizon	A_1	A_2	IIB_{2tg}	IIB_{2g}	IICg
Particle size distribution %					
Gravel separate 2mm.	0.0	1.1	3.6	0.0	0.01
C. sand 2-.5mm.	10.6	9.2	4.1	3.5	5.4
M. sand .5-.2mm.	32.8	28.3	20.1	17.4	17.8
F. sand .2-.02mm.	52.7	60.6	47.2	57.4	53.4
Silt .02-.002mm.	1.2	1.1	1.8	3.8	2.4
Clay .002mm.	4.5	3.4	29.3	19.4	23.0
Extractable cations meq./100 gm.					
Na	0.12	0.11	2.58	1.79	1.33
K	0.05	0.03	0.08	0.09	0.07
Ca	0.03	0.03	1.07	0.65	0.54
Mg	0.16	0.12	5.49	4.37	4.10
C.E.C.	0.97	0.47	9.58	7.03	6.48
Base sat. %	37.11	61.70	96.24	98.15	93.20
Saturation extract soluble cations meq./100 gm					
Na			0.54	0.67	0.65
K			0.00	0.00	0.00
Ca			0.05	0.03	0.07
Mg			0.00	0.05	0.02
$EC10^3$/cm.25°C			4.50	9.57	5.64
$CaCO_3$ eq	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	6.3	6.3	7.2	7.3	6.5
Ohms R 60°F	3704	3478	395	326	389
Organic matter					
% Carbon	0.18	0.09	0.10	0.05	0.03
% Nitrogen	0.03	0.003	0.02	0.01	0.004
C : N	6	30	5.0	5.0	7.5
Exchangeable bases expressed as % of total exchangeable bases					
Na	12.37	23.4	21.29	15.93	10.50
K	5.15	0.38	0.83	1.28	1.08
Ca	3.09	6.38	10.64	8.82	7.25
Mg	16.49	25.33	57.30	61.45	62.96
Base sat. %	37.11	61.70	96.24	98.15	93.2
Clay minerals					
C.E.C./100 gm. clay	21.55	13.82	32.69	36.23	28.17
Minerals identified			Kaol.v.v.s. Mont.v.s.	Kaol.v.v.s. Mont. s	Kaol.v.v.s. Mont. vs

ted B_2. The C is either saturated or nearly so. Profile 85 situated in a granite-aeolian sand provenance, is very low in exchangeable calcium, calcium being lower than sodium throughout the profile. The basic trend in profile 85 is similar to that of profile 210 however.

Calcium plus hydrogen dominate the exchange complex in the A horizons, in the B and C however exchangeable magnesium exceeds 50% of the exchange capacity. The exchangeable sodium figures show a strange distribution, they are lowest in the A_1 and are higher in the A_2 than in the B_2. In profile 85 Exch.Na is 23.4% in the A_2! Because it is only 51.7% base saturated however the horizon is acid and the resistance is over 3,000 ohms.

The C.E.C./100 gm. clay in both profiles is lowest in the A_2 and highest in the B horizons.

Carbon percentage as well as C/N ratios are low throughout the profile. C/N ratios of 6 and 7 for the A_1 are abnormally low for the surface horizons suggesting a high degree of decomposition of the organic matter present.

Genesis and classification

The most striking feature about the analyses of Rocklands is in the nature of the A_2: it is more saturated with bases, has higher exchangeable sodium, potassium, calcium and magnesium than the A_1 yet it has the lower C.E.C./100 gm. clay of the two not in proportion with the lower organic matter content. Exchangeable sodium one of the most mobile cations in soils is moreover higher in the A_2 than the B. It has thus both the properties of illuvial and eluvial horizons.

It is thought that laterally moving groundwater has brought salts, chiefly of sodium, into the A_2. Under the influence of high sodium and magnesium concentrations on the clay complex both dispersion and leaching of the clay into the B horizon, and partial destruction of the lattice so lowering the exchange capacity of the clay in the A, have taken place. At the same time vertical leaching of the profile has resulted in the increase in base saturation with depth as well as the increase in exchangeable magnesium with depth. Profile 210 is cultivated, the high calcium figures in the A are probably due to liming, in profile 85 it can be seen that leaching has reached a stage where the exchangeable calcium maximum is in the B_2. Movement of clay into the B has produced an abrupt textural change from an albic A_2 to a natric B_2 (aided by a lithological discontinuity already present).

Profile 85 in a higher rainfall area receives considerably more seepage water than profile 210 this is reflected in the fact that the B_2 in profile 85 is strongly gleyed while in 210 it is only in the C that strong gley is encountered. The lower calcium/sodium ratio of the granites compared with the sedimentary rocks of both Klipheuwel and Malmesbury formations, is reflected in the nature of the two profiles receiving runoff from these two separate provenances. Exchangeable sodium in profile 85 is greater than exchangeable calcium throughout the profile but in profile 210 situated in a sedimentary rock provenance calcium exceeds sodium throughout the profile.

Rocklands is a natrustalf probably an aquic natrustalf. Profile 85 is a natraqualf but profile 210 which is the more normal example shows wetness deeper than required for the aqualf sub-order.

Morphologically and chemically Rocklands might be called a degraded alkali soil (de Sigmond) or a solodised solonetz. Since these names imply a particular type of genesis the writer hesitates to apply them as Rocklands is developing towards a solonetzic soil not from a solonetz to a solod.

Physical characteristics and land use

While the A horizons are rapidly permeable the B_2 is slowly to very slowly permeable. These soils receiving runoff in winter are completely waterlogged unless drained during the rainy season. By standards used by the Soils Research Institute the deep members (which are more common) have irrigable values of B_2 to B_1 depending on the proximity to any drainage lines. Profile 85 is a B_2/C soil. X

For the most part Rocklands is not cultivated, it supports a sparse grass and Port Jackson-Rooikrantz (Australian Acacias) vegetation. Recently the trees are being uprooted and the soil prepared for vines. Below profile 85 for example where a dense Port Jackson thicket was, trellised grapes are to be planted.

Associated soils and mapping

Rocklands occurs in well defined bottomlands. It is generally the sole occupier of these bottomlands though it is sometimes associated with deep fine sands the sites of which suggest alluvial origin but which are suspected to have been wind deposited. These sands usually fit into the definition of Maputa series.

Originally two phases were mapped, viz. deeper and shallower than 20". However it was found that generally Rocklands is deeper than 36" so that the differentiation was abandoned.

Rocklands series definition

A_1/Ap less than 10% silt + clay. More than 40% fine sand and more fine sand than coarse + medium sand.

A_2 equally coarse as the A_1 with an abrupt transition to the B_2

B_{2t} Very coarse prismatic with less than 35% clay but more than twice the clay percentage of the A_2. Ped surfaces must have darker colours than ped interiors. pH less than 7.5 Evidence of wetness - mottles with chromas of 2 or less or base chromas of 2 or less. Must fall within the definition of a natric horizon (U.S.D.A. 1961)

B_3/C A B_3 may or may not be present. The C is gleyed somewhere within it. A B_3 with a gradual transition to a C with rock structure is not permitted within the definition.

LANGVLEI SERIES

Of wide but limited occurrence, Langvlei is limited to the bottomlands in Malmesbury sedimentary rock provenances. It is only of significant area in the south-eastern part of the area where Swartland is the dominant soil. Langvlei is represented by profiles 47A and 32.

Site

It is limited to bottomland sites where active deposition of materials other than salts no longer takes place. The series-proper is found only in well developed bottomlands. In the minor colluvial valleys a better drained variant occurs which, through mapped as Langvlei, does not conform to the series definition.

Parent material

Langvlei formed in fine textured alluvial and alluvial-colluvial deposits. A variety of parent materials occur. The common factors in all cases are coarse textured surface deposits overlying clayey deposits. The clays may overly coarser materials or may overly weathered rock at depth. In all cases, high salt concentrations are important constituents in the formation of this soil. A water table usually occurs below 50 inches.

The lithological composition of Langvlei is between that of Swartland and that of Daljosophat with regard to degree of weathering into primary particles. Langvlei formed in a mixture of clay and rock fragments in various degress of weathering whereas no rock fragments other than those highly resistant to weathering form parent materials for Daljosophat. Daljosophat moreover, occurs in provenances where the rocks are schistose so that less accumulation of salts occurs than in Langvlei.

It is difficult to compare Daljosophat and Langvlei in terms of chronological age for the streams in Langvlei are largely still insequent young streams. Since these streams are not as near maturity as the Berg river, comparisons in height above present base levels are not valid. Cases where Langvlei grades into Daljosophat in bottomlands near the Berg river point to them having comparable chronological age. Langvlei is younger - similar materials to those Langvlei formed in have been found overlying terrace clays but not vice-versa. The difference in age is not considered significant.

Morphology

A coarse textured A_1/Ap abruptly overlies a coarse prismatic B_2 sandy clay horizon. The B_2 is invariably yellowish brown with dark brown clay skins. It is sometimes mottled and has carbonate concretions in the lower part.

PROFILE No.: 47A Langvlei series

LOCATION : Lat. 33°42' Long. 18°50' on the farm Klein Langvlei

SITE : Bottomland

ELEVATION : 300 ft.

PARENT MATERIAL : Alluvium Malmesbury graywacke provenance

Horizon	Depth inches	
Ap Ochric	0-14	10YR 4/2 dark greyish brown (10YR 6/2 lt.Br.Gr.) fine sandy loam; hard, apedal; rare iron concretions; abrupt transition
IIB_{21t} natric	14-28	10YR 4/3 brown to dark brown ped surfaces, 10YR 5/6, 5/4 yellowish brown interiors, sandy clay; frequent distinct to faint fine 7.5YR 5/6 strong brown mottles, extremely hard, strong very coarse prismatic breaking to fine and medium blocky; abundant soft iron-manganese nodules; occasional carbonate concretion; gradual transition.
IIB_{22t}	28-48	10YR 5/8, 5/4-yellowish brown, 2.5Y 6/4 light yellowish brown, 7.5YR 5/6 strong brown sandy clay loam; few faint fine 4Y 6/1, occasional large 5Y 6/2 light olive grey mottles; very hard, moderate very coarse prismatic breaking to coarse blocky; occasional soft black iron-manganese concretions; clear transition.
$IIIC_1$	48-72	7.5YR 5/6 strong brown gravelly sandy clay loam; few faint large 10YR 6/6 brownish yellow mottles; firm, apedal to weak fine blocky; abundant quartz and graywacke gravel; clear transition.
IVC_{2g}	72 plus	5Y 6/2 light olive grey fine sandy loam; many large distinct 7.5YR 5/8 strong brown, few faint fine 5GY 6/1 and 5G 6/1 greenish grey mottles; friable, apedal.

Lab. No.	B7487	B7488	B7489	B7490	B7491
Depth inches	0-14	14-28	28-48	48-72	72-84
Horizon	Ap	IIB_{21t}	IIB_{22t}	IIIC	IVC_{2g}
Particle size distribution %					
Gravel separate 2mm.	0.2	0.0	0.4	28.4	0.6
C. sand 2-.5 mm.	9.3	5.7	5.3	43.0	8.0
M. sand .5-.2mm.	14.1	5.9	11.3	9.3	16.8
F. sand .2-.02mm.	53.3	31.7	43.3	14.3	50.2
Silt .02-.002mm.	12.1	20.1	7.5	3.5	8.5
Clay .002mm.	10.8	38.1	35.8	31.0	17.7
Extractable cations meq./100 gm.					
Na	0.28	0.95	1.20	2.37	1.81
K	0.25	0.34	1.34	0.20	0.12
Ca	1.57		2.34	2.32	1.00
Mg	0.81		8.04	6.36	2.74
C.E.C.	3.27	11.40	10.91	8.40	4.88
Base sat. %	88.99	100 plus	109.25	133.92	116.18
$CaCO_3$ eq.	0.0	$MgCO_3$ present	0.0	0.0	0.0
pH 1:1 H_2O	6.1	7.3	7.6	8.4	8.5
R 60°F Ohms	8536	534	481	534	480
Organic matter					
% Carbon	0.39	0.10			
% Nitrogen	0.05	0.004			
C : N	7.8	25.0			
Extractable cations expressed as % of total exchangeable bases					
Na	8.5	8.33	10.06	21.06	31.92
K	7.65	2.98	2.85	1.77	2.11
Ca	48.01		19.63	20.62	17.63
Mg	24.77	$MgCO_3$ present	67.44	56.53	48.32
Base sat. %	88.99	100 plus	109.25	133.92	116.18
Clay minerals					
C.E.C./100 gm. clay	30.27	29.22	30.47	27.09	27.57
Minerals identified		Kaol.v.v.s.	Kaol.v.v.s.	Kaol.v.v.s.	Kaol.v.v.s.
		Ill.Med	Ill.v.v.s.	Ill.v.v.s.	Ill.v.v.s.
		Mont.med.	Mont.v.v.s.	M.L.v.v.s.	M L. v.v.s.

PROFILE No.: 32 Langvlei series
LOCATION : Lat. 33°41' Long. 18°52' on the farm Langvlei
SITE : Bottomland
ELEVATION : 390 ft.
PARENT MATERIAL Alluvium Malmesbury graywacke provenance

Horizon	Depth inches	
Ap Ochric	0-10	2.5Y 5/4 light olive brown (2.5Y 7/3 light grey to pale yellow Dry) loamy fine sand; hard, apedal; occasional iron shot concretions; abrupt transition
IIB_{21t} Natric	10-20	10YR 5/8 yellowish brown (Moist and dry) sandy clay; extremely hard, moderate coarse prismatic breaking to moderate coarse blocky; prominent 10YR 4/3 brown clay skins; clear transition
$IIIB_{22t}$ Calcic	20-34	10YR 5/6 yellowish brown (Moist and dry) gravelly fine sandy clay loam; extremely hard, weak blocky; abundant large calcium carbonate concretions; moderately developed 10YR 4/6 brown clay skins; gradual transition.
IV B_3	34-52	10YR 6/6 brownish yellow fine sandy clay loam; common fine faint 10YR 5/8 yellowish brown mottles; firm, weak blocky; occasional fine sub-angular quartz, abrupt transition
V C(W.T.)	52-62	(From previous description - water table at time of sampling had risen to 52") 10YR 7/8 yellow gravelly clay, common diffuse yellow weak fine distinct 5GY 6/1 greenish grey mottles; abundant sub-angular quartz gravel and small stones
W.T.	62 plus	Free water

Lab. No.	B7439	B7440	B7441	B7442
Depth inches	0-10	10-20	20-34	34-52
Horizon	Ap	IIB_{21t}	$IIIB_{22t}$	IVB_3
Particle size distribution %				
Gravel separate 2mm.		0.6	27.2	4.5
C. sand 2-.5mm	15.9	7.4	4.0	6.4
M. sand .5-.2mm.	13.5	8.6	8.5	13.8
F. sand .2-.02mm.	58.7	37.2	43.7	48.3
Silt .02-.002mm.	4.9	5.0	13.4	9.5
Clay .002mm.	6.2	42.7	26.5	22.8
Extractable cations meq./100 gm.				
Na	0.36	5.15	6.70	6.10
K	0.23	0.37	0.24	0.27
Ca	1.06	2.36	$CaCO_3$ present	
Mg	0.41	4.56		$MgCO_3$ present
C.E.C.	2.01	10.11	11.13	7.57
Base sat. %	102.5	123.0	100 plus	100 plus
Saturation extract soluble cations meq./100gm.				
Na		3.07	5.61	0.27
K		0.00	0.04	0.00
Ca		0.16	0.36	0.20
Mg		0.07	0.00	0.00
$EC10^3$/cm.25°C		15.77	17.83	11.35
$CaCO_3$ eq.	0.0	0.0	5.4	$MgCO_3$ present
pH 1:1 H_2O	6.1	8.1	8.8	8.9
R 60°F Ohms	999	122	81	146
Organic matter				
% Carbon	0.45	0.22	0.07	0.02
% Nitrogen	0.05	0.04	0.02	0.01
C : N	9.0	5.5	3.5	2.0
Exchangeable cations expressed as % of total exchangeable bases				
Na	13.8	16.72	9.65	
K	11.16	2.97	1.79	3.56
Ca	51.45	17.68		
Mg	19.9	36.09		
Base sat. %	102.5	123	100 plus	100 plus
Clay minerals				
C.E.C./100 gm. clay	32.41	23.67	42.00	33.2
Minerals identified		Kaol. v.v.s. Ill. m.s Mont. med.	Kaol. v.v.s. Ill. s. Mont. s.	Kaol. v.v.s. Ill. v.v.s. Mont. v.v.s.

With depth, the B_2 becomes lighter textured and mottling becomes more common. A clear transition separates the B from the C. Somewhere within the C it is gleyed.

Although lithological discontinuities exist within the solum, no fine stratifications occur in the A and B horizons. All traces of stratification have been obliterated by soil forming processes, in fact the prisms are often continuous through lithologically discontinuous horizons.

Black, shot-size, soft iron-manganese concretions are commonly found in the B. Their significance is not known.

Chemical properties

Below the A, the soil contains free salts. While the A is acid, the B is alkaline; pH in the lower part of the B often approaches pH9. These high pH values are caused by the high exchangeable sodium percentages.

Exchangeable calcium or calcium plus hydrogen exceeds 50% of the exchange capacity of the Ap thus keeping the pH low (and resistance high) notwithstanding the high exchangeable sodium content. The sudden drop in exchangeable calcium and increase in magnesium from the A to the B coincides with the increase in pH (and resistance decrease). Exchangeable sodium is higher than 15% in some part of the B. Exchangeable sodium plus exchangeable magnesium are greater than 50% of the total exchangeable bases/exchange capacity throughout the B.

The leaching pattern of salts may be seen in the distribution of cations through the profile. The peak of sodium accumulation is below that of magnesium, which is below that of calcium; calcium in turn being below potassium. In profile 32 it can be seen that accumulations of magnesium carbonates are below those of calcium carbonates.

Profile 47A is an example chosen from a slightly higher lying area in which the surrounding soils are not as salty as those surrounding profile 32. This is reflected in the chemical properties, profile 32 is both more saline and more alkaline than profile 47A. Within the pit 47A the lateral leaching pattern was dramatically demonstrated. In the side of the profile higher upslope an almost indurated caliche layer was encountered, whereas in the side sampled only rare calcium carbonates were found (the analysis indicates only the presence of magnesium carbonates.)

Genesis and classification

Incomplete leaching of sodium, magnesium and calcium in a vertical as well as lateral direction has resulted in zones of accumulation with sodium the deepest, and the greatest in the lower part of the bottomland, magnesium having moved less far and calcium and potassium least far. Potassium appears to have not moved at all and instead shows a relative accumulation in the A. Salts, chiefly of sodium and magnesium have accumulated in these soils by the lateral leaching and runoff of water from the surrounding Swartland series. This accumulation of salts is at present still taking place as evidence the hastened spreading of saline areas in the bottomlands up the slope under cultivation experienced in the wheatlands. Those Langvlei members situated in areas in which the Swartland is highly saline are more alkaline than those where Swartland is only weakly saline. For example, the colluvial deposit described in profile 24 is not alkaline since the surrounding soils, though identical with Swartland, are not saline.

Under the deflocculating (dispersing) action of sodium and magnesium, clay and organic matter have been leached vertically from the A to accumulate in the B as dark clay skins on the ped surfaces forming a natric B Horizon.

Langvlei and Daljosophat have formed in comparable positions from comparable materials. The two soils are however dissimilar. Langvlei has lower clay percentages than Daljosophat and can thus less easily develop slickensides although the clay minerals are similar. Actually with the higher C.E.C./100 gm. clay Langvlei would seem to have a greater proportion of expanding clay minerals than Daljosophat which should cancel the differences present in clay percentage, the higher sodium content moreover should cause the clay in Langvlei to expand more than that in Daljosophat. Obviously then the difference in structure must be in genetical causes other than clay mineral expansion.

Langvlei was formed in materials less weathered into primary particles than Daljosophat. Langvlei formed in a mixture of rock fragments of varying sizes as well as primary sand, silt and clay particles. The parent material as a mass was thus less homogenous than that of Daljosophat, expansion and contraction of the materials resulted in the formation of vertical cracks rather than in differential expansion and contraction and formation of slickensides and a fine angular blocky type of structure. With illuviation of clay, organic material and coarser fragments into these cracks, so coating the surfaces of the cracks planes of weakness in the material formed, so that with each subsequent expansion and contraction the possibility of forming slickensides and a parralellepiped type of structure decreased as the thickness of the illuvial coatings increased. Thus before the material had been weathered into a homogenous mass vertical planes of weakness had been formed and the foundation for the formation of stable prisms formed. It is easy to realise that once the trend to form prisms or to form slickensides and wedge shaped peds has begun in a material it would be difficult to change from one to the other, prisms are stable structures in expanding materials once planes of weak cohesion are present; wedges and slickensides are also stable for by the rapid mixing of materials and turnover of peds no permanent vertical planes of weak cohesion can form.

Because the parent material of Langvlei had a higher sodium content and was in a position which continued receiving sodium, the dispersion of clay in the A and leaching and reflocculation in the B predisposed it to the formation of a Natric B with prisms. Daljosophat's parent material having been transported further was less saline and alkaline so that clay movement in this case was probably mainly mechanical and thus of less significance than that of Langvlei where illuviation is mechanical as well as by flocculation.

Reduction of iron caused by the presence of a permanent water table has resulted in gley colours in the C horizon of Langvlei.

Langvlei series is wetter than Swartland; it is in central concept an argidic natrustalf. Profile 47A is a drier example than profile 32, 47A being a ustalfic natrargid and profile 32 a natrustalf. Further up the gradient, in the same bottomland, from profile 47A, profile 47 had a weakly formed duripan (abnormal for the area) so that it is possible in drier regions Langvlei will grade into nadurargids and in moist regions to the natrustalfs.

Physical characteristics and land use

The B_2 is dense and impermeable. The site, poor drainage, accumulation of salts from surrounding soils, and salinity of the soil itself preclude Langvlei from being used under intensive irrigation systems. Its irrigable value as defined by the Soils Research Institute (19--) is C.

Langvlei is used in some areas for wheat production. It is normally not cultivated. It is sometimes used for wine grape production because of its greater depth to bedrock than the surrounding soils. At Kuilenberg is an example better drained and less saline (Mixed Malmesbury-Klipheuwel formation provenance) which supports a fair vineyard. Poorly drained or very saline members, as at the Boland Landbouskool, are left uncultivated.

The deep colluvial valley soils eg. profile 24 are used in the wheatland areas for grape production, these soils are better drained and less saline than Langvlei but nevertheless they often are alkaline and the vines stunted.

Associated soils and mapping

Langvlei occurs in easily defined bottomland positions in in association with youngalluvium and with an undefined colluvial soil eg. profile 24. Langvlei occurs in areas of Swartland and to a lesser extent of Kanonkop. Where the topography (in the Swartland and Kanonkop areas) changes from convex to concave, Langvlei or an associate may be expected. Soils conforming to the series definition of Langvlei are commonest in areas of Swartland. In areas of Kanonkop bottomlands are less strongly developed and resemble more closely the colluvial profile 24.

The colluvial soils are found in concave landscape positions which are generally steeper than those in which Langvlei is found. They are not as saline or alkaline as Langvlei because of the greater lateral leaching possible. They have been mapped together with Langvlei because they are in positions receiving salts from the surrounding soils. Where, as is the case in profile 24, the surrounding soils are not alkaline, this soil is acid, but where the surrounding soils are alkaline it is alkaline and/or saline. Because of the variability and the limited occurrence of these soils they were left undefined, they may yet be defined in further surveys where Kanonkop occurs to a greater extent since they occur in the weak bottomlands of Kanonkop.

Langvlei series definition

A_1/Ap	no finer than fine sandy loam with an abrupt transition to the B_2
B_2	coarse prismatic, 30% to 50% clay. Values in ped interiors 4 or greater and chromas 3 or greater with dark coatings on the ped surfaces. pH greater than 7. Exchangeable Magnesium + Exchangeable sodium percentages greater than 50% Base saturation 100% or greater. Alkali earth carbonates present in the lower B. Extractable sodium (NH_4Ac) increases from B to C or within the B No B_3 with a gradual transition to a C with rock structure is permitted. Either clear or abrupt transition to the C
C	somewhere within it the C must be gleyed.

No strongly developed intersecting slickensides or structure with wedge shaped peds are permitted in the solum.

PROFILE No.	24
LOCATION	Lat. 33°42' Long. 18°54'
SITE	Narrow colluvial valley lower mid slope 3% slope
ELEVATION	550 ft.
PARENT MATERIAL	Colluvial Malmesbury graywacke material

Horizon	Depth inches	
Ap	0-11	10YR $^{4}/_{3}$ brown (10YR $^{6}/_{4}$ lt.Y.Br.Dry) fine sandy loam; very hard, apedal; occasional round fine Fe/Mn shot; gradual transition. pH 5.15, R60°F 2350.
B_{21t}	11-19	10YR $^{4}/_{4}$ dark yellowish brown (10YR $^{6}/_{4}$ lt.Y.Br.Dry) fine sandy clay loam; hard, apedal; occasional round fine Fe/Mn concretions; gradual transition. pH 5.65, R60°F 2700
B_{22t}	19-31	10YR $^{4}/_{4}$ dark yellowish brown (10YR $^{6}/_{4}$ lt.Y.Br.Dry) clay loam; very hard, apedal; frequent Fe/Mn concretions; gradual transition. pH 6.1, R60°F 2050
B_{23t}	31-48	10YR $^{4}/_{4}$ dark yellowish brown (10YR $^{6}/_{4}$ lt.Y.Br.Dry) clay loam; very hard to extremely hard, moderate fine blocky; few faint fine (10YR $^{7}/_{6}$) yellow mottles; occasional Fe/Mn concretions gradual transition. pH 6.2, R60°F 1900
C	48-64	10YR $^{4}/_{4}$ dark yellowish brown (10YR $^{5}/_{4}$ Y.Br.Dry) sandy clay; few small diffuse 10YR $^{7}/_{6}$ yellow mottles; extremely hard, weak blocky; occasional Fe/Mn concretions. pH 5.96, R60°F 1700

Remarks: The Swartland series described in this landscape had acid B horizons with lowest R60°F at 1100

DALJOSOPHAT SERIES

Of somewhat limited extent along the banks of the Berg River, Daljosophat is represented by profiles 174 and 182. It is generally more extensive on the eastern bank of the river than on the west and has not been found further downstream than the farm Soetendal.

Site

Daljosophat is limited to low lying, more or less flat river terraces at approximately 20 ft. above the present base level of the Berg River. Daljosophat is most extensive at the confluences of the minor tributaries with the Berg river. Slope of these terraces varies from less than 1% to 2%. As can be seen just north of Wellington, a distinct step of about 5 ft. separates this terrace level from the young alluvium. Due to colluviation the transition to the upland soils is seldom as distinct as this, except where the terrace clays bound on terrace boulders and sand, where again distinct steps are found.

Parent material

Daljosophat formed in clayey materials with an overlying sand and gravel mantle. The expanding lattice type clays were river deposited derived mainly from the Malmesbury sediments. Terrace stones of Table Mountain sandstone are rarely found in the clay, they are less common than the angular quartz normally associated with the Malmesbury sediments. While this clay is thought to be river deposited it is not thought to have been transported very far. The fact that it is most extensive at the confluences with minor streams would appear to point to a deposition by these streams onto a flat surface (a delta-type of deposition).

The overlying sand and gravel mantle undoubtedly has a mixed origin, well rounded Table Mountain sandstone boulders, together with angular quartz probably from the Malmesbury sediments is mixed with a sandy material, which at times has strong affinities with the aeolian material of Ofazi series. It appears that the sandier materials were deposited by the Berg River perhaps with later sorting and removal of finer materials by wind to be re-deposited elsewhere The poorer sorting of the surface materials as opposed to that of underlying clays points to a rapid flow of water which must have occurred during the cutting down into these deposits coinciding with the recent (20ft.) lowering in sea level.

Morphology

The A_1 (Ap) horizon is generally a dark yellowish brown gravelly loamy coarse sand which sets hard on drying. This overlies

PROFILE No.:	182 Daljosophat series
LOCATION :	Lat. 33°39' Long. 18°57' on farm Smithfield
SITE :	Bottomland – second terrace of Berg River 0–1% slope towards river
ELEVATION :	350 ft.
PARENT MATERIAL :	Terrace material – alluvium

Horizon	Depth inches	
A_1 Ochric	0–6	$2.5Y^{4}/_{3}$ dark grey brown ($2.5Y^{7}/_{1}$ lt.Gr.Dry) coarse sandy loam; frequent to abundant rusty ($2.5YR^{3}/_{6}$ dark red) root holes; hard, apedal; gradual transition.
IIA_2	6–14	$10YR^{5}/_{4}$ yellowish brown ($10YR^{7}/_{2}$ lt.Gr.Dry) loamy coarse sand; abundant rusty ($2.5YR^{3}/_{6}$ dark red) root holes; soft, apedal; frequent laterite fragments; clear transition.
$IIIA_2$	14–20	$10YR^{5}/_{5}$ yellowish brown ($10YR^{7}/_{3}$ v.p.Br.Dry) gravelly coarse sand; soft, apedal; abundant laterite fragments; abrupt transition.
$IVB_{21(t)}$	20–25	$10YR^{6}/_{3}$ pale brown ($10YR^{8}/_{2}$ white Dry) gravelly sandy loam; tonguing into a $2.5Y^{7}/_{4}$ light olive brown (Dry and Moist) mottled many distinct medium $7.5YR^{5}/_{6}$ strong brown clay; hard, moderate fine blocky tending to medium prismatic; abundant clay skins/pressure planes; gradual transition
$IV\ B_{22(t)}$	25–35	$2.5Y^{5}/_{4}$ light olive brown ($2.5Y^{5}/_{4}$ lt.Ol.Br.Dry) clay; many faint medium $10YR^{5}/_{6}$ yellowish brown mottles; very hard, strong medium and fine blocky to wedge shaped tending to very coarse prismatic; occasional long slickensides; abundant clay skins/pressure planes; gradual transition
$IVB_{23(t)}$	35–47	$10YR^{4}/_{3}$ brown to dark brown (Dry and Moist) clay; extremely hard, strong coarse blocky; frequent long slickensides, abundant clay skins/pressure planes; abundant black decayed rootlets; occasional fine iron shot; clear transition
$VB_{3(t)g}$	47–56	$5Y^{5}/_{2}$ olive grey (Dry and Moist) silty clay loam; many distinct fine $5YR^{5}/_{6}$ yellowish red mottles; hard, weak to moderate fine blocky; frequent fine quartz gravel; abundant clay skins/pressure planes clear transition.
$VI\ C_1$	56–65	$5Y^{5}/_{2}$ olive grey clay; many diffuse fine $10YR^{5}/_{8}$ yellowish brown mottles; hard, strong fine blocky; occasional short slickensides, occasional soft black Fe/Mn nodules; gradual transition
$VIIC_{2t}$	65–75	$2.5Y^{5}/_{6}$ olive brown sandy clay loam; frequent medium distinct $7.5YR^{5}/_{8}$ strong brown mottles; slightly hard, apedal occasional thick clay skin

Lab. No.	B7365	B7366	B7367	B7368	B7369	B7370
Depth inches	0–6	6–14	20–25	25–35	35–47	47–65
Horizon	A_1	IIA_2	IVB_{21t}	IVB_{22t}	IVB_{23t}	$VB_{3g}+VIC_1$
		Particle size distribution				
Gravel separate 2mm.	7.7	0.0	9.3	5.7	0.0	1.1
C.sand 2–.5mm.	42.5	67.9	14.7	12.5	11.8	10.8
M.sand .5–.2mm.	12.2	14.3	6.4	6.3	5.7	3.7
F.sand .2–.02mm.	15.6	5.9	15.3	14.8	15.0	11.2
Silt .02–.002mm.	17.4	6.5	9.6	13.3	17.0	37.1
Clay .002mm.	12.9	7.3	55.6	54.7	52.2	39.0
		Extractable cations meq./100 gm.				
Na	0.04	0.02	0.99	1.80	2.65	4.05
K	0.24	0.08	0.38	0.21	0.16	0.13
Ca	1.39	0.66	1.68	1.97	2.32	2.78
Mg	1.14	0.62	5.00	9.58	11.69	12.98
C.E.C.	3.50	1.18	8.79	14.08	17.61	16.78
Base sat. %	80.28	116.94	91.12	96.30	95.4	111.50
		Saturation extract soluble cations meq./100 gm.				
Na	0.14	0.06		0.54	1.25	1.07
K	0.06	0.01		0.00	0.00	0.00
Ca	0.18	0.06		0.07	0.22	0.09
Mg	0.04	0.00		0.00	0.00	0.07
$EC10^3$/cm.25°C	4.267	1.098		1.85	4.96	8.23
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	6.0	6.5	6.38	6.6	6.9	7.5
Ohms R 60 °F	111.7	347.8	685.1	453.1	247.6	189.7
		Organic matter				
% Carbon	0.80	0.15	0.17	0.08	0.13	0.01
% Nitrogen	0.07	0.02	0.05	0.02	0.04	0.01
C : N	11.4	7.5	3.4	4.0	3.25	1.0
	Exchangeable cations expressed as % of total exchangeable bases					
Na			11.26	8.95	15.04	24.13
K	5.14	5.07	3.86	1.49	0.90	0.69
Ca	34.57	43.47	19.11	13.49	11.92	14.37
Mg	31.42	44.92	56.88	54.19	66.38	77.35
Base sat. %	80.28	116.94	91.12	96.30	95.4	111.50
			Clay minerals			
C.E.C./100 gm.clay	27.1	16.6	15.8	25.74	23.73	43.0
Identified minerals			Kaol.v.v.s. Ill.med.	Kaol.v.v.s. Ill.v.v.s. Mont.ms	Kaol.v.v.s. Ill.v.v.s. Mont.vs	Kaol.v.v.s. Ill.v.v.s. Mont.med.

PROFILE No.: 174 Daljosophat

LOCATION : Lat. 33°42' Long. 18°59' near roadside Wellington-Daljosophat road

SITE: Gently sloping second terrace of Berg River 0-1% slope

ELEVATION : 350 ft.

PARENT MATERIAL Terrace material - alluvium

Horizon	Depth inches	
Ap ochric	0-9	10YR 4/4 dark yellowish brown (10YR 6/4 lt.Y.Br.Dry) gravelly loamy coarse sand; soft, apedal; abundant sub-angular quartz gravel; gradual transition.
A_3	9-14	10YR 5/6 yellowish brown (10YR 7/3 v.p.Br.Dry) gravelly coarse sandy clay loam; soft, apedal to weak fine blocky; weakly developed clay skins; abundant sub-angular quartz gravel, occasional laterite fragments; clear transition.
IIB_{21t}	14-25	10YR 6/3.5 pale brown (10YR 6/6 Br.Y.Dry) gravelly clay; many distinct medium 2.5YR 4/6 red (5YR 4/8 Y.R.Dry) mottles; slightly hard, moderate to strong fine blocky; strongly developed clay skins/pressure faces; frequent sub-angular quartz gravel; gradual transition.
$IIIB_{22t}$	25-37	10YR 5/8 yellowish brown (10YR 6/4.5 Br.Y.Dry) clay; many distinct medium 2.5YR 4/6 red, many diffuse medium 7.5YR 5/6 strong brown mottles; hard, moderate fine blocky; strongly developed clay skins/pressure faces; occasional fine sub-angular quartz and iron concretionary gravel; gradual transition.
$IIIB_{23t}$	37-51	7.5YR 5/6 strong brown (Moist and Dry) clay; in places few diffuse fine 10R 4/6 red mottles; very hard to extremely hard, moderate coarse blocky to wedge shape tending weakly to prismatic, in places moderate to strong fine blocky; where no mottles present abundant weak slickensides, occasional long slickensides have 2.5Y 6/2 light brownish grey surfaces; strongly developed clay skins/pressure faces; gradual transition.
$IIIB_{3t}$	51-69	10YR 5/5 yellowish brown (Moist and Dry) clay; very hard, moderate medium prismatic to moderate coarse blocky in places; frequent long slickensides; frequent iron-shot concretions, frequent black Fe/Mn dendrites; abundant clay skins/pressure faces.

Lab. No.	B7359	B7360	B7361	B7362	B7363	B7364
Depth inches	0-9	9-14	14-25	25-37	37-51	51-69
Horizon	Ap	A_3	IIB_{21t}	$IIIB_{22t}$	$IIIB_{23t}$	$IIIB_{3t}$
Particle size distribution %						
Gravel separate 2mm.	38.7	58.7	18.9	10.1	8.7	12.4
C. sand 2-.5 mm.	51.4	42.5	8.7	11.9	11.1	8.2
M. sand .5-.2mm.	8.3	5.8	2.9	5.0	5.2	5.1
F. sand .2-.02mm.	29.3	23.8	15.9	16.8	21.7	20.7
Silt .02-.002mm.	6.3	4.0	8.5	7.4	6.1	7.4
Clay .002mm.	7.6	25.5	65.7	59.9	57.1	60.1
Extractable cations meq./100 gm.						
Na	0.05	0.07	0.42	0.93	1.47	2.60
K	0.06	0.10	0.10	0.08	0.10	0.09
Ca	0.50	0.47	2.58	1.64	2.12	3.80
Mg	0.44	1.14	4.35	7.54	8.23	12.58
C.E.C.	1.49	3.38	9.69	10.76	11.30	18.51
Base sat. %	70.46	52.66	76.88	94.70	105.48	115.50
Saturation extract soluble cations meq./100 gm.						
Na						1.15
K						0.00
Ca						0.26
Mg						0.00
$EC10^3$/cm.25°C						3.124
$CaCO_3$ eq.	0.0	0.0	0.0	0.0	0.0	0.0
pH 1:1 H_2O	5.55	5.5	5.8	6.2	6.3	7.65
Ohms R 60°F	6007	5216	2266	1160	600	284
Organic matter						
% Carbon	0.30	0.32	0.19	0.15	0.10	0.10
% Nitrogen	0.03	0.05	0.05	0.03	0.02	0.02
C : N	10	6.4	3.8	5.0	5.0	5.0
Exchangeable cations expressed as % of total exchangeable bases						
Na	3.35	2.07	4.33	8.64	12.33	7.60
K	4.02	2.95	1.03	0.74	0.83	0.47
Ca	33.55	13.9	26.62	15.24	17.78	18.56
Mg	31.23	33.72	44.89	70.74	69.04	65.96
Base sat. %	70.46	52.66	76.88	94.70	105.48	115.5
Clay minerals						
C.E.C./100 gm. clay	19.6	13.25	14.74	17.96	19.78	27.47
Identified minerals			Kaol.vs. Ill.mw	Kaol.vvs. Ill. m	Kaol.vvs. Ill. s.	Kaol.vvs. Ill. vs. M.L. s.

an A_2 or A_3 equally gravelly with an abrupt transition to the B_{21t}. The B is a pale brown, distinctly mottled red, sandy clay, with strong fine blocky, tending to medium prismatic structure (especially noticeable when dry). Slickensides or pressure faces are always present in some part of the B, the degree of development generally increasing with depth. Although discontinuities within the clay are obvious due to the presence of gravel lines, no fine stratifications remain.

Wetness of the soils is evidenced in the mottling, gley colours as in profile 182 are not however, normal. It is interesting here to note that, while the horizons between 47 inches and 65 inches show gley colours, the horizons below does not, although it is expected to be just as wet.

The degree of expansion showed in these soils varies from long, strongly developed intersecting slickensides with light coloured surfaces as those of the IIB_{23t} in profile 174, to the shiny surfaces normal to the B_{21t}. These shiny surfaces are unidentifiable (with a 10X hand lens) as to whether they are clay skins or pressure faces.

In expanding clay materials such as these, it is difficult to distinguish the limits of the B horizon. The B_{21} is a textural, structural and consistence B. It probably does contain illuvial clay discernable by thin section studies. Where to demarcate the boundary between the B and the C is a problem. Since the clays are expanding, soil structure will be formed to that depth that they are alternately wet and dried.

Chemical characteristics

Base saturation is high throughout, increasing with depth to super-saturation in the lower parts of the B Although no carbonates occur in the two examples cited there are rarely found members with calcium carbonate nodules. Although highly base saturated the soils are on the acid side except at depth, this is due to two factors viz. the low exchangeable sodium contents in the upper part of the profile and to the high buffer capacity of the clay type.

Calcium is the dominant cation in the A horizons, decreasing with depth. In the B magnesium is dominant. Exchangeable sodium, like magnesium, increases with depth reaching more than 10% of the exchangeable cations somewhere in the lower part of the B.

In the analysis of profile 182 the anomaly of a higher water extractable sodium content than ammonium acetate extractable Na content occurred. This can only be ascribed to incorrect experimental procedure or method in the determination of ammonium acetate extractable sodium. The low resistance and high conductivity figures lend weight to the correctness of the saturation extract figures.

Profile 182 the more saline of the two, is situated in an area of Malmesbury graywackes, the surrounding soils are irrigated with a water from this area, as well as receiving runoff from the surrounding soils. Profile 174 however is situated in the middle of a broad terrace; no longer receives runoff and is at present not cultivated. The water running through its course is from a schist and Table Mountain sandstone provenance. In the area surveyed the latter case is more normal so that resistances should generally be over 2,000 in the A decreasing with depth in Daljosophat approaching something like 300 or less in the lower part of the B. The upper B is not saline or alkaline (in contrast with Langvlei series which has high pH and low resistances in the upper B.)

Profile 182 is a virgin profile at the roadside. It probably had a marsh vegetation at earlier times as shown by the high carbon percentage in the A_1, high enough to make it an umbric horizon whereas profile 174 which has been cultivated at some stage has a low carbon percentage. Carbon percentages as well as Carbon:Nitrogen ratios decrease with depth, the latter being 5 or less in the B.

Genesis and classification

As pointed out previously, the recognition of illuvial clay accumulations in such expanding clay materials is difficult. Expansion and contraction of the clay causes the formation of shiny surfaces which resemble clay skins. Physical orientation of clay particles parralel with shear planes probably occurs. There is, moreover, a rapid turnover of structural units i.e. the peds are not stable from one season to another. New peds are formed mechanically by shrinking and swelling processes all the time, so that any dark coatings of clay and organic matter are incorporated into the soil mass and do not remain as thick dark coatings (which incidentally once formed would help stabilise individual peds by demarcating permanent planes of fracture on drying).

It is well to enquire why Swartland with the same clay materials shows such distinct ped surfaces and clay skins and very rarely slickensides. The answer lies in the nature of the parent materials. Swartland's B has formed by the gradual weathering in situ of the graywacke. Soil formation (and thus clay illuviation and structure formation) has kept pace with, and is often ahead of the weathering process. Daljosophat has formed in materials already weathered (to the extent that the primary clay and sand fractions are separate particles). The moment these clays were deposited and subjected to alternating wet and dry conditions physical mixing began preventing the formation of permanent peds. An example of this was noticed in the field (Profile 313) where a thin layer of terrace clay was deposited on the Malmesbury sediments to be again covered by colluvium from the graywackes. The terrace clay had strong slickensides but the other materials from the graywackes were weakly prismatic with no slickensides and had well developed clay skins. Strong slickensides moreover demarcated the boundaries of the separate materials, showing the lack of affinity between them.

Soil formation in Daljosophat has proceeded far enough for all evidence of fine stratifications to be obliterated, soil structure has been formed, accumulation of organic matter in the A_1 and leaching into theB has taken place. (The decrease in C:N ratios shows the organic matter to be more humified and thus not due to presence of plant roots but to the downward movement of humified materials). Leaching of sodium, and to a lesser extent of magnesium into the B has taken place resulting in a relative accumulation of calcium and potassium in the A.

In all probability, an accumulation of clay has taken place in the B. It can however at this stage not be definitely said whether the B is argillic or cambic. It can not be placed in the 7th Approximation if it is cambic, it should fit the Camborthids probably an undefined Vertic Camborthid but for the fact that it is moist in the lower solum for longer than seven months. If the B is argillic/natric then it is an undefined Vertic Natrustalf since it is too moist for the aridisols. If the B is neither cambic nor argillic then Daljosophat would be a crypto vertic hapludent. Were the gravelly horizons absent, little hesitation would occur in calling it a vertic hapludent; it hasn't the structure necessary for the vertisol order, so crypto vertic hapludent is probably best until it can be definitely placed by further study.

Physical characteristics and land use

The B horizon is practically impermeable, site is flat and sodium and magnesium nearing upper limits of tolerance to most crops so that such a soil could not be recommended for extensive irrigation. With the normal depth of the upper coarse material encountered, Daljosophat seldom varies from the value B_2 as defined by the Soils Research Institute.

Due to the accident of site-alongthe banks of the Berg river, Daljosophat is used mainly for the production of wine grapes when cultivated. With the use of semi intensive drainage systems it is usually irrigated where cultivated. Vines on this soil appear susceptible to sunburn - a combination of burning and physiological drought probably due to the shallow root system-the result of the presence of the dense B.

On the deeper more gravelly (terrace gravels) members apricots are grown.

Associated soils

Daljosophat normally occurs in a well defined landscape bounding with alluvium on the one side and with upland soils and Langvlei on the other side. Within this landscape Daljosophat is associated with deposits of a varying depth of terrace boulders and fine sands overlying either terrace clays or in the higher lying positions, overlying clays derived from the underlying sedimentary rocks.

Daljosophat series definition

A_1/Ap coarse textured - no finer than fine sandy loam

A_2/A_3 chromas greater than 2 values greater than 4. Abrupt transition to

B_{2t} More than 50% clay. Moderate to strong medium to fine blocky. No grade of prismatic structure stronger than weak. No prominent coatings on ped surfaces darker than the matrix by a value of 2 or a chroma of 2. Evidence of expansion and contraction evident in the B Chromas of upper part of the B are no darker than the overlying A horizon. pH is less than 7 in the upper 10 inches of the B. Gley colours are permitted below 20 inches of the upper limit of the B. There must be slickensides in such gleyed material. Exchangeable sodium is less than 15% and base saturation more than 70% increasing with depth. Gradual transition to

B_3/C No rock structure. Fully base saturated.

BOTRIVIER SERIES

This soil is of limited occurrence found only in well developed valley bottomlands in granite areas, mainly in the northern half of Paardeberg. It's distinctive morphology is typified by profiles 82 and 145.

Site

Typically Botrivier occupies level relict bottomland sites varying from 10 ft. to 20 ft. above the present watercourses. It is seldom in a position in which it can at the present time receive much in the way of runoff, salts, or alluvium. There is typically a distinct step in topography between this soil and the alluvium, whether young or old.

Parent material

Botrivier has formed from a granitic alluvium not very strongly weathered and seldom having been transported very far. Felspars are usually evident to the naked eye in the C, and are also present to a lesser extent in the sand fractions of the B.

Morphology

Horizon differentiation is very distinct. A grey brown coarse textured A_1/Ap overlies an equally coarse lighter-coloured A_2. The A_2 abruptly overlies a dark coloured prismatic B horizon. There is invariably fine albic tonguing in the upper part of the prisms. Ped interiors of the B are not as dark as the clay coated exteriors, mottling is usually present in the B. The B lies abruptly on a light coloured mottled olive duripan. This duripan is at times massive indurated, and at other times is made up of coarse blocky cemented duripeds. The duripan is too hard to be penetrated with a pick, it was only in non representative pedons such as profile 208 that it was possible to describe it at depth. From laboratory studies(1) it appears that degree of cementation decreases with depth, this was not noticed in the field however except at Dudley Vale where in a ravine undercutting of the duripan by water action is to be seen.

The depth of the A horizons varies considerably from six inches up to four feet with about two feet being normal. The B is sometimes thin and discontinuous, other times it is found up to two feet thick. Viewing the whole soil individual, the transition of the A to the B is wavy with the crests of the waves, i.e. shallow soils, lying parallel to the direction of the valley bottom.

(1) J.J.N. Lambrechts - Dept. Soil Science, Stellenbosch University

PROFILE No.: 82 Botrivier series

LOCATION : Lat. 33°37'. Long. 18°46' on farm Dudley Vale

SITE : Relict bottomland minor tributery of Mosselbank River 1% slope

ELEVATION: 550 ft.

PARENT MATERIAL Granite alluvium/colluvium

Horizon	Depth inches	
A_1 Ochric	0-4	10YR$^5/_2$ grey-brown (10YR$^7/_2$lt.Gr.Dry) sand; loose to soft, apedal; gradual transition
A_2 Albic	4-17	10YR$^6/_2$ light brownish grey (10YR$^8/_2$white Dry) loamy sand; soft, apedal; frequent rusty root holes; abrupt transition.
IIB_{2t} Natric	17-24	5Y$^4/_1$ dark grey sandy clay; few fine distinct 2.5Y$^4/_4$ olive brown mottles; N$^3/_0$ very dark grey (N$^4/_0$ dk.Gr.Dry) thick clay coatings cover ped surfaces; fine albic (N$^8/_0$ white Dry 10YR$^7/_3$very pale brown moist) tonguing is present in the upper three inches; extremely hard, moderate to strong prismatic (weakly columnar) varying from very coarse to medium, breaking to coarse blocky; abrupt transition.
IIC_{siM} salic duripan	24-51	2.5Y$^6/_2$ light brownish grey (moist and dry) sandy loam; many medium diffuse 7.5YR$^6/_8$ reddish yellow mottles; rare 5Y$^6/_1$ light grey to grey clay skins down fissures; extremely hard, cemented.

Lab. No.	B7394	B7395	B7396	B7397
Depth inches	0-4	4-17	17-24	24-51
Horizon	A_1	A_2	IIB_{21t}	IIC_{siM}
Particle size distribution %				
Gravel separate 2mm.	1.2	0.0	4.9	3.9
C.sand 2-.5mm.	43.8	45.5	25.1	37.9
M.sand .5-.2mm.	18.6	19.0	9.6	16.5
F.sand .2-.02mm.	26.5	25.0	16.8	24.3
Silt .02-.002mm.	5.2	7.5	4.0	14.1
Clay .002mm.	4.9	4.6	46.9	7.1
Extractable cations meq./100 gm.				
Na	0.16	0.07	2.48 1,29	1.47
K	0.23	0.15	0.45 0,45	0.14
Ca	0.51	0.33	3.18 3,00	2.69
Mg	0.50	0.22	6.48 6,47	2.18
C.E.C.	1.74	0.99	12.14	6.34
Base sat. %	68.9	77.8	103	102
$CaCO_3$ eq.	0.0	0.0	0.0	0.0
pH 1:1 H_2O	6.0	8.2(6.0)	7.35	8.23
Ohms R 60°F	3794.4	4163.3	236.8	170.7
Saturation extract soluble cations meq./100 gm.				
Na			1.19	1.72
K			0.00	0.01
Ca			0.18	0.14
Mg			0.01	0.20
EC10^3/cm.25°C			7.28	21.28
Organic matter				
% Carbon	0.40	0.11	0.28	0.04
% Nitrogen	0.03	0.01	0.05	0.01
C : N	13.34	11.0	5.6	4.0
Exchangeable cations expressed as % of total exchangeable bases				
Na	9.2	9.09	10.25	29.03
K	13.2	15.15	3.57	2.00
Ca	29.31	33.33	23.82	39.35
Mg	17.24	22.22	51.38	29.62
Base sat. %	68.9	77.77	103.7	102.2
Clay minerals				
C.E.C./100 gm. clay	35.51	21.52	25.88	89.29
Minerals identified			Kaol.v.s. Ill. t. Mont. s.	Kaol.v.s. Mont. m.s.

PROFILE No.	145 Botrivier series
LOCATION :	Lat. 30°33' Long. 18°51' on farm La Rhine
SITE :	Second Botrivier Terrace, Relict Bottomland 0-1% slope
ELEVATION	500 ft.
PARENT MATERIAL	Granite alluvium/colluvium

Horizon	Depth inches	
A_1 Ochric	0-1	10YR3/2 very dark grey brown (10YR4/2 dk.Gr.Br. Dry) sand; slightly hard, apedal, gradual transition.
A_2 Albic	1-8	10YR6/3 pale brown (10YR8/3 v.p.Br.Dry) sand; frequent very fine rusty root holes; slightly hard, apedal. A one inch thick albic 10YR7/3 very pale brown (whiter than N8/0 Dry) overlies and tongues weakly and finely into the B_{2t}. Abrupt transition
IIB_{21t} Natric	8-16	10YR6/3 pale brown (10YR7/2 lt.Gr.Dry) clay loam; with thick prominent 10YR3/1 very dark grey to 10YR2/2 very dark brown clay coatings on ped surfaces and down root channels. Colour varies to 5Y6/3 pale olive in places, with many fine distinct 5YR4/6 yellowish red mottles. Extremely hard, moderate coarse prismatic breaking to coarse blocky; abrupt transition.
IIC_{sim} duripan	16-32	5Y8/1 white 5Y7/1 light grey and 5Y6/1 grey loam; many large distinct 7.5YR5/8 strong brown and 5Y5/3 olive mottles; extremely hard, massive cemented. In places moderate to strong coarse blocky, extremely hard, cemented duripeds were found. Clay skins occur down fissures.

Lab. No.	B7408	B7409	B7410
Depth inches	0-8	8-16	16-32
Horizon	A	IIB_{21t}	IICM
Particle size distribution %			
Gravel separate 2mm.	4.0	3.7	0.6
C. sand 2-.5mm.	33.6	22.2	30.7
M. sand .5-.2mm.	15.6	6.1	9.4
F. sand .2-.02mm.	36.8	18.9	24.8
Silt .02-.002mm.	8.6	15.1	23.5
Clay .002mm.	8.1	39.9	15.4
Extractable cations meq./100 gm.			
Na	0.12	1.78	2.43
K	0.11	0.29	0.22
Ca	0.44	1.75	1.63
Mg	0.33	6.68	6.55
C.E.C.	2.49	11.67	8.31
Base sat. %	40.16	89.97	130
$CaCO_3$ eq.	0.0	0.0	0.0
pH 1:1 H_2O	5.75	6.05	7.3
Ohms R 60°F	4995.0	222.0	277.5
Organic matter			
% Carbon	0.22	0.17	0.06
% Nitrogen	0.02	0.02	0.01
C : N	11.0	8.5	6.0
Saturation extract soluble cations meq./100 gm.			
Na		1.13	0.83
K		0.00	0.00
Ca		0.11	0.08
Mg		0.14	0.05
$EC10^3$/cm.25°C		8.47	8.23
Exchangeable cations expressed as % of total exchangeable bases			
Na	4.82	5.57	14.77
K	4.41	2.48	2.03
Ca	17.67	14.05	14.31
Mg	13.25	56.04	60.01
Base sat. %	40.16	89.97	130.32
Clay minerals			
C.E.C./100 gm. clay	30.74	29.24	53.96
Minerals identified		Kaol.v.v.s.	Kaol. str
		Ill. med.	Ill. med.
		M.L. med.	M.L. med.

1,60 0,22 1,55 6,50 9,87 90,08

PROFILE No. 208

LOCATION Lat. 30°33' Long. 18°51' on farm La Rhine

SITE Relict bottomland 0-1% slope ± 100 yds. upstream from prof. 145

ELEVATION 500 ft.

PARENT MATERIAL Granite alluvium

Horizon	Depth inches	
Ap	0-9	2.5Y 5/2 Grey brown (10YR 6.5/1 lt.Gr.Dry) sand; soft, apedal; gradual transition.
A_2	9-17	10YR 6/2 light brownish grey (10YR 7/1 lt.Gr.Dry) sand; soft to slightly hard, apedal; abrupt transition.
IIB_{21t}	17-23	5Y 5/3 olive, 5Y 4/3 olive brown, 2.4Y 5/2 grey-brown sandy clay loam; extremely hard, strong medium to coarse prismatic breaking to medium blocky; with prominent 10YR 4/2 dark grey brown clay skins on ped surfaces; abrupt transition.
IIIB and C_M	23-36	2.5Y 6/4 light brown (2.5Y 8/4 p.Y.Dry) coarse sandy loam; common medium diffuse 7.5YR 6/8 reddish yellow mottles, rare 2.5YR 4/8 red root holes; extremely hard cemented with inclusions of weak to moderate coarse blocky material; 10YR 3/1 very dark grey clay skins; gradual transition.
IV C_M and B	36-40	2.4Y 5/2 grey-brown sandy clay loam, coarse sandy loam and very coarse sand with a lens of gravel; rare 2.5YR 4/8 red root holes; extremely hard cemented with inclusions of weak coarse blocky material; 10YR 4/1 dark grey thick clay skins; gradual transition.
IV C_M	60-70	2.5Y 6/2 light brownish grey (2.5Y 7/2 lt.Gr.Dry) coarse sandy loam and coarse sandy clay loam; many large diffuse 10YR 5/8 yellowish brown mottles; extremely hard cemented with inclusions of weak coarse blocky material; very thick 2.5Y 4/2 dark grey brown clay skins.

REMARKS: On the other side of the profile the first discontinuity dips down to 60 inches and in one corner up to 70 inches, i.e. the overlying sand is 70 inches deep.

Other than the lens of gravel evidence of stratification; the nature of the parent material; is no longer evident, although texture varies considerably in the C and B and in

Profile No. 208 continued.

the C no definite boundaries to each textural class could be discerned. No mechanical analysis was done on the various parts the textures being merely assessed in the field, it is thus possible that varying degrees of cementation influenced the assessment - cemented materials invariably feel of a much coarser texture than they actually are.

Chemical properties

The pH increases with depth being acid in the A and alkaline in the B and C. The pH figure of 8.2 for the A_2 of profile 82 is high. An independent determination by the writer puts this at 6.0 which is in accordance with resistance and exchangeable sodium and magnesium figures.

The A horizon is leached of most of its cations, hydrogen being the dominant one. Profile 82 shows a surprisingly high potassium content in the A. A movement of potassium within the A is indicated as well as an accumulation of it relative to the other cations. Exchangeable magnesium increases suddenly from the A to the B being greater than 50% of the exchange capacity in the B. The B is either saturated or nearly so. The peak of sodium accumulation is found in the C_m which is fully saturated or super saturated with cations. In the C the exchangeable sodium percentage is 14.77% in profile 145 and 29.03 in profile 82 - figures which are reflected in the high pH of these horizons.

The C.E.C./100 gm. clay figures for the C are high, this is attributable to the cementation of clay. Lambrechts[1] found that by removing iron the silt + clay percentage determined in the C of profile 145 increased from 29.8% to 37.7%. This is notwithstanding the fact that cementation of the C appears to be chiefly by silica (the material does not soften in HCl but disintegrates on boiling in NaOH) Due to cementation of clay into silt sized particles, clay estimated by normal methods is low so that calculated C.E.C./100 gm. clay is unduly high.

Eluviation of organic matter from the A_1 into the B_2 has occurred in both profiles. In profile 82 the figures demonstrate this movement very well, carbon percentage is highest in the A_1, is low in the A_2 and again high in the B_2 (·28% organic carbon). The decrease in C/N ratio from the A to the B_2 show the more humified condition of the organic matter in the B, as is to be expected where movement is by the process of dispersion of humus rather than mechanical movement.

Physical characteristics and land use

The B_2 and the C are both very dense and highly impermeable. The flat nature of the site where these soils are found to any great extent, together with the wavy nature of the B horizon renders the draining of these soils rather difficult. According to standards used by the Soils Research Institute, the irrigable value of Botrivier is B_2 or C depending on depth of the A horizons.

Roots do not enter the soil deeper than the B to any appreciable extent and seldom into the C, so that with members shallower

(1) Lambrechts, J.J.N.: Dept. Soil Service, Stellenbosch University

than about 20 inches, crops alternately suffer drought and waterlogged conditions. These soils are however generally put to wine grapes, or as in the case south of Paardeberg on members about 4 feet deep, fruit trees apparently do well. In the vicinity of profile 82 the effect of depth of soil on tree growth is very well shown, the height of tree being roughly proportional to twice depth of A horizons.

Associated soils and mapping

Botrivier occurs either alone in well defined terraces surrounding the alluvia in the bottomlands, or in the bottomlands themselves as a complex association with a deep sand resembling Fernwood series, organic alluvial soils similar to Krakeel series (Langkloof Survey) and strongly gleyed alluvia and soils such as profile 142. Where these complexes occur it is not possible to separate the various members at normal mapping scales.

Genesis and classification

The site in which Botrivier is normally found, viz. as terraces on either side of younger bottomland alluvia as well as being found in true bottomland sites has led to the idea that this soil is a relict. It's stranding is possibly linked with the final 20 ft. emergence of the coastline.

The tonguing of an albic into the natric horizon shows that the soil is at the present stage undergoing a process of destruction of the natric rather than the formation of the natric. Since this process was not seen anywhere else in other natric or argillic horizons this is taken to show this soil as "older" than those soils found with natric horizons elsewhere. (A step further in the soil development process)

If the particle size distribution figures are corrected to bring the B and C horizons to about the same clay content as down below by using the factor $3/2$, these figures are obtained:-

	Profile 145		Profile 82	
	$B_2(x\,3/2)$	C	$B_2(x\,3/2)$	C
C. sand %	33.3	30.7	37.5	37.9
M. sand %	9. 0	9.4	14.4	16.5
fi.sand %	28.2	24.8	25.2	24.3
Silt %	22.5	23.5	6.0	14.1
Clay %	17.0	15.4	17.1	7.1
Silt + Clay %	39.5	38.9	23.1	21.2

As has been pointed out previously the silt figures are high due to cementation so that silt + clay figures are a better indication of presence or lack of lithological discontinuities. From the figures above it can be seen that there is no definite discontinuity in particle size distributions between B and C horizons. The greater clay content of the natric is therefore attributed entirely to illuviation of clay from the A and to weathering of the felspars originally present in the B to form clays.

As is normal with most soils where the C is similar to the parent material from which the B was formed, the C is less weathered than the B. Abnormally however the transition from B to C is abrupt and smooth showing the C (the duripan) to be a soil horizon and not a relict land feature from which the soil has formed as could be suggested. The duripan decreases in degree of cementation with depth also showing it is not at present weathering and is more probably in a state of formation in places.

In the bottomland west of Paardeberg between Welgemeend and Doornfontein where the lowering of the stream has not kept pace with the lowering of base levels elsewhere a member of Botrivier series was found with a duripan thin and weak enough to auger through, a strong water table which rose two feet up this auger hole was encountered below the duripan (a winter observation). This water table is considered to be a significant feature of genesis of Botrivier.

From the abovenamed arguments as well as studies on distribution of Botrivier and its associated soils its genesis is hypothesised below.

Botrivier has formed from a granitic alluvium rich in felspars. In fairly level positions receiving runoff with salts a natric horizon formed overlying a gleyed C. This soil probably was similar to profile 142, a soil found in association with Botrivier, in which the water table still persists in the C.

With the lowering of the base level and consequently of the water table; under influence of the high sodium content of the C, clay destruction took place. The silica released by this clay destruction cemented the C, probably being aided by the small amount of silica present in the ground waters leached out of the weathering granites. This cementation of the C preserved it in the same unweathered stage it had been in when gleyed, since it was so dense moreover, anaerobic conditions persisted so that gley colours were retained. (it is possible the light chromas are as a result of destruction of clay coatings on sand grains so that colours are basically those of the primary sand particles). At the same time leaching of salts and clay out of the A into the B continued, clay moving chiefly in the dispersed state under the influence of high sodium (and magnesium)

PROFILE No.	142
LOCATION	Lat. $30^{o}34'$ Long. $78^{o}51'$ on farm Botriviersvlei
SITE	Broad alluvial plain 0-1% slope
ELEVATION	500 ft.
PARENT MATERIAL	Alluvium

Horizon	Depth inches	
A_1	0-8	10YR $^{6}/_{1}$ grey loamy coarse sand; loose, apedal; gradual transition.
A_2	8-26	10YR $^{6}/_{1}$ light grey (N $^{7}/_{0}$ lt.Gr.Dry) loamy coarse sand; soft to slight hard, apedal; clear transition.
IIB_{21t}	26-32	10YR $^{2}/_{1}$ black clay; firm, weak blocky tending to prismatic moist; gradual transition.
IIB_{3gt}	32-43	5Y $^{5}/_{1}$ grey sandy clay; slightly firm weak blocky; weak distinct olive mottles, moderately developed dark grey clay skins; clear transition.
$IIIC_g$	43-60	5G $^{5}/_{1}$ greenish grey gravelly clay, few distinct olive mottles increasing to many with depth; firm, weak to moderate medium wedge shaped; many nearly vertical slickensides/pressure faces; frequent fine sub-angular quartz gravel.
W.T.	60 plus	The water table is actually at 24" as evidenced by a previous pit sited near this in which after three days of being dug water was found to within 24" of the surface.

content on the exchange positions. A stage having been reached in the upper part of the B that the clay was largely sodium (and magnesium) saturated the clay became unstable, its destruction resulting in formation of fine albic tonguing. It is possible that silica released by this destruction was leached into the C thus causing the upper C to be more cemented than the lower part. The formation of the duripan is however seen as chiefly caused by the presence of gradual lowering of the water table, a feature essential to its formation since if the duripan formed by leaching from above its very dense nature would preclude it from forming to any great depth (once formed, little further passage of water is possible through it.) As the water table descended cementation of the material left dry behind it took place. Simultaneously with the lowering of the base level, the stream began cutting into, and removing the bottomland soil in places and depositing alluvium in other places resulting in the complex pattern of soils found in these valleys. As down-cutting proceded remnants of Botrivier were left as benches along the streams often in most unlikely positions for the occurence of a bottomland soil. High up in the Botrivier-La Rhine water shed is for example an individual of Botrivier series about 20 ft. above the alluvial organic present bottomland. Often what appears to be two separate levels are found. In the abovenamed valley for example, further downstream Botrivier is found as a complex with young alluvium not more than 12 ft. above the present base level. At Dudley Vale an example was found on a convex topography surrounded by individuals on a flat topography with no apparent difference in morphology.

Since the streams dissecting Botrivier are young, correlations with Berg River terrace levels are rather hazardous, it would seem, however that Botrivier is of the same geological age as Daljosophat, if the bench level of Botrivier may be taken as corresponding with the 20 ft. emergence.

With a natric horizon and a duripan Botrivier is a Nadurargid It is not orthic as it has no assessable calcium carbonates present. In older systems it would have been defined as a magnesium solonetz.

Botrivier series definition

A_1 coarser textured than fine sandy loam less than 12 inches thick.

A_2 Values greater than 5 and chromas less than 4 or if this is lacking, a thin albic horizon tonguing finely into the underlying B_2 must conform to the colour requirements of the A_2 An abrupt transition to the B_2.

B_{2t} A prismatic dark coloured (or light coloured with prominent thick dark clay coatings on the ped surfaces - chromas and values of less than 4). More than 35% clay, more than 50% (Exchangeable Na + Exchangeable Mg) must be fully base saturated or if not the underlying C must be over saturated. R 60^{o} F less than 250 ohms or conductivity greater than 4×10^{3} mmho/cm. 25^{o}C (Sat. extract E.C.E.)
Abrupt transition to the C

C_m A duripan which does not soften in HCl and does not contain free carbonates. pH less than 7. With the colours of strong gley.

CHAPTER IV - SOIL GENESIS

Soils are the end products of the interaction and expression of the soil forming factors:- climate, organisms and topography; on the parent material over a given length of time. Of all soil forming factors, only time is independent of the other factors.

Climate, that is climate within the soil mantle, depends not only on external climate, but also on topography and type of material. The organisms living in the soil mantle vary according to the climate of the material as well as the nature of the material. Topography results from the eroding force of external climate over a given time acting on the parent material and parent surface. Parent materials of soils are themselves the end products of the forces of erosion climate and organisms on the parent rock over a given time.

The writer concurs with de Villiers (1962) that soils are the end products of soil forming factors at present operating, on the parent material. If one factor is changed the soil, being no longer in equilibrium with soil forming factors, must necessarily change. Time, as a soil forming factor, is important only in so far as it takes time for the soil to reach equilibrium with soil forming factors. Once equilibrium is reached, time no longer influences soil formation as long as the other factors remain constant. (In time the other factors do change - topography and therefore soil climate tends towards an equilibrium with eroding forces and thus changes with time until equilibrium is reached.)

Soils on those land-surfaces unaffected by events of the Pleistocene are presumed to be in equilibrium with their environment. Those soils on surfaces affected by the Pleistocene are largely also in equilibrium with environment or tending towards equilibrium. Only in those affected by events in recent times, is time considered an important soil forming factor.

Few instances were encountered where changes in topography resulted in soil differences without an accompanying change in parent material. This is to be expected in young landscapes and in semi-arid climates - only on well formed pediment slopes where there is a uniformity of parent materials do pure topographic (catenary) effects evidence themselves, such slopes are absent in the Western Province. Examples do occur where soil morphology is affected by topographic position.

The differences between Langvlei and the narrow colluvial valley soils (profile 24) i.e. of accumulation of salts in the solum and of gleying in the C; are directly attributed to topographic effects. Langvlei occurs in flat bottomland positions which are inherently poorly drained, while the colluvial valley soils occur in weakly formed bottomland positions with steeper slopes - positions in which accumulating waters rapidly drain away into the bottomlands.

The gleying in the B and C of Swellengift is the result of the flat topography in which it is found. Excess water in the Swellengift landscape drains away very slowly due to the flat topography with the result that anaerobic conditions persist in the B and C of Swellengift for, at the least, the whole rainy season.

In the area studied, parent material is the most important soil forming factor. This is to be expected since little climatic variation within areas of homogenous parent materials occured, the higher rainfall being limited to the granites, and the low rainfall to the sedimentary rock areas.

<u>Parent material as a soil forming factor</u>

Parent material is the material in which the soil was formed. The underlying rock is not the parent material of the soil and nor is the rock from which the materials originate. Discordia, Windmeul and Paardeberg all formed in granite-derived materials; these materials differed vastly from each other, however.

The intensity of climatic soil forming factors - weathering and leaching is low under the conditions pertaining in the aréa. The nature of the soils are thus closely correlated with the nature of their parent materials. Swartland is derived from the salt-rich Malmesbury graywackes, so is itself salt-rich. Swellengift, formed from the leached Klipheuwel sediments, is acid. In the phyllites and schists, the salts in the Malmesbury sediments have been recrystallised during metamorphism with other constituents to form new minerals. Kanonkop and Zwartfontein, soils formed from the metamorphic rocks, are acid soils because their parent materials contain no free salts (salts which are released by physical weathering alone).

The presence of discontinuities in lithology of the parent material of all the main soils in the area complicates the elucidation of leaching patterns. It seems that sodium and magnesium are the only cations to be moved to any extent.

Low weathering intensity encountered in the area is indicated by the presence of illite even in the upper colluvial horizons of Swartland and the presence of felspars in the clay fraction of Kanonkop and Zwartfontein. The clay minerals in Swartland are mainly inherited as such from the parent material. In Kanonkop and Zwartfontein clay minerals are formed by the alteration of the primary micaceous minerals (sericite and chlorite). The presence of only rudimentary soil formation in both of these soils is attributed to the fact that the schists and phyllites are less prone to physical weathering than are the graywackes - in Swartland physical weathering can liberate clays but in the metamorphic rocks only chemical alteration results in clay mineral formation.

The nature of the parent material as an important soil forming factor is most significant in the granite areas. Two basic types of material are encountered, viz. young poorly weathered material and highly weathered (lateritic/oxic/ferralitic) material. The highly weathered material (see Discordia series) is thought to be a relict of the Tertiary period.

During the Tertiary period, under weathering conditions more intense that at present prevailing, the granites were deeply and strongly weathered. This weathering took place in all probability on a flatter surface than that on which the material occurs today. Under the high rainfall necessary to produce lateritic weathering, the material could only have accumulated to the depths it occurs at on a gently sloping surface. As pointed out by de Villiers (1962) there is an interaction between topography (steepness of slope), rainfall and the depth to which weathering products may accumulate in equilibrium with that slope and rainfall. Weathering of the material exposed on the Tertiary surface produced a sesquioxide rich kaolinitic lcay. Almost all of the primary silicate and micaceous minerals in this material are weathered to clay and sesquioxides; most of the by-products have been leached out. In places this material on exposure has hardened irreversably in its upper regions.

Physical weathering of this hardened material on exposure has liberated clay and sesquioxides to produce an oxic soil - Discordia. Where a young coarse granite drift overlies the pre-weathered material, it has not broken up and Windmeul series has formed. Where a similar young granitic drift overlies weathered granite (with granite structure prcminent) Paardeberg series is found.

Differences in the state of division into fine particles of their parent materials has been the major influence in causing the resultant morphological differences between Daljosophat and Langvlei. This difference in texture of the parent materials is the result of different modes of deposition. The parent material of Langvlei has not been transported far, is a mixture of colluvial and alluvial debris. Daljosophat has formed in a river deposited clay, of the same origin as Langvlei but broken up into primary particles by the mechanical action of the river.

Zonality - the major soil forming processes in the area

As has been pointed out by many pedologists the theory of climatic zonality as first propagated by the Russians is not applicable in Africa where homogenity of parent material does not occur to the same extent that it does in Asia and the United States. Van der Merwe (1948) did apply zonal theory to South African soils. Indeed this is one of the few criticisms which can be directed at him. While professing to the zonal theory, he did not adhere to it. What he classified in his legend were the zonal (Climatic) soils formed from the modal parent material. Soils which formed on parent materials other than the modal parent material, as envisaged by him, were relegated to the intrazonal order. Van der Merwe failed to recognise that there exist climatic zonal soils for each and every parent material. In the area studied, for example, Zwartland is zonal on the salt rich Malmesbury graywackes and Kanonkop on the more acid less argillaceous phyllites.

The zonal soil in the area studied formed in argillaceous materials is an argid. Depending on the base status of the parent material either a natrargid or a haplargid will form.

Slabber (1945) and van der Merwe (1941) both put the soils into the podsolic soil group on the basis of the light textured and light coloured A and heavy dark coloured B horizons. Van der Merwe considered the soils truncated podsolic soils. Loxton (February, 1962) has called the soils "Noncalcic brown soils of the S.W. Cape". These soils have a weak horizon development, active lateral eluviation of clay, weak illuviation into the B and kaolinite as the dominant clay mineral. Loxton's classification was based largely on van der Merwe's. Van der Merwe recognised no difference between soils in the South Western Coastal Belt (Boland) and the Southern Coastal Belt (South Western Districts-Swellendam-Caledon). In the area studied lessivage processes are strong, and kaolinite and illite are the dominant clay minerals. The reason for poor horizon differentiation often being encountered is the youth of the landscape not weak illuviation into the B.

It would appear that under similar annual precipitations similar soils form from similar parent materials whether in a winter rainfall or a summer rainfall area. Milkwood Kraal defined by Beater in Natal derived from Ecca shales appears analogous to Swartland

On the formation of heuweltjies in the area

In the area there occur, isolated mounds from one to five feet higher than the surrounding soils and 15 ft to 16 ft in diameter. While they are relatively rare in occurrence here, they are of interest considering their abundance north of Malmesbury and especially in the Piquetberg area.

These mounds or "heuweltjies" ("heuwels") as they are known differ from those to the North by the absence of a lime pan parallel to the surface of the mound. During the coarse of the survey, pits were dug in a number of them. They are normally dark in colour (chromas and values less than 3), organic rich and of more or less uniform texture to a depth of 4 ft. in shales to 9 ft in sand deposits over shales. They have higher pH values and finer textures than the surrounding soils where the latter are acid and/or sandy.

Van der Merwe (1941) states "there is no doubt whatsoever that these mounds (in the Stellenbosch area) are of a different origin to those occurring in the drier regions - Malmesbury .. Districts". The writer can not agree. There seems no reason why the same mechanism can not be applied to the formation of both types of mounds although they differ morphologically.

Of the heuweltjies in the Stellenbosch area van der Merwe states that "The consensus of opinion is that two factors - trees and ants - are responsible for the formation of these mounds". The trees are believed to catch up dust in the air thus building the mound. The ants incorporate organic matter in the soil mass.

Those test pits made in heuweltjies in the area surveyed have the following factors in common - (a) a remarkable absence of stones in the upper five feet notwithstanding the presence of stone lines and gravel in the surrounding soils; (b) a remarkable uniformity of texture usually to over six feet although surrounding soils have well developed textural B horizons; (c) accumulations of salts of calcium and of organic matter (the organic matter being well mixed with the soil); (d) termite channels and, in those mounds still inhabited, fungus gardens.

The heuweltjies are believed to be formed by termites (rysmiere). These termites are not of the mound building type but of the subterranean type. In building their underground home these termites must remove soil particles in order to form channels. The particles are carried from the lower part of the soil into the upper part or onto the surface. By the continual building and rebuilding of the channels the soil massis eventually well mixed. This explains why in sandy areas - sand on clay - the heuweltjie has a much finer texture in the surface horizon than the surrounding soils but in the heavier textured soils there is not much difference between texture of the heuweltjie and that of the surrounding soils. During their channelling termites undermine gravel particles which are lowered by gravitation to near the lower extremity of the termite activity. Particles 2 mm and smaller in diameter are carried upwards by the termites. The coarser materials probably are deposited away from the mound and the fine materials are used to build the walls of the channels.

In the area studied, the highest heuweltjies were encountered in sandy materials. In the Malmesbury shale areas they are only slightly higher than the surrounding soils. In order to build the walls of the channels, fine materials are essential. In sands the termites must thus extend their activities deeper in order to procure these fine particles than in the shale areas where fine particles are present in the surface horizons. (Fine materials from the sides)

During digestion of soil particles and their cementation as channel walls the termite secretes calcium carbonates thus increasing the pH of the medium. The calcium in all probability ~~being~~ is derived from the underlying sediments. Du Toit (1939) with regard to the heuweltjies in the Malmesbury Piquetberg area states that they are associated with the occurrence of limestones. For the production of fungus gardens in the termitaria, a nearly neutral pH is essential. It is therefore to be expected that where there is no source of calcium the termites can not thrive and where there is abundant calcium present so will more migratory termites (flying ants) be able to produce termitaria.

Undoubtedly another source of cations is the digested remains of organic matter. In the course of a decade many tons of organic matter must be carried into the termitaria - each worker termite on the collecting routine carries roughly his own weight in organic material with each trip he makes. This is where the higher nitrogen, phosphorus and potash content of the heuweltjies as recorded by Juritz (1909), comes from.

Accepting the fact that termite channels occur in all heuweltjies in the area covered in this study, it had been suggested that the termites are secondary features and not the cause of the heuweltjie This would be a remarkable coincidence. The questions "Where is the material which has been removed from termite channels, and what of the expansion which must occur from the lowering of the bulk density of the soil by termite action?" can not be answered except by accepting fully the idea that termites are responsible for the heuweltjies in this area.

To return to van der Merwe's idea of a separate operating mechanism for heuweltjies in the dry areas (he includes Malmesbury in this dry group) all pits examined in heuweltjies in this area had termite channels evident, none had a lime pan. A heuweltjie in granitic material 3 miles from Malmesbury had no lime pan nor did one on the farm Ongegund in the shales, notwithstanding the lower rainfall. The absence of lime pans in heuweltjies in this area is ascribed by the author to the absence of limestones in the underlying rock, i.e. the lower calcium content of all rocks in this area than of those in Piquetberg where lime pans are found in the heuweltjies.

The writer believes the lime pan in the heuweltjies to the north to be caused by capillary movement of water carrying lime upwards into the heuweltjie where it is deposited parallel to the surface of the mound.

Near Rocklands just outside the area surveyed, there occur soils, resembling Swartland, with carbonates in the profile. These carbonates are inherited from the parent material. Here a mound with lime accumulation was seen (but no pit was dug). If in similar soils both type of heuwel is encountered with underlying rock being the only difference, the lime pan must clearly be related to the rock and if termites formed the one type of heuwel it is reasonable to expect the lime pan to be the secondary feature.

Chapter V - A PHILOSOPHY ON SYSTEMATICS

Pedology is a young science, it has not reached the maturity of Zoology Botany or Physics nor the senility of pure Chemistry. The Chemist knows what compounds are possible and what their properties will be if they be made. The Zoologist and Botanist know where new entities when found would fit in their systems of classification, they do not know the properties of these unfound entities. The soil systematist however, not only does not know what new soils await to be discovered; he would not be able to classify them into higher categories for the simple reason that there is no classification into which any soil may fit comfortably. In chemistry Mendeljeef recognised and predicted the properties of gallium, scandium and germanium in his classification of the elements even before they were discovered.

There do exist old soil classification systems into which any soil may be forced, the categories are however meaningless. To make the plight of the academically minded soil systematist worse, there is no internationally accepted classification system for soils. Classification systems used, other than in the United States, are often a conglomeration of misnomers. Terms such as lateritic, podsolic, pseudopodsolic, lateritic-podsolic! etc. are commonly used in the same systems with the terms ferralitic or oxisolic. Within the last sixty years the meaning of some of these words have become so warped that only the user and his intimate colleagues know to what he is referring. During the 1965 international soils conference the argument arose as to what was a podsol. If a podsol is so ill-defined as to result in confusion, ponder what the addition of the suffix -ic may result in - Podsolic - podsol-like. To go a step further add the prefix pseudo - . Pseudo-podsolic means a "sham podsol-like" soil. A pseudopodsolic soil resembles a podsolic soil but isn't one genetically; a podsolic soil resembles a podsol (in some vague manner) but isn't one; and now the systematists are up in arms as to the meaning of the basic term - podsol. A most unhappy state of affairs.

Probably this state of affairs would never have resulted had soils been classified instead of soil-forming processes. To the writer's way of thinking it is only logical to start a subject at the beginning. If it is soils which are to be classified then the classification must start with the soil individual as studied by means of the pedon. The individuals are classified into series; the series into families; families into subgroups and so on, up to the order level. The botanist and zoologist have only recently begun using genetic factors in theirclassifications. Why must the soil systematist be different? Admittedly it is easier to start at the top and work down, but this results in artificial classification - one not based on the lower categories which are after all the most important they carry the most accessory information about the entity classified.

Regarding the approach to building up a classification system in soil science there are two schools of thought. The European school starts building the church steeple, descends the bell tower to the chapel when the structure starts toppling over for it has no foundations. The Americans however have discarded the old unstable structure for a new one based on what the system intends to classify, viz. soils (U.S.D.A. 1960) The Americans are more fortunate than their European counterparts in having a wealth of data concerning their lower categories - the foundation of soil classification; yet the European school in its stubbornness can not see that the foundation must be in the lower categories and that therefore by abandoning their old structure and working together with the Americans they will both gain tremendously.

The question of applicability of the 7th approximation to soils in South Africa is commonly raised. It has been found wanting particularly in the oxisol and vertisol orders and in separating alfisols from ultisols. (de Villiers 1962; de Villiers and Loxton 1963; and Loxton 1962). What then is South Africa's contribution to to soil systematics. The writer wishes to state quite emphatically that South Africa can as yet contribute very little to the international field of systematics. Until we have studied our soil series we can not hope to make any contribution. It is pathetic to see each debutante soil systematic section throughout the world producing their own great group classification - their proud contribution to soil science. On what are these classifications based? Often based on reconnaissance surveys at scales of $1{:}10^6$ or longer, these classifications are truly map legends - if the classes are undefined and it is now known what soil series they include they cannot be grouped and called a classification.

South Africa's contribution to international soil systematics can be in one direction only viz. to study her own soils at the series level. When we know enough of our series we may contribute to one of the existing classification systems our knowledge and our criticism. The obvious system; which we, in helping will in turn be helped by; is that of the Americans. To quote Loxton (1962) "the 7th approximation .... seems to offer the greatest promise for a natural system of classification. The principles of the scheme have a logical soundness, and with modifications and improvements ... the system should find a permanent place in South Africa."

The greatest advantage of the 7th Approximation is that unlike older systems, it is open to changes with advance in knowledge to quote the U.S.D.A.: "It has been said:"classification is the mirror, in which the present condition of science is reflected; a series of classifications reflect the phases of its development!"" The European school of soil classification could well ponder over this philosophy asking themselves how far their classification has advanced in the last half-century,drawing parralel conclusions as to the condition of their science.

Some problems in soil classification

In nearly all of the soils studied in the area surveyed, clay movement had taken place to the extent that clay skins were evident in the B and/or C horizons. Where there are clay skins in the B_2, as in most soils described, the problem of whether the B_2 is argillic or not is confused by the presence of lithological discontinuities between the A and B horizons.

In Swartland for example the C horizon often has clay skins as well developed as, or even better developed than, the B_2. The C would never be considered anything but a C because of the presence of rock structure in it. The essential feature of Swartland, is that the parent rock has become sufficiently weathered to allow formation of soil structure. Carbonates, if present in the parent rock are still present in the B. Salts present in the parent rock have not significantly been leached from the B to the C. Weathering has been mainly physical, so liberating clays present in the parent rock. Swartland has, however well developed clay skins on ped surfaces (chiefly on vertical but also on horizontal surfaces). The matrix appears to have no illuvial clay - it is very dense so pores are too fine to be studied with a hand lens - cross section microscopic studies may show clay skins in the pores. The writer does not believe sufficient clay movement has taken place into the B for it to be natric, yet there are sufficient clay skins and the base status is sufficient to warrant definition as natric. Were the lithological discontinuity absent between the A and the B, the B might be designated cambic on the basis of not having sufficient illuvial clay to be natric.

In Daljosophat a similar problem was encountered. Here the problem was exaggerated by the expansion of the clays causing shiny ped surfaces which under a hand lens could not be truly identified as illuvial clay coating nor as pressure faces. In Daljosophat - a deep deposit of illitic clay, tending to weakly montmorillonitic at depth no clear differentiation between B and C horizons could be found. Due to the nature of the parent material, soil structure was present to 6 ft. and deeper. In Daljosophat then too, the B is essentially a cambic B, but the presence of illuvial clay (here presumed present) below a lithological discontinuity could cause it to be designated argillic

In both Swartland and Daljosophat microscopic study of thin sections would answer the problem. In this field no work has as yet been done in South Africa - a need sorely felt - all microscopic work on soils to date has been minerological.

In Katarra another problem concerning horizon designation was encountered. The deep and shallow phases of Katarra should be separated at the series level. In fact the two depth extremes do not fall into the same great group. The problem is where to draw the line between the two. The separation into phases was done to avoid the problem - the genetic implications of varying sand depths was ignored in classification.

In binary materials such as Katarra, clay skins are found in the horizon immediately underlying the discontinuity. Thus the artificial condition results that if the pedon is studied to a depth of 4 ft. it may be defined as an A_1-C profile, whereas if it is studied to 6 ft. it becomes an A_1, A_{21}, A_{22} ... IIB_{21t} ... C profile. A B_{21t} at 3 ft. must have greater genetic implications than one at 6 ft. and at 10 ft. few people would call it a B horizon. No one seems to have defined the depth of A material possible before the underlying material is designated C_t rather than B_{2t}. Loxton (1962) also avoided the problem by defining a deep sand variant of Kroonstad series.

Further, more intensive studies of Katarra will be necessary to be able to define the two soil series involved. The one defined as Katarra in this study is the shallow member. The "deep phase" was not studied in sufficient detail to enable definition of a separate series.

The application of the 7th approximation to the soil series defined

The fifteen soil series have been placed in the 7th approximation. In some cases problems other than those mentioned above were encountered. Since these problems were largely due to weaknesses inherent in the classification system it is as well to state them. These weaknesses have been pointed out before by de Villiers (1962); de Villiers and Loxton (1963) and Loxton (1962).

Swartland is essentially an argid. Yet if the key is used it is possible to place it in the Ustalfs. As pointed out by De Villiers and Loxton (1963), to separate Argids and Ustalfs, long-term direct moisture tension studies are needed. Even were these figures available, the ambiguity of the limits set would lead to difficulties.

Argids are defined in part as soils which most of the time are dry unless irrigated; the soil and not just the solum must be dry for the most part the substratum below the soil is dry. Ustalfs are are usually moist in some part of the solum but have periods in excess of 3 months when some part or all of the solum is dry. Apparently argids are dry for more than six months a year.

As has been pointed out, (Chapter 3), Swartland series is drier when cropped to wheat than when fallow ploughed. The length of the dry period is thought to vary between 4 months for the fallow ploughed soils and 6 to 7 months for the members cropped to wheat. The soil order therefore changes from season to season. Long term means would be essential in assessing Swartland's moisture regime.

While the writer concurs that the idea behind the separation on the basis of moisture regime is a good one, it does not seem a valid differentiating characteristic in practice. It is even possible eg. Langvlei series, to separate two members of the same series at the order level using moisture regimes as differentia. (Here it was position in landscape which caused one profile to be wetter than the other - the surmise of difference in wetness being based on morphology.)

An anomaly occasionally encountered in coarse sands is the presence of clay lamellae in some pedons and not in others of the same series in the same individual. Since the presence of lamellae in psamments separates sub-groups, it is felt that the total thickness of lamellae differentiating at this level should be defined. The lamellae studied in this area have always been thin, the total thickness never exceeds 1 cm. The fact also, that lamellae in Katarra have been found in the A_2, shows that, unless they occur close together with a considerable total thickness (even if not sufficient to be argillic) they have little genetic significance.

The preweathered material in Windmeul, as has been pointed out previously, poses a problem not only in horizon designation but also in classification. C material is defined amongst other properties as "material relatively little affected by pedogenic processes .. modified by weathering outside the zone of biological activity, .. or by cementation .. by iron. These alterations include chemical weathering deep in the soil. Some soils are presumed to have developed in materials already highly weathered, and such weathered materials that do not meet requirements for A or B is considered C". (Quotation U.S.D.A. May, 1962). A cambic B horizon is defined as an altered subsurface horizon. To quote U.S.D.A. August, 1962: "Soil forming processes have changed or altered the material enough to ... form structure of texture is suitable; to liberate some free iron oxides, to form silicote clays, or both; .. and to obliterate most evidences of the original rock structure."

The definition of cambic horizons and C horizons overlap each other when applied to old highly-weathered materials. Had the material in Windmeul's subsurface weathered under the present erosion cycle it would unhesitatingly be defined as a cambic horizon. Since it is presumed to be relict of a previous erosion cycle it is possible to define it either as a cambic horizon or as C material, i.e. the strongly weathered material does not belong in the solum but is a landscape feature, now parent material of the new soil. The anomaly is that the major difference between C material and cambic material is one of genesis. If weathering has taken place to form clays within the zone of biotic activity the horizon is cambic if outside the zone of biotic activity it is C material. This problem is essentially the same as that encountered in Daljosophat in demarcating the boundary between the B and C horizons where both are equally strongly structured (caused by the nature of the parent material).

With regards to the definition of oxic horizons, it is felt that the limit on felspar percentage set at 1% is too low especially in dealing with soils whose parent materials have high felspar contents. The parent material of Discordia is a highly weathered granitic material. Only kaolinite is found in the clay fraction, structure and consistence are that of oxisols, cation exchange capacity of the clay is very low yet there are often more than 1% felspars in the finer sand fraction. Felspar percentage probably never exceeds 5% in Discordia (In profile 112 felspar percentage varies between 0% and 3% in the finer fractions being absent in the coarse sand fraction). For granites to weather as far as they have in forming Discordia would take much more drastic weathering conditions than is needed to weather a sandstone to the same stage. Perhaps to set the limit at 5% for soils from rocks with more than 50% felspars, 2% of those with 25% to 50% felspars and 1% for those with less than 25% felspars would be a better limit for diagnosing oxic horizons on felspar content. This would how-however result in confusion when dealing with soils formed in mixed drift materials as well as in cases such as the one in point, where ferralitic weathering formed the parent material of the soil and not the soil (i.e. on old land surfaces). Here the parent material is very low in felspar content compared with the parent rock and ferralitic weathering no longer takes place.

SUMMARY

A systematic soil survey of the area was carried out following the basic methods advanced by the United States Department of Agriculture in their "Soil Survey Manual". Fifteen soil series were defined and mapped.

During the soil survey the soils as well as the geomorphology of the area in which they occurred were studied. The major part of the area has been affected by marine planation during the late Tertiary and subsequently by river denudation and planation, so that the topography is today gently undulating with the crests of the undulations in the same plane.

In most of the soils the most striking genetic process which has taken place is the downward movement of clay. In the Malmesbury graywacke areas, and in the bottomlands, clay has moved under the dispersing effect of sodium and/or magnesium to produce Natric B horizons. On the more acid rocks, eg. Klipheuwel sandstones and the phyllites and schists, lessivage processes are not as strong, argillic B horizons are however to be found.

Parent material and geomorphological history were found to influence soil formation more strongly than other soil forming factors. An oxisol-Discordia series - was found to have developed from laterised granite of Miocene age. The soil which developed from granite not preweathered - Paardeberg series - showed only weak soil development. Preweathering within the area has not affected the soils formed from the sedimentary rocks. The formation of the duripan in Botrivier series is attributed directly to the geomorphological changes in the area in which it is found. Here the lowering of the water table present in the C has allowed clay destruction under the influence of a high pH to release silica which has cemented the original Cg to form a duripan.

The most widely distributed soils in the area are Swartland series and Kanonkop series. Swartland, formed from Malmesbury graywackes, has a natric B which is saline and often alkaline. Kanonkop, formed from Malmesbury phyllites, has a weakly formed argillic B.

Of the fifteen series described only five could be recommended for extensive irrigation. These series, viz. Discordia, Windmeul, Fernwood, Ofazi and Maputa all occur mainly around the two mountains Paardeberg and Paarlberg. These are also the only soils which are at present irrigated to any great extent.

In fitting the soils into the 7th Approximation classification system the lack of long term moisture tension curves was felt. From superficial observations; it would appear that the separation of orders on the basis of moisture tension, can result in the ambiguity that a soil may change its order according to its stage in the crop rotation, eg. Swartland series.

In soils with cambic B horizons, viz. Daljosophat and Windmeul series; the extent of the solum as it is defined in the 7th Approximation was found to be arbitrary. The difference between a cambic B and C material becomes ambiguous when dealing with preweathered parent materials.

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Appendix 1: Analytical methods and analysists

Particle size distribution

Analyst : Mrs. A.M. Odendaal

Method : Pipette method as set out in "Analytical Methods Division of Chemical Services 1955 with slight modifications in sampling times.

Exchangeable cations and exchange capacity

Analyst : Miss I. Sichel assisted by Mr. L. Oosthuizen

Method : Modified from the basic method generally used as set out in "Soil Chemical Analysis" M.L. Jackson 1958. Soil is leached with N NH_4Cl (pH 7.0); excess NH_4Cl removed with 80% E_tOH and soil leached with $\frac{N}{10}$ HCl. The HCl leachate is used to determine C.E.C. by determining NH_4^+ by the Kjeldahl method. Na + K are determined in the NH_4Cl leachate by means of an Eel Flame photometer, and Ca and Mg by the versenate method.

Saturation extract soluble cations

Analyst : Miss I. Sichel assisted by Mr. L. Oosthuizen

Method : As described in "Diagnosis and improvement of saline and alkali Soils". Agric. Handbook No.60 U.S.D.A., 1954. Cations determined as per exchangeable cations.

Carbon and Nitrogen percentages

Analyst : Miss I. Sichel assisted by Mr. L. Oosthuizen

Carbon Method : Modified Walkley-Black method using $K_2Cr_2O_7$ and $FeSO_4.(NH_4).SO_4$ with barium diphenylamine sulphate as an indication.

Nitrogen Method : Modified Kjeldahl method using salicylic acid and $K_2SO_4 + H_gO$ for digestion. NaOH with $Na_2S_2O_3$ (to reduce the mercury) is added to release the ammonia.

pH, Resistance and Free Carbonates

Analyst : Mrs. A.M. Odendaal

Methods : pH by Beckman glass electrode pH meter on water saturated paste.

Resistance by means of an Ohm meter with buzzer and soil paste cup on the saturated soil paste.

Free carbonates by means of a Collins calcimeter. (Reference : J. Soc. Chem. Ind. Vol. 25,1906,p.521.)

Clay mineral analysis

Analysts: Physical Chemistry Section, Soils Research Institute under Dr. C.F.S. van der Walt

Method : X-ray diffraction method

Sesquioxide analysis

Analyst : Mr. E.C. Haumann

Method : Na_2CO_3 fusion method

Free iron

Analyst : Mr. F. de Wet

Method : A combination of the methods suggested by:
Deb B.C. in J. of Soil Sci: 1, 1950
Mitchell and MacKenzie in Soil Sci: 77, 1954
Soviet Soil Sci. No. 4, 1961, p. 443

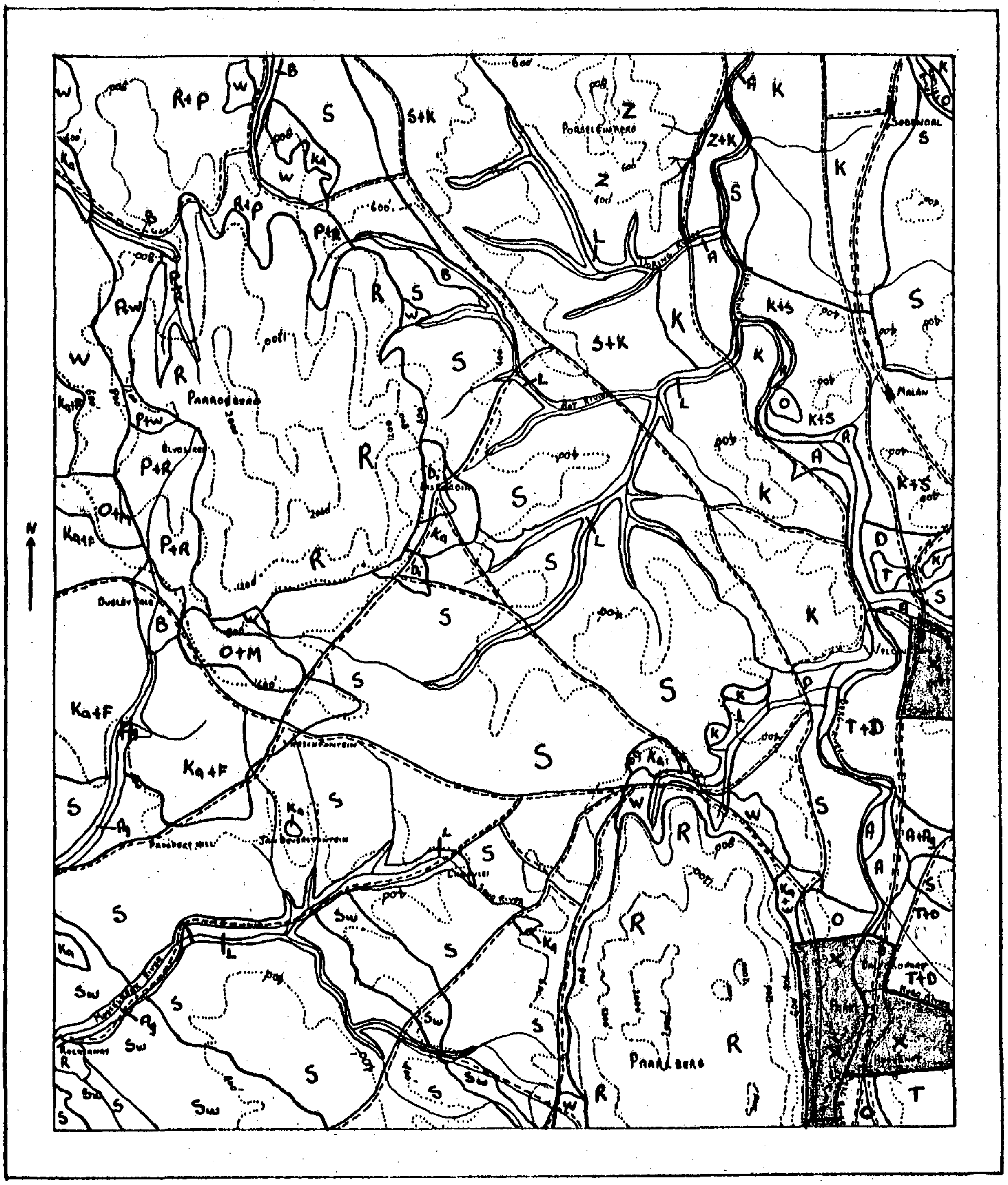
Infiltrometer studies

Carried out by: R.J. van der Bergh

Method : Using a double ring infiltrometer as designed by the Rhodesian dept. of Agriculture.

MAP 3: Simplified Soil Map

(Map at 1:50,000 being draughted)



Approximate Scale 1:150,000

MAP LEGEND

S	Swartland	Ag	Rocklands	A	Alluvium
Sw	Swellengift	B	Botrivier	R	Rock
K	Kanonkop	D	Daljosophat		Built up area
Z	Zwartfontein	Di	Discordia		Railway lines
L	Langvlei	O	Ofazi		Major roads
Ka	Katarra	F	Fernwood		Elevation in feet
P	Paardeberg	M	Maputa		Major drainage lines
W	Windmeul	T	Terrace gravels		