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1 Notes on the Soils of Lesotho

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Notes on the Soils of Lesotho

by

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THE LAND RESOURCES DIVISION

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The Directorate of Overseas Surveys is the survey organization of the British Government's Ministry of Overseas Development. It undertakes geodetic surveys, topographical mapping and land resources investigations under the British programme for Technical Assistance to developing countries.

The Land Resources Division of the Directorate undertakes or assists with the assessment of land resources, and the making of recommendations for their development and use. It works within the fields of geology, geomorphology, soil science, plant ecology, climatology, hydrology and irrigation, agriculture and forestry.

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PREFACE

The information presented in this bulletin was collected by D. M. Carroll during a sixteen month tour in Lesotho from January 1964 to May 1965. He was then a member of the Overseas Pool of Soil Scientists of the Ministry of Overseas Development, seconded to the Government of Basutoland (now Lesotho) under the Special Commonwealth African Assistance Plan. In this period semi-detailed surveys of selected development areas for the Lesotho Agricultural Department were carried out, as well as more extensive field work for a land resources survey.

Since the completion of this survey, the Overseas Pool of Soil Scientists has been amalgamated with the Land Resources Division of the Directorate of Overseas Surveys, under whose auspices the report and maps have been produced. The analytical data were supplied by C. L. Bascomb, Soil Chemist of the Soil Survey of England & Wales, at Rothamsted Experimental Station.

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ABSTRACT

This report presents soil information collected during a land resources survey of Lesotho (Basutoland).

The influences of geology, geomorphology, climate and vegetation on soil formation in Lesotho are discussed. The properties of Lesotho soils are described and a provisional soil classification is suggested. The major well developed soils of the lowlands are fersiallitic soils and claypan soils found over pediplaned Karroo strata. Vertisols have developed over alluvium, dolerite sills and in topographic depressions, while eutrophic brown soils have developed over peneplained basalt in the foothills, and rendzinas over steep basaltic mountain slopes. Twenty selected profile descriptions with analytical data are presented as an appendix. A provisional soil map at 1/250,000 accompanies the report.

RÉSUMÉ

On trouvera dans ce document diverses données pédologiques recueillies au cours d'une étude portant sur les ressources naturelles de Lesotho (Basutoland). Les auteurs décrivent les effets de certains facteurs géographiques sur l'évolution des sols de la région ainsi que les caractères de ces sols, en proposant une classification provisoire. Dans les parties basses du pays les principaux sols bien développés sont les suivants: sols fersiallitiques et sols lessivés recouvrant des couches de roche de Karrou formant pédiment. Des vertisols se sont formés au-dessus des alluvions et des filons doleritiques, ainsi que dans les dépressions. Au-dessus des basaltes formant pénéplaine parmi les contreforts des montagnes on trouve des sols bruns eutrophes; et sur les pentes basaltiques abruptes il y a une couche de rendzines. Un appendice contient vingt profils accompagnés de données analytiques. Une carte pédologique au 1/250 000 est annexée au document.

PART I - INTRODUCTION

Lesotho, previously known as Basutoland, forms an enclave within the Republic of South Africa; it lies between latitudes 28° 35′ and 30° 40′ south, and longitudes 27° 00′ and 29° 30′ east. Some two-thirds of its 30,344 square kilometres (11,716 square miles) is mountainous and subject to a rigorous winter climate. The country's economy at the time of writing depends on a livestock industry, subsistence agriculture, the earnings of labour outside the territory and grants from the United Kingdom Government.

This technical bulletin describes the major soil types of Lesotho; it accompanies a land resource study, 'The Land Resources of Lesotho' (Bawden and Carroll, 1967) and presents the more detailed pedological information used in the compilation of that report. There is little previously published information on the soils of Lesotho. Van der Merwe (1941) and Venter (in Staples and Hudson, 1938) briefly discussed some of the country's soils, and the Lesotho Agricultural Department has produced a provisional classification of the major soil types.

In this bulletin, the factors affecting the formation of soils in Lesotho are outlined and the properties of each soil type described, both in a generalized form and also by reference to representative profile descriptions, and their corresponding analytical data. These soil types are classified in terms of the mapping units used for the 'Soil Map of Africa' (D'Hoore, 1964) and their distribution is shown on a provisional soil map at 1/250,000 scale.

TEAM COMPOSITION

The survey was carried out by D.M. Carroll, with the assistance of I. Tennent, Land Use Planning Officer of the Lesotho Department of Agriculture, during the investigation of the potentially irrigable soils. The Soil Conservation Service of the Department of Agriculture supplied labour, transport, stores and equipment as required.

PROCEDURE

Throughout the soil survey considerable use was made of vertical panchromatic aerial photographs taken by the Aircraft Operating Company, Johannesberg, partly in 1961 and the remainder in 1962. Those of the eastern and most mountainous part of the country are at a scale of 1/40,000, the remainder being at a scale of 1/30,000. The Directorate of Overseas Surveys has produced a series of 1/50,000 scale contoured topographic maps from earlier photography taken in 1962. The soil survey, during which soil boundaries were plotted on these maps, was carried out in three stages:

Stage I

Semi detailed surveys of potentially irrigable alluvial soils were made. Provisional soil boundaries based on land form differences were drawn on the 1/30,000 air photographs. The soils were examined in the field in inspection pits and auger holes. The soil boundaries, adjusted where necessary, were transferred to the 1/50,000 maps.

Stage II

Detailed surveys of two development areas, Mejemetlata and Thaba Phatsoa covering about 103 square kilometres (40 square miles), were made. Provisional soil boundaries based on differences in landform were marked on the air photographs. Special mosaics at 1/10,000 scale were constructed for the survey by the Aircraft Operating Company, Johannesberg, which were used as field documents. Soil inspection pits and auger holes were made in the main soil types distinguished, and the provisional soil boundaries were checked in the field. The results were compiled as two overlays to the mosaics: a soil and land capability overlay, and a development plan overlay, the latter being made in collaboration with the Soil Conservation Officer.

Stage III

Reconnaissance soil survey of the remainder of Lesotho was the largest part of the project. It was based on a division of the country into landform units. Those for the mountainous area were established on 1/50,000 topographic maps by M. G. Bawden of the Land Resources Division, Directorate of Overseas Surveys and P. J. Beaven of the Tropical Section of the Road Research Laboratory, based on a study of the air photographs (see Bawden and Carroll, 1967). The lowland landform units were established by D. M. Carroll also by air photograph interpretation. Field checking of the landform unit boundaries and their adjustment as necessary, was followed by an examination of the soil cover for the units by means of inspection pits and auger holes. Profile pits were described and sampled for all the important landform units. The distribution of the different soil types and the associated landform units was plotted on 1/50,000 scale maps.

The terminology and method of description of profiles was generally in accordance with the procedure outlined by the Soil Survey staff of the United States Department of Agriculture (1951) and as later modified by the same authors (1960).

The soil maps resulting from these surveys were compiled by the Directorate of Overseas Surveys into a territorial soil map at 1/250,000 scale which accompanies this bulletin.

The 1/50,000 scale maps of the potentially irrigable areas, the 1/50,000 scale landform unit - soil maps, as well as the 1/10,000 overlays for the development areas can be consulted at the Soil Conservation Office in Maseru, Lesotho.

ACKNOWLEDGEMENTS

The authors wish to thank the Soil Conservation Section of the Lesotho Department of Agriculture for their help and the provision of ancillary staff for fieldwork. In addition, they are grateful to many Southern African and British pedologists for much helpful discussion of pedological problems. The authors also thank their colleagues at the Directorate of Overseas Surveys and Rothamsted Experimental Station for their aid at all stages of the work.

PART II - FACTORS AFFECTING SOIL FORMATION

GEOLOGY

The geological succession in Lesotho is relatively simple as all the formations found there form part of the Beaufort and Stormberg series of the Karroo system, which range in age from Triassic to Lower Jurassic (Table 1). The lowest members of the succession are undisturbed sedimentary rocks, which are capped by several thousand feet of basaltic lava. Numerous dolerite intrusions occur, both as dykes and large sills.

TABLE 1 The geological succession in Lesotho (Stockley, 1947)

Karroo System	Stormberg Series	Lower Jurassic	Drakensberg Beds
		Upper Triassic to Rhaetic	Cave Sandstone
			Red Beds
			Molteno Beds
	Beaufort Series	Triassic	Upper Beaufort Beds
Dolerite intrusions		Rhaetic and Lower Jurassic	

The *Upper Beaufort Beds* are yellowish weak sandy shales with some sandstones and reddish mudstones. Illite is a common constituent of these and other fine-grained Karroo rocks (Du Toit, 1954) and soils derived from them contain inherited illite in their clay fraction.

The *Molteno Beds* mostly consist of coarse yellow felspathic sandstones alternating with white arkosic grits; grey shales or mudstones also occur in the southern part of the country. Molteno sandstones are more compact than those above and below them in the geological succession and appear to weather more slowly. The soils derived from Molteno sandstones have a much higher content of medium and coarse sand than soils derived from other sandstones in Lesotho. In some localities, Molteno sandstones are slightly calcareous and weather to a stiff, brown calcareous clay.

The *Red Beds* are composed of red and brown felspathic sandstones and sandy shales. These are not weathering colours, but the true colour of the rock, since ferric oxide was deposited simultaneously with the other rock-forming components (Stockley, 1947); the resulting soils vary from 10 YR to 2.5 YR in hue and have a high chroma. Truly red soils can form from Red Beds material without being necessarily influenced by the weathering products of dolerite. Most Red Bed rocks are fine-grained and the texture of the soils derived from them is dominated by the fine sand fraction.

The *Cave Sandstone* is a hard, massive and unbedded, fine-grained aeolian sandstone with white or yellow colours. It contains fresh mica and felspar and weathers to a pale coloured clay-rich material. Microcline is the commonest felspar in Cave Sandstone and other Karroo rocks (Du Toit, 1954) and provides a primary source of potassium ions.

Dolerite occurs as dykes of all sizes or as thick and extensive sills and inclined sheets. This dark coloured, medium grained rock contains plagioclase felspar, augite and much chloritic material, and iron ore minerals. Biotite and olivine are common component minerals.

The *Drakensberg Beds* consist of very uniform compact or amygdaloidal basalt or olivine basalt lava flows, the outcrop of which covers the major part of Lesotho above 1850 metres (6,000 feet). The mineral compositions and textures of the lavas are generally similar to those of the dolerites, but the lavas often contain a high proportion of glassy material. Tuff, agglomerate, ash and tuffaceous sandstone horizons occur locally within the basalt flows, but do not significantly affect soil formation.

GEOMORPHOLOGY (See relief map opposite)

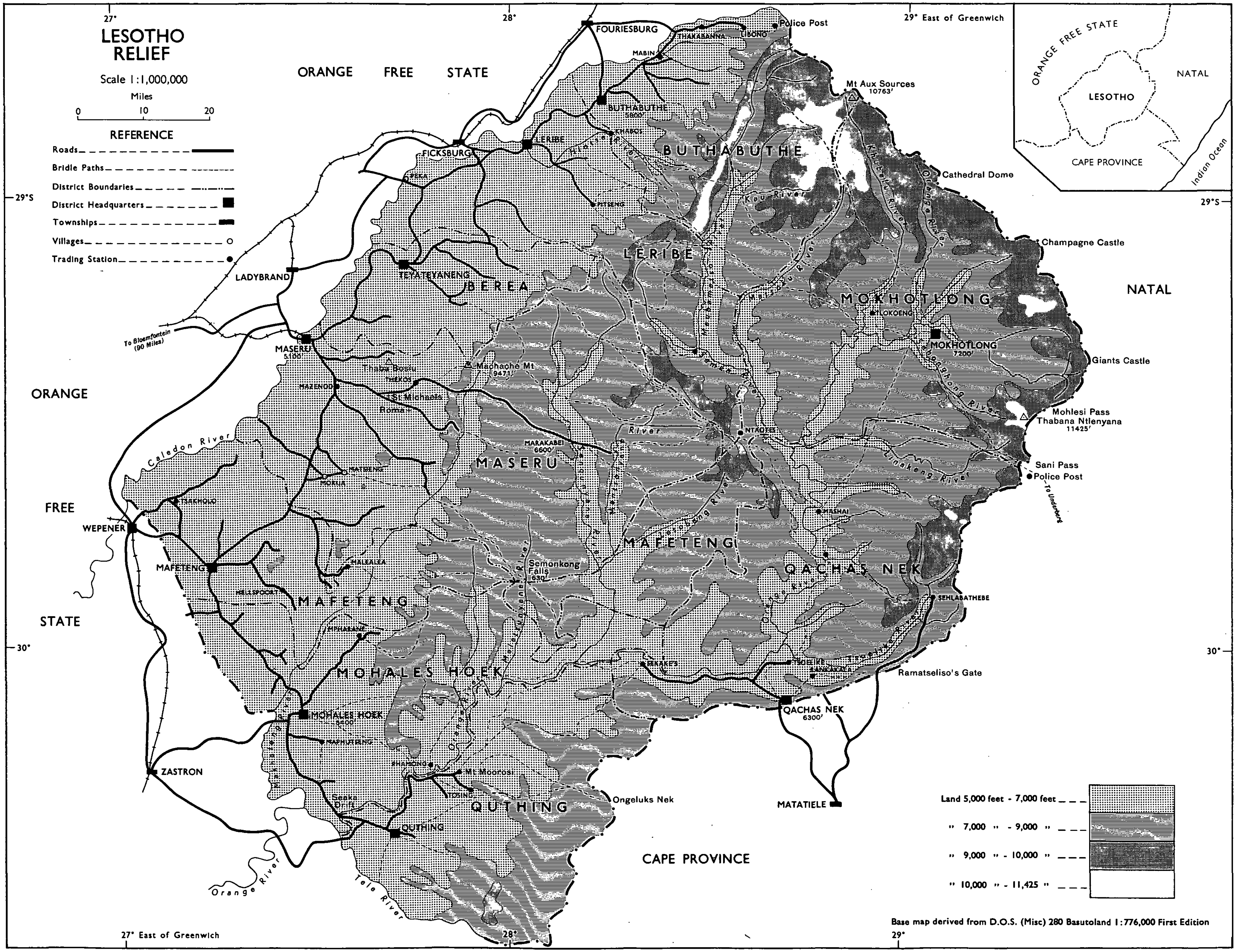
Lesotho can be divided into two physiographic provinces; the lowlands and the mountains. The lowlands form part of the South African Highveld; the mountains, known as the Malutis in Lesotho, form part of the great Drakensberg range. The mountain province can be further divided into a foothill region and a mountain region.

(a) The Lowlands

The lowlands of Lesotho consist of a belt of sedimentary rocks, which outcrop along the country's eastern border; the width of the belt varies from three to fifty kilometres (two to thirty miles) and its elevation is between 1,500 and 1,850 metres (5,000 to 6,000 feet) above sea level. The lowlands are a part of the 'African' surface described by King (1962).

In the extreme west of Lesotho, there are extensive plains, underlain by Beaufort and Molteno rocks, with a general elevation of about 1,500 metres (5,000 feet); they are composed of broad, coalescing pediments, which merge smoothly into convex senile interfluves. These plains seem to represent a more recent base-level, which erosional processes now operating are cutting. The broken and hilly topography of much of the Molteno and Red Beds outcrop has been produced by headward stream erosion and slope retreat. The result of this dissection is a pattern of slightly concave pediments passing up slope into spurred interfluves with broad, gently sloping convex crests.

Soil formation in the lowlands is only indirectly related to the underlying bedrock because both slope crests and pediments are covered by mantles of colluvially re-worked material. It is now generally believed that during the Quaternary era, Africa had its own palaeoclimatic sequence (D'Hoore, 1964) and it seems likely that the thick mantles covering pediment slopes today were formed by long periods of intense erosion during a pluvial stage of an interglacial period, followed by gentle colluviation and accretion. Sediments of this kind, termed 'pedisediments' by South African pedologists cover large areas of the lowlands to depths of over 20 metres (60 feet). The material is well stratified and is mainly composed of a greyish calcareous clay. It is usually overlain by more recent sandy sheetwash or creep deposits, and because of the morphology of this composite profile, it has been called 'pseudopodsolic' by some pedologists. The pedisediment is now being eroded into deep gullies (dongas) which may represent the sites of old buried drainage channels.



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Many other lowland soils do not have a residual origin, although a clear transition from weathering rock to the soil's B horizon may sometimes be observed. There appears to have been considerable reworking of soils overlying the crests and upper parts of slopes; the many stone-lines and bands of rounded grit encountered, indicate that soil creep and other colluvial processes are active even on very gentle slopes. Interfluve crests are usually occupied by fersiallitic soils without marked horizon differentiation; their common boundary with the 'pseudopodsolic' soils is the landform boundary separating slope crest and pediment.

The outcrop of numerous doleritic intrusions greatly modifies the lowland landscape. Narrow dykes form hummocky ridges extending for many miles; the soils over the dykes are shallow and stony. Thick sills rise a thousand feet above the surrounding plains in the extreme west of the lowlands; the broad pediment slopes at the foot of these sills are covered by dark clays.

There are two different kinds of alluvial deposit within Lesotho. In the first kind, both flat and inclined terraces are found along stream courses and small rivers, where fine textured alluvium from mountain sources is deposited; this material gives rise to a dark heavy clay soil. The second kind is of deep, weakly stratified sandy alluvium occurring along the Caledon River, a major tributary of the Orange River. Here the alluvial material from basaltic sources is greatly diluted by sandy material from the outcrops of sedimentary rocks surrounding these terraces; the resulting soils are mostly only coarse or medium textured and their distribution pattern is complex.

(b) The Foothills

A conspicuous escarpment marks the eastern boundary of the lowlands; it is virtually unbroken in a north-west to south-east direction and is as high as 300 metres (1,000 feet) in places. This escarpment is composed of rocks of the Red Beds capped by the harder Cave Sandstone which above the escarpment forms plateaux or structural platforms with a general elevation of 1,850 metres (6,000 feet). Isolated remnants of these plateaux occur as steep-sided inselbergs throughout the lowlands.

Many of these plateaux have been covered by vast outpourings of the Drakensberg lavas. The region known as the 'foothills' in Lesotho comprises both the gently sloping pediments at the base of the mountains and the sandstone plateaux themselves. The soils overlying Cave Sandstone are yellow brown and coarse to medium textured and those of the pediment slopes are red friable clays. Both groups of soils appear to be reworked and contain stone lines.

(c) The Mountains

The basaltic mountains cover over two-thirds of Lesotho, mostly as a montonous sequence of steep ridges and deep valleys. The general steepness of these slopes allows only poor profile development in the soils of the mountains, and accounts for the widespread distribution of shallow, immature soils. Deep soils only occur where the topography is flat enough to permit the accumulation of colluvial material. Colluvial soils of this kind cover flats in valley floors and the remnants of dissected valley floodplains, which are now sited on montane spurs flanking the major rivers.

The steep mountain slopes level off at about 2,800 metres (9,000 feet) to an extensive rolling upland plateau; this plateau has been dated by Dixey (1942) as late Jurassic and forms a major part of the Gondwana surface described by King (1962). Although the action of frost and ice promotes rapid physical weathering of the basaltic rocks, there is little chemical weathering at these high altitudes and wind and water remove most of the rock debris before it can develop into soil.

CLIMATE

The climate of Lesotho ranges from semi-arid to humid. The total annual rainfall averages about 740 millimetres (29 inches) over the whole country and varies from less than 500 millimetres (20 inches) a year in the valley of the Orange River and 600 - 900 millimetres (25-35 inches) in the lowlands to over 1,000 millimetres (40 inches) in the mountains. These amounts are concentrated in the summer months from October to April and little rain falls in the remainder of the year. Both the annual totals and the seasonal distribution of rainfall can vary greatly from year to year. Much of the total rainfall occurs as heavy thundershowers. Snow covers the upper slopes of the mountains for several months every year. Relative humidity is highest in the summer months, when its value ranges from 45% to 80% throughout the day.

The temperature in Lesotho varies from place to place according to altitude and decreases with increasing elevation. The mean temperature in the lowlands during June is about 7°C (45°F) with average maxima and minima of about 15°C and 0°C (59° and 32°F) respectively. In January, the mean temperatures are around 21°C (70°F) with average maxima and minima of 25°C and 15°C (77° and 59°F). Extreme temperatures as high as 37°C (98°F) and as low as -10°C (14°F) have been reported. Frost occurs throughout the winter months and is a powerful agent of mechanical weathering. The open pan evaporation is probably over 1750 millimetres (70 inches) per annum in the lowlands and less than 1250 millimetres (50 inches) in the mountains.

The mountainous nature of the country's topography greatly affects winds and the moisture they carry. Rain shadow effects are common in the major river valleys of the mountains. Strong winds in the dry season desiccate and erode the soil.

The aspect of a mountain slope influences the amount of radiation and wind-borne precipitation that it receives. North-facing slopes have a warmer climate than south-facing slopes; evaporation is more pronounced and snow lies for shorter periods. Under these conditions, the rates of oxidation and leaching are higher and the soils on these slopes are brown, friable clays.

The dry and cold winter climate of Lesotho does not favour rapid chemical weathering and the harsh winter climate of the upper mountains almost completely inhibits soil development.

The intensity of leaching generally increases with increasing altitude, although the black clays of the mountains are able to maintain their high content of bases, because they are only slowly permeable and occur on steeply sloping sites that quickly shed rainwater. Soils derived from Cave Sandstone at elevations of about 1850 metres (6,000 feet) have a lower base saturation than the morphologically similar soils derived from similarly fine grained sandstones in the lowlands at elevations of about 1500 metres (5,000 feet).

VEGETATION

Lesotho is a grassland country and there is an almost complete absence of natural tree growth. These grasslands may be climax communities and Acocks (1953) has suggested that conditions are too dry or too frosty to permit the development of trees. Other Southern African botanists, however, prefer to regard such grasslands as fire sub-climax communities (Rattray, 1960). A sub-climax successional to shrub may occur at any altitude if the site is sheltered enough.

Many years of veld fires and overgrazing have greatly influenced the formation of the present vegetation, and the mismanagement of land has encouraged the invasion of the grasslands by shrubs.

Much of the lowlands of Lesotho have been mapped as *Cymbopogon - Themeda* grassveld (Acocks, 1953). The most important component of this veld type is *Themeda triandra*, virtually pure stands of which may be found on soils derived from dolerite. *Eragrostis* and other hardy grasses replace *Themeda* in over-grazed areas. Sour grasses become more numerous in the wetter northern section of the lowlands and Acocks has described this area as a transitional zone from *Cymbopogon - Themeda* grassveld to Highland Sourveld. Remnants of the Highland Sourveld itself occur in sheltered valleys below about 2,100 metres (7,000 feet) as a mixture of small evergreen shrubs and trees. Most of the grasslands of the foothills and the lower mountain slopes have been included by Acocks in his *Themeda - Festuca* Alpine Veld type; *Themeda triandra* is still the dominant species. On the highest mountain slopes, above an elevation of about 2,600 metres (8,500 feet) short leaved and short stemmed grasses of the Fescue type predominate. *Festuca* spp. also occur at lower elevations on colder and moister south-facing slopes. The grass cover of the mountain tops is sparse and much bare ground is exposed.

Although the natural vegetation of Lesotho is grassland, the surface horizons of many lowland soils have low carbon contents even in the soil's virgin state, and are usually structureless with high colour values. Shallow soils over dolerite or basalt usually have a higher organic matter content as these materials provide a base-rich weathering environment, which stimulates the growth of a thicker grass cover. There is a dense mass of vigorous roots in the black clays of the lower mountain slopes and the products of decomposition of dead roots are easily absorbed by the soil's colloidal complex with the result that a strong, stable granular structure is developed. This grade of structure is chiefly associated with *Themeda* and is usually lacking in areas where alpine grasses are dominant.

Grassland gives only limited protection against erosion, particularly as much of the country's rainfall is of high intensity and is concentrated into only a few months of the year. In these conditions, it is not surprising that the parent materials of many Lesotho soils are erosional mantles and not weathering bedrock.

PART III - THE SOILS OF LESOTHO

The most important soils of Lesotho, both agronomically and pedologically, are described in this chapter. No attempt has been made to erect a taxonomic soils classification at this stage and it has been found convenient to describe the country's soils in terms of the mapping units of the 'Soil Map of Africa' (D'Hoore, 1964).

The general level of investigation was not detailed enough to permit the mapping of soil series and most soils are included in sets. Sets are flexible groupings of soils with like profiles; they can be broadly defined in terms of a modal soil and variations from it (Taylor and Pohlen, 1962). The constituent soils need not be geographically associated and are not necessarily of equal taxonomic rank. Each set has been given a geographical name after a locality in which the set is commonly found. The soil sets and other mapping units used in Lesotho are shown in Table 2.

In the following sections, a broad definition of each soil mapping unit is given, and the characteristic sites as well as morphological and chemical profile properties of its constituent soil sets are discussed. The raw mineral soils and lithosols, however, are not described in detail as they are of small pedological importance.

TABLE 2 Soil sets and mapping units

UNITS OF 'SOIL MAP OF AFRICA' OCCURRING IN LESOTHO		LESOTHO SOIL SET	SELECTED PROFILES (IN APPENDIX)
A Raw mineral soils	Aa Rocks rich in ferromagnesian minerals	-	-
	Ac Rocks, not differentiated	-	-
B Weakly developed soils	Ba Lithosols on lava	-	-
	Bb Lithosols on rocks rich in ferromagnesian minerals	-	-
	Bd Lithosols on sedimentary rocks	-	-
	Bo Juvenile soils on riverine alluvium	-	A, B
C Calcimorphic soils	Ca Rendzinas and brown calcareous soils	Mokhotlong	C, D
D Vertisols	Da Of lithomorphic origin	Phechela	E
		Semonkong	F, G
	Dj Of topographic depressions	Thulo	H
		Khabos	I
F Claypan soils (Highveld pseudo-podsolic)	Fa Not differentiated	Maseru	J, K
		Sephula	L
G Brown soils of semi arid regions	Gb Not differentiated	Mats'aba	M
H Eutrophic brown soils	Hb On soils rich in ferromagnesian minerals	Machache	N
J Fersiallitic soils	Ja On sandy parent material	-	-
	Jd Not differentiated	Leribe	O, P
		Berea	Q
L Ferrallitic soils	Lc Dominant colour yellowish-brown, not differentiated	Thebe	R

A RAW MINERAL SOILS

This class of mapping unit includes both hard rocks and the coarse detritus mainly formed by the processes of physical weathering. These materials may be regarded as 'non-soil' since biological soil-forming processes are almost completely lacking in them. There are two divisions in Lesotho:

Aa ROCKS RICH IN FERROMAGNESIAN MINERALS

This division describes the basaltic rocks exposed on the plateaux and steep slopes of the mountains and doleritic rocks mainly occurring in the lowlands.

Ac UNDIFFERENTIATED ROCKS

This division is composed of a variety of sedimentary rocks found in the lowlands.

B WEAKLY DEVELOPED SOILS

Weakly developed soils of two types occur in Lesotho: lithosols and lithic soils; and juvenile soils on recent deposits. The former, of which there are three subdivisions have a low level of profile development, which is reflected in very weak horizon differentiation. They are stony and shallow, with solid rock within 30 cm (12 in) of the surface. The juvenile soils have no clearly differentiated genetic horizons, which is mainly due to the brevity of the soil forming period. Only one subdivision of this category is found in Lesotho.

Ba LITHOSOLS ON LAVA

Soil development is retarded on the steep basaltic mountain slopes.

Bb LITHOSOLS ON ROCKS RICH IN FERROMAGNESIAN MINERALS

The poor development of these soils is caused by the slow weathering of dolerite under the present climatic conditions of Lesotho, but may also be the result of site steepness.

Bd LITHOSOLS ON UNDIFFERENTIATED ROCKS

These soils form over a variety of lowland sedimentary rocks. These parent rocks have only a low content of weatherable minerals and are subject to strong erosional processes associated with the intense rainfall and marked relief of the country; they can only form a mature soil under favourable geomorphological conditions.

Bo JUVENILE SOILS ON RIVERINE ALLUVIUM

Site: the distribution pattern of these soils is complex; they usually occur as thin strips bordering the Caledon and Orange Rivers, sometimes in association with vertisols.

Morphology: these are coarse and medium textured soils with an AC profile. There can be considerable variation in their morphology within quite a small area. Their thin surface horizon is usually much lighter in colour than their friable, structureless, dark brown subsurface horizons. They may have an occasional layer of dark clay in their profile, but they are in general, not well stratified.

Three local mapping units, covering soils of this kind were used in a survey of the country's alluvial soils; the units were principally separated on differences of soil texture:

1. Texture not finer than loamy fine sand; often uniform colours throughout the profile.

2. Texture not finer than fine sandy loam (profile A).

3. Texture not finer than friable fine sandy clay loam; darker colours and some weak structural development (profile B).

Chemical properties: soil reaction is neutral at the surface and becomes slightly more alkaline with increasing depth. The whole profile has a moderate to high exchangeable base content; although these soils have a relatively low exchangeable potassium content, their base saturation is always very high. The organic carbon percentage is low in the sandier soils, but increases with increasing depth.

C CALCIMORPHIC SOILS

Ca RENDZINAS AND BROWN CALCAREOUS SOILS

Definition: these are AC profile soils with thick, well structured dark surface horizons (mollic epipedons). They are rich in clays with a 2:1 lattice structure and have a high content of exchangeable bivalent cations.

Site: these soils form on steep basaltic mountain slopes under a cover of alpine or semi-alpine grassland; the total annual rainfall of these areas varies from 750 mm (30 in) to over 1,000 mm (40 in). Variations within this class are mostly caused by differences of aspect. Rendzinas are found on south facing slopes, which are cold, damp and snowbound for long periods. Northern slopes are warmer and drier for much of the year; soils on these slopes (profile T) are browner and more friable than the typical rendzina.

Mokhotlong set (profiles C, D)

Morphology: a very thin layer of dark grey brown loose loamy sand colluvium usually overlies the A horizon, which consists of 30-40 cm (12-15 in) of black, stony or gritty firm clay; this horizon has a strongly developed fine or medium granular structure, and the soil mass is firmly bound by a network of vigorous grass roots.

The parent material is a layer of gritty sandy loam in shades of grey or brown overlying solid basalt lava.

Chemical properties: the rendzinas of the lower mountain slopes have a slightly acid to neutral reaction and a high organic matter content; X-ray analysis shows their clay complexes to be dominated by montmorillonitic clay minerals. Values of cation exchange capacity and base status are high. The content of exchangeable calcium and magnesium is very high, but these soils contain very little exchangeable sodium.

With increasing altitude, leaching increases and weathering decreases. The soils of the upper mountain slopes are acid with only moderate base status.

D VERTISOLS AND SIMILAR SOILS

Definition: these soils have an AC profile and a dark thick clayey surface horizon. Their structure is often prismatic or coarse blocky, although the surface may have a finer structure produced by a self-mulching process. Their permeability is slow and their internal drainage is poor. Most profiles show some of the effects of mechanical re-working such as dry season cracks and slickensides, but gilgai micro-relief is not well developed in Lesotho. The clay fraction of these soils is dominated by 2:1 lattice clays; cation exchange capacities are high and they are highly base-saturated, mostly with bivalent cations.

Da VERTISOLS OF LITHOMORPHIC ORIGIN

This unit has been divided into two sets:

(a) **Phechela set** (profile E)

Site: these soils mostly occur on gently sloping clay plains overlying and adjacent to dolerite sills; they are partly of sedimentary origin and partly formed from dolerite colluvia. They are confined to the driest part of the lowlands with a marked dry season and a mean annual rainfall of about 600 mm (24 in).

Morphology: these soils are weakly self-mulching and cracks to the base of the A horizon are common. The solum is usually shallow.

The A horizon consists of a thick black clay, with coarse blocky or prismatic structure, often breaking to finer blocks. Its consistence is firm or hard and this horizon often contains some carbonate concretions or stones.

The C horizon is a greyish brown gritty and stony sandy clay loam or even coarser material, often with an abrupt boundary to hard and only partially weathered dolerite. There are abundant carbonate concretions and sometimes small black manganese shot in this horizon.

Chemical properties: the whole soil is strongly alkaline and almost completely base saturated. The cation exchange capacity is very high and the soil has a moderate organic carbon content.

(b) Semonkong set (profiles F and G)

Site: these soils form from colluvial material of basaltic origin over level areas in the foothills and mountains. They are found in the foothills at elevations of 1,850-2,000 metres (5,000-6,500 feet) along drainage lines and in other low-lying areas; they pass upslope into eutrophic brown soils. They occur in the mountains at elevations of about 2,450 metres (7,500 feet) and cover either floodplains in the upper reaches of rivers or extensive flats; they are usually associated with rendzinas.

Morphology: these are deep soils and bedrock is rarely seen in the profile. They are self-mulching and deep cracks are common.

The A horizon consists of a black clay with a medium blocky structure; prismatic structures also occur, but these usually break into blocks. The soil's consistence is firm or hard. This horizon does not contain carbonate concretions.

The C horizon is a clay in shades of grey or brown; it may be slightly mottled. It is compact, with massive structure. Carbonate concretions or segregations may sometimes be noted in this horizon.

Chemical properties: soils of this set in the foothills have a high cation exchange capacity and percentage saturation; they are neutral at the surface and become slightly alkaline with increasing depth.

Soils with similar morphology occurring in the mountains are less weathered and more highly leached; they are slightly more acid and their percentage saturation is lower. Both types, however, have a moderate organic matter content.

Dg VERTISOLS OF TOPOGRAPHIC DEPRESSIONS

This unit has been divided into two sets:

(a) Thulo set (profile H)

Site: these soils may occur as relatively thin strips of bottomland along drainage lines or over much wider areas on the gentle lower slopes of dissected pediplains; their most extensive development is in the western and southern lowlands. These soils are formed from colluvial pedisediment in sites where the leaching of silica and bases is retarded. These vertisols grade upslope into claypan soils; the details of a soil with intermediate properties are given in Appendix I (profile U).

Morphology: the surface of these soils is usually crusty and there is little tendency to self-mulching. Cracks penetrate most of the A horizon and separate it into roughly wedge-shaped prisms. Slickensides are a common feature of these soils.

The A horizon consists of up to 60 cm (2 feet) of black clay or fine sandy clay with prismatic or coarse blocky structure. The soil is very hard when dry and sticky and plastic when wet. There is often some small black manganese shot in this horizon.

The parent material of these soils is pedisediment; it is usually a calcareous clay with greyish colours (5Y hue), which becomes paler with increasing depth. There are often abundant calcareous concretions in this horizon.

Chemical properties: these soils are slightly acid at the surface, but become strongly alkaline in the C horizon, where high values for $CaCO_3$ equivalent are found. The cation exchange capacity and base saturation values are high throughout the profile. The soil has a moderate organic matter content.

(b) Khabos set (profile I)

Site: most of these soils occur in the broad flood plains of major rivers such as the Phuthiatsana; they are derived from fine-textured alluvium. These soils are also found over alluvial terraces in valleys flanked by sandstone cliffs and are associated with coarse and medium textured alluvial soils in a complex pattern. They may also occur along drainage lines in small stream catchments near to the mountains and it is often difficult to separate these soils from those of the Thulo set.

Morphology: the variable morphology of these soils reflects the heterogeneous nature of their parent materials. The soils are often covered by a few inches of brown sandy colluvial drift; ploughing causes the development of a darker, finer topsoil.

The soil is only weakly self-mulching and tends to be crusty. Cracks and slickensides are sometimes seen in their profiles.

The A horizon is a black to very dark grey fine sandy clay with a coarse blocky structure; its consistence is very hard or very firm. There are no carbonate concretions in this horizon.

The C horizon is grey brown or dark brown and these colours often become paler with depth. Although it is fine textured, the structure of this horizon is finer than that of the A horizon and its consistence is less extreme. There are often some carbonate concretions in this horizon.

The units used to map vertisolic types in a semi-detailed survey of the alluvial soils of Lesotho were separated on the properties of the A horizon. The most common unit had properties similar to those described above, while another had a similar colour and textural range, but differed in possessing a finer structure and a more favourable consistence. A poorly drained unit was also recognised.

Chemical properties: these soils are often moderately acid at the surface, but neutral or only slightly acid in the C horizon (profile I is atypical in this respect). Cation exchange capacity and percentage saturation values are moderate in the A horizon and are somewhat higher in the C horizon. Extractable sodium appears to be relatively low in this set. These soils have a moderate organic carbon content.

F CLAYPAN SOILS

Fa NOT DIFFERENTIATED

Classification: this is the most extensive soil type in the lowlands of Lesotho; it forms part of the widespread group of soils in Southern Africa termed Highveld Pseudo-Podzolic soils and Sols Lessivés by D'Hoore (1964) and Highveld Prairie by Van der Merwe (1941). Murdoch (1964) has suggested that the geographical qualification is misleading as these soils are not confined to the South African Highveld and in this report the simple term 'Claypan soil', used by de Villiers (1965) and other pedologists to describe soils of this type in Natal, has been adopted. These soils can also be described under great groups of the Alfisol order in the latest USDA soil classification (Soil Survey Staff, 1960).

Definition: these are soils of the ABC type with a textural or argillic B horizon. There is a characteristically clear or abrupt boundary between the structureless sandy A horizon and the clay-rich B horizon with well expressed structure. The saturation of the exchange complex exceeds 50 per cent. Horizon A is acid and horizon B may be weakly alkaline.

Genesis: these soils appear to have developed from a parent material of recent surface accumulations of sand and the underlying pedisediment. The lithological discontinuity is sharply defined and is often marked by a grit line of rounded iron concretions, whose shape suggests a transported origin. Both iron and lime concretions co-exist within the pedisediment, which is calcareous, and lime concretions commonly form about a nucleus of an iron concretion. The A horizon is often found to overlie both solid sandstone and the argillic B horizon of these claypan soils.

Vertical and lateral clay illuviation appears to be occurring in the upper part of the B horizon and this process may also help to maintain the sharp differences between A and B horizons and the activity of the soil fauna may effect a rough sorting of material.

Further detailed studies, with mineralogical and particle-size determinations, are necessary to fully explain the genesis of this interesting and important group of soils.

(a) Maseru Set (profiles J, K)

Site: these soils cover pediment slopes in the lowlands; these pediments are covered with mantles of colluvially reworked material and the claypan soils are formed from these mantle materials and not directly from the underlying bedrock. The claypan soils occur in areas where the mean annual rainfall varies from 500-900 mm (20-35 in).

Morphology: the A horizon has a total thickness of 30-45 cm (12-18 in) in non-eroding or non-accumulating sites. The boundary to the B horizon is usually abrupt and grit lines are not uncommon at the base of the A horizon; a layer of pisolitic ferruginous grit over 30 cm thick can be seen in gullies by the Mafeteng-Wepener road.

The A horizon is a brown (typically a dry colour of 10 YR 5/3) loamy fine sand or fine sandy loam. It is usually structureless, but forms coarse clods when dry. There may sometimes be a weak structural development in the top few centimetres of the horizon, particularly under a permanent grass cover. The horizon's consistence is loose or, more rarely, friable.

An A2 horizon may sometimes be present. This is a thin, discontinous layer with higher colour values and lower chromas than the overlying A1 horizon; it usually has some fine, faint yellowish mottles and spots of pseudo gley. The maximum accumulation of concretions generally occurs in this horizon. Temporary perched water tables occur in some of these soils; they result from intermittent saturation of the surface horizon above the impermeable B horizon.

The predominant matrix colour of the B horizon is greyish-brown, (2.5 Y 5/2, moist is very common) often diffusely intermottled with yellowish brown; it tends to increase in value with increasing depth. Its texture is usually a fine sandy clay. Ped exteriors in the upper part of this horizon often have darker coloured illuvial coatings of clay and possibly dispersed organic matter. The structure in the B horizon is moderate to strong medium blocky or prismatic; columnar structure has occasionally been observed in donga or drainage line exposures. The consistence of the horizon is very hard or very firm and it is only slowly permeable. It contains iron and, rarely, lime concretions. The tops of the structural units are sometimes covered with a dust of very fine quartz.

The C horizon consists of very hard and dry pedisediment, which has the appearance of a relict gley. It is yellowish brown or light grey and is usually diffusely mottled. The texture can be quite variable, but is mostly clay-rich and the horizon is generally apedal. Calcium carbonate occurs as powdery segregations or as concretions; these concretions often enclose smaller iron concretions and were probably formed when the pedisediment was an actively gleyed material. Thick carbonate concretionary deposits can be found in some drainage lines. Manganese occurs as black stains or as small soft concretions. There may be several distinct layers in the pedisediment, which may attain a depth of 20 metres (60 feet); it may have such features as grit or stone lines, buried topsoils, and fossil root channels.

Chemical properties: the A horizon is usually moderately acid. Its base saturation is moderate and its cation exchange capacity is low; the quantities of extractable cations are low. The organic carbon content is low. The soil reaction of the B horizon varies from mildly to strongly alkaline. The cation exchange capacity is moderate to high and is very much greater than that of the coarser-textured A horizon; percentage saturation values are high. This horizon has high extractable Mg and Na contents; the Ca/Mg ratio falls markedly from the A to the B horizons. The extractable sodium contents of some soils of this set approach those of typical alkali soils; profile J has more than 15 per cent exchangeable sodium. The degree of alkalinity cannot be correlated with changes in any morphological feature. The organic carbon figures sometimes show a secondary maximum in the B horizon.

The principal clay minerals of the A horizon of these soils have micaceous structures; kandite minerals also occur in varying proportions. The B and C horizons appear also to contain mixed layer minerals.

(b) Sephula set (profile L)

Site: these soils cover the senile, weakly convex interfluves in areas of pediplaned Molteno and Beaufort rocks; the rocks underlying the interfluve crest are mostly sandstones or sandy shales. The rainfall in these areas is about 500-750 mm (20-30 in) a year.

Morphology: these soils differ from those of the Maseru set in degree rather than in kind. Their A horizon closely resembles those of Maseru set soils, but Sephula set soils do not have an A2 horizon and the boundary between the A and B horizons is clear rather than abrupt. The B horizons of the Sephula set soils often have rather coarser textures and their colours have redder hue and higher chromas than those of the Maseru set. The parent material of the Sephula set soils is pedisediment, which may be partly contaminated by the weathering products of the underlying arenaceous rock.

Chemical properties: the A horizons of soils of this set closely resemble those of the Maseru set soils in their chemical properties. The proportion of bases in the B horizon differs, however, and probably reflects the different positions of the soils in the landscape; extractable K is high in the B horizons of the Sephula set, while the extractable Na content does not seem to rise to the dangerous proportions of an alkali soil.

G BROWN SOILS OF SEMI-ARID REGIONS

Gb UNDIFFERENTIATED SOILS Mats'aba set (profile M)

Definition: these are reddish-brown soils, containing considerable reserves of weatherable minerals and appreciable quantities of clay minerals with a 2:1 lattice. The base saturation of the B horizon is generally moderate.

Site: these soils are confined to dolerite outcrops under a rainfall of 625-875 mm (25-35 in) per annum; these outcrops are mostly sills or sheets as most dykes are narrow and steep-sided and do not encourage soil accumulation. The areas covered by these soils are small and cannot be adequately represented on the 1:250,000 soil map.

Morphology: the A horizon is a dark red brown friable fine sandy loam with a weak blocky or subangular blocky structure; this horizon is continually replenished by new colluvial material and has a moderate content of weatherable minerals.

The B horizon is red brown or even yellowish red, but does not have a hue redder than 5 YR; it is a friable fine sandy clay loam with weak blocky structure. This horizon may be slightly stony or have some manganese concretions. The lower part of the B horizon is sometimes a mixture of structures and the coarser peds are usually darker and firmer.

The C horizon is decomposing gritty material often enclosing spheroidal dolerite boulders and overlying hard, but weathered rock; this horizon is yellowish brown or brownish yellow and is speckled with white felspars and black manganese stains.

Chemical properties: soil reaction throughout the profile is lightly acid. The cation exchange capacity is low to moderate and the percentage saturation moderate; both increase with increasing profile depth. Organic carbon values are low. Profile M is more acid and base unsaturated than the modal soils of this set.

H EUTROPHIC BROWN SOILS

H_b ON SOILS RICH IN FERROMAGNESIAN MINERALS Machache set (profile N)

Definition: these are permeable reddish-hued soils with clearly expressed structure; they have an appreciable reserve of weathering material and moderate cation exchange capacities and base saturations.

Site: these soils occur on pediment slopes at the foot of the basaltic mountains under a rainfall of 750-875 mm (30-35 in) per annum.

Morphology: horizons are not clearly defined in the profile of these soils and their depth and stoniness is very variable. Their fabric is earthy and there are no clearly visible clay skins, although some peds take on a slight gloss in the rainy season.

The A horizon is a dark brown friable clay loam with weak granular structure; its texture when estimated in the field is usually somewhat coarser than the texture determined in the laboratory.

The B horizon is a friable clay with a weak fine to medium sub-angular blocky structure; the upper portion of this horizon is usually reddish brown and the colour changes with increasing depth to yellowish red or red. Stone lines and gravel accumulations can often be observed; rounded Fe Mn concretions increase in number towards the base of the B horizon. There is usually a clear boundary to weathering basaltic rock at the base of the profile.

Chemical properties: the pH of the A horizon is moderately acid (about 5.5) and increases slightly with depth. Cation exchange capacity, percentage saturation and the exchangeable bases values are moderate. The soil has a moderate organic matter content. The dominant clay minerals of these soils are kandites, but thev also contain some micaceous minerals.

J FERSIALLITIC SOILS

J_a FERSIALLITIC SOILS ON SANDY PARENT MATERIALS

These soils have properties of both lithosols and fersiallitic soils; they cover relatively small areas of land and are of minor pedological or agronomic importance.

Site: this type of soil is found over reduced interfluves developed from certain sandy Molteno rocks. It occurs throughout the lowlands, but is most common to the south of Mafeteng.

Morphology: the sandy nature of the local bedrock is clearly reflected in the morphology of these soils; their texture is rarely finer than sandy loam and there is only a slight increase in clay content with increasing profile depth. Common colours are yellowish brown or brown and the whole soil is structureless. There is nearly always a sharp boundary to the underlying rock and the depth of the soil is very variable.

Chemical properties: no chemical analyses have yet been made of this type of soil, but its reaction is moderately to strongly acid and, because of its low clay and organic matter contents, its cation exchange capacities and base contents are probably very low.

J_d UNDIFFERENTIATED FERSIALLITIC SOILS

Definition: these are soils with an ABC profile and a relatively high content of free sesquioxides. The clay minerals are kandites, with lesser or greater amounts of 2:1 lattice types; the Lesotho soils are not therefore truly fersiallitic and probably represent an intergrade to brown soils of semi-arid regions. The cation exchange capacity of the whole soil is low and the base saturation is commonly greater than 40 per cent.

Two important sub-divisions are recognized in Lesotho:

(a) Leribe set reddish brown soils (profiles O, P)

Site: these soils cover the crests and upper erosion slopes of spurred interfluves in some areas of Red Beds sandstone; they appear to be formed by the colluvial reworking of the weathering products of sandstone and possibly dolerite.

Morphology: all the soils in this set have a hue redder than 7.5 YR. The profile is deep and lacks clearly defined horizons. The soil's fabric is earthy and there are no signs of easily recognizable clay skins.

The A horizon consists of 25-40 cm (10-15 in) of red brown loamy fine sand, which passes quickly to friable fine sandy loam; this horizon is virtually apedal, although some structure may develop in the surface rooting zone.

The B2 horizon is typically a red friable fine sandy clay loam; this material is commonly structureless, but with increasing profile depth, the soil's consistence becomes firmer and a weak blocky structure is developed.

The soil's parent material is a firm red clay, sometimes containing concretions, which may merge into or stop abruptly at the underlying weathering sandstone.

Chemical properties: the A horizons of the Leribe set soils are strongly acid. Values of the cation exchange capacity and the extractable cations are low, except for those of extractable K, which are moderate. The base saturation of this horizon is usually a little greater than 40 per cent. The organic carbon content is usually less than 0.5 per cent.

Soil reaction commonly shows a secondary minimum in the upper part of the B horizon, but increases again in its lower portions. Cation exchange capacity increases slightly in the B horizon and the extractable Mg content increases while that of extractable K decreases.

The clay minerals of these soils consist of a mixture of illitic and kandite types.

(b) Berea set yellowish brown soils (profile Q)

Site: these soils are found in areas of Red Beds and Molteno sandstones, where they cover the crests and upper erosion slopes of spurred interfluves. Some are residual in origin and form, at least in part, from the underlying buff coloured sandstones, while others are mostly formed from colluvial drift material also derived from these rocks. The total annual rainfall of these areas is about 625-750 mm (25-30 in).

Morphology: all the soils in this set have a hue as yellow as or yellower than 7.5 YR. The profile is rarely deeper than one metre (3 feet) and horizon development is poor.

The A horizon consists of 25-40 cm (10-15 in) of brown or yellowish brown loamy fine sand, which is loose or friable and virtually apedal.

The B horizon is a yellowish brown or, more rarely, a strong brown friable fine sandy loam or fine sandy clay loam. A weak fine blocky structure can sometimes be found in this horizon. Rounded iron concretions become abundant towards the horizon base, sometimes forming a grit layer or an uncemented concretionary horizon. 44

The C horizon is commonly a yellowish brown fine sandy clay mottled with variegated weathering colours; its consistence is firm and compact and it has a medium blocky structure. This material may merge into weathering sandstone which sometimes shows marked columnar structure, or there may be an abrupt boundary between it and the sandstone.

Where the soil can be shown to be residual, the B horizon overlies a yellowish gritty sandy loam which includes abundant fragments of weathering sandstones; this material passes into a soft and friable yellowish brown sandstone, which merges through a harder and paler zone with bluish tinge into a solid yellow sandstone.

Chemical properties: the A horizons of these soils are moderately acid (pH 5.5-6.0). Cation exchange capacity and extractable cation values are low; percentage saturation is moderate. The organic carbon content is usually less than 0.5 per cent.

The pH range of the B horizons of the Berea set soils is similar to that of their A horizons. Cation exchange capacity is low and percentage saturation is moderate; extractable Mg increases slightly.

The clay fraction of the Berea set soils is dominated by micaceous minerals, but a moderate amount of kandites are also present.

L FERRALLITIC SOILS

Lc NON DIFFERENTIATED FERRALLITIC SOILS, DOMINANT COLOUR YELLOWISH BROWN

These are deep, virtually structureless soils, with poor horizon development. Although they have a low base saturation, their cation exchange capacities of about 30 meq per 100 g clay suggest that they have a higher reserve of weatherable minerals than typical ferrallitic soils. They can be distinguished from the morphologically rather similar fersiallitic soils of the Berea set by their pH values, which are about a unit lower.

Site: soils of this type cover gently undulating plateaux of Cave Sandstone in the northern portion of the foothill zone, where the rainfall rises to about 875 mm (35 in).

Thebe set (profile R)

Morphology: all the soils in this family have a hue of 7.5 YR or 10 YR. The surface horizon usually consists of a shallow colluvial layer of humic-stained brown loamy fine sand; it overlies about 40-50 cm (15-20 in) of a loose and apedal horizon of brown fine sandy loam. There is a gradual increase of clay content with increasing depth. The subsoil is yellowish brown or strong brown; it is either structureless or has only minimal structural development and its consistence is loose or friable. Some rounded iron concretions are usually found scattered throughout the sub-surface horizons.

There is nearly always a sharp boundary between subsoil and the underlying bedrock, which is often weathered to a depth of several feet.

Chemical properties: these soils are very strongly acid throughout their profile and their base saturation is extremely low. Their organic carbon content is over one per cent, which is considerably more than that of other soils derived from sedimentary rocks in Lesotho.

PART IV - THE SOIL MAP

This reconnaissance soil map is based on information collected during a land resources survey of Lesotho (Bawden and Carroll, 1966). The preliminary phase of this investigation consisted of a stereoscopic examination of aerial photographs in conjunction with 1/50,000 maps, to recognize and define differences in the landscape. Elements of the landscape were selected, within which a reasonably uniform distribution pattern of soils and vegetation might be expected. Typical elements were studied in detail in the field, and the investigation later extended to cover the rest of the country in less detail.

The units shown on the soil map were produced by combining similar landscape elements; the boundaries of each mapping unit therefore separate areas that are both physiographically and pedologically distinct. As more than one soil type may be associated with any landscape element, the mapping units are shown in the map legend as either simple units or as binary associations; the predominant constituent of an association is placed first in the descriptions of the mapping units given below. The names of the soil types, of which the mapping unit is composed, have been chosen to match those names used for the 'Soils Map of Africa' (D'Hoore, 1964); these soil types are described in detail in Part III.

THE MAPPING UNITS

1 Lithosols on lava (Ba)

These shallow and stony soils occur on the higher mountain slopes, where their development is limited by both steepness and a harsh climate.

2 Lithosols on lava/Basalt rock debris (Ba/Aa)

This mapping unit covers much of the gently undulating Upland Plateau, where much bare rock is exposed.

3 Lithosols on lava/Calcimorphic soils (Ba/Ca)

These soils are found on many lower mountain slopes. Calcimorphic soils develop on sites with relatively gentle slopes or with an aspect favourable to the growth of non-alpine grasses.

4 Lithosols on rocks rich in ferromagnesian minerals (Bb)

This unit describes the shallow soils forming over steep slopes on dolerite intrusions in the western lowlands.

5 Lithosols on rocks rich in ferromagnesian minerals/Eutrophic brown soils (Bb/Hb)

These soils occur on the steeper slopes of the foothill region. The eutrophic brown soils are found on stable or accumulative sites.

6 Lithosols on sedimentary rocks/Sedimentary rock debris (Bd/Ac)

The steep, rocky or eroded sites occupied by these soils cover large areas of the lowland and Orange River regions.

7 Lithosols on sedimentary rocks/Fersiallitic soils (Bd/Jd)

Soils of this mapping unit occur in the more broken country of the lowland and Orange River regions. Deeper soils of fersiallitic type are found as isolated pockets within the unit.

8 Lithosols on sedimentary rocks/Ferrallitic Soils (Bd/Lc)

This combination of soils is found on steep or eroded land of the Berea Plateau. Ferrallitic soils only occur where site conditions favour the development of deep soils.

9 Juvenile soils on recent riverine alluvium (Bo)

These soils are confined to narrow terraces bordering the two major rivers of Lesotho, the Orange and Caledon, and some of their tributaries.

10 Calcimorphic soils/Lithosols on lava (Ca/Ba)

This unit occurs on lower mountain slopes, often in association with unit 3. The gentler terrain of unit 10 however, ensures the predominance of calcimorphic soils over the shallower and less well developed lithosols.

11 Calcimorphic soils/Vertisols (Ca/Da)

These soils can be found on very gently sloping sites within the mountains. Vertisols of the Semonkong set form in positions where colluvial materials can accumulate.

12 Vertisols of lithomorphic origin (Da)

These soils are confined to clay plains overlying doleritic intrusions in the western lowlands and constitute the Phechela set.

13 Vertisols of lithomorphic origin/Calcimorphic soils (Da/Ca)

This unit is found on level sites within the mountains. It differs from the similar unit 11 in its higher proportion of vertisols.

14 Vertisols of topographic depressions (Dj)

These soils cover alluvial floodplains in the lowlands (Khabos set) or may form the lowest number of a sequence of soils on slopes developed from sedimentary rocks (Thulo set).

15 Claypan soils (Maseru set) (Fa)

This unit describes the most extensive group of soils in the lowlands, the soils of the Maseru set, which cover dissected pediment slopes in the lowlands.

16 Claypan soils/Vertisols (Fa/Dj)

These soils are found on very gentle slopes in the low-lands; vertisols of the Thulo set form on level ground adjacent to drainage lines.

17 Claypan soils (Fa)

This unit occurs most extensively in the western lowland plains. Claypan soils of the Maseru set cover the lower slopes, and the senile interfluves are covered by soils with less clearly defined claypan soil properties (the Sephula set).

18 Claypan soils/Fersiallitic soils (Fa/Jd)

This unit includes fersiallitic soils on some spurred interfluves and some crests; these sites are too small to be mapped separately and they have been grouped with larger areas of dissected pediments overlain by claypan soils.

19 Claypan soils (Sephula set) (Fa)

These soils are confined to convex senile interfluves in the plains of the western lowlands.

20 Claypan soils (Fa)

Sephula set soils cover senile interfluves in the plains of the western lowlands, but, for convenience in mapping, this unit also includes small portions of the correspond-ing pediment slopes, which are overlain by Maseru set soils.

21 Euthropic brown soils/Vertisols (Hb/Da)

These soils form over the gentle slopes of the foothill region. The vertisols of the Semonkong set only occur along drainage lines or on other low-lying sites.

22 Fersiallitic soils (Jd)

Fersiallitic soils cover large areas of the lowlands; they form over the crests and upper slopes of spurred interfluves and isolated hills of sedimentary rocks. Soils of the Leribe and Berea sets often occur in inti-mate association and could not be differentiated at this scale of mapping.

23 Fersiallitic soils/Lithosols (Jd/Bd)

The soils of this unit are mostly of fersiallitic type, but some shallow, stony or badly eroded soils also occur in association with them and have been included in the unit. This combination of soils is most common in the Orange River region, but it also occurs in drier parts of the lowlands.

24 Fersiallitic soils/Claypan soils (Jd/Fa)

In this unit, areas of claypan soils on upper pediment slopes, which are too small to be mapped separately, have been combined with adjoining more extensive areas of fersiallitic soils; isolated examples of this unit occur throughout the lowland and Orange River regions.

25 Fersiallitic-Lithosol intergrades (Ja)

These soils, which have properties intermediate between the fersiallitic soils and the lithosols, occur on reduced interfluves of Molteno sandstone; they are found throughout the lowlands.

26 Ferrallitic soils/Lithosols (Lc/Bd)

Ferrallitic soils overlie Cave Sandstone in the northern part of the foothill region. They are found on relatively level and uneroded land; lithosols occur on steeper or eroded land.

APPENDIX I - SOIL PROFILE DESCRIPTIONS AND ANALYSES

PROFILE A **JUVENILE SOIL ON RIVERINE ALLUVIUM**

LOCATION:	By Caledon River bank, on Agricultural Experimental Station, Maseru.
CLIMATE:	About 760 mm (30 in) annual rainfall.
SITE:	Very slightly convex broad river levee.
PARENT MATERIAL:	Developed from riverine alluvium.
VEGETATION:	Poor grass at edge of ploughed land.
SOIL DRAINAGE:	Free, permeability rapid.

HORIZON	DEPTH cm (in)	DESCRIPTION
1	0 - 38 (0 - 15)	Brown, 10 YR 5/3, dry (brown, 10 YR 4/3, moist) loamy fine sand; structureless; loose consistence, dry; slightly wavy, clear boundary to:
2	38 - 94 (15 - 37)	very dark greyish brown, 10 YR 3/2, moist; loamy fine sand with lenses of finer material; very weak medium blocky structure, breaking easily into granules; friable consistence, moist; slightly wavy, gradual boundary to:
3	94 - 191 (37 - 35) plus	dark brown, 10 YR 3/3, moist, passing to brown 10 YR 4/3, at 115 cm; fine sand; structureless; loose consistence, dry.

PROFILE A

HORIZON DEPTH cm	1 3-15	2 43-54
Moisture 100-105°C %	1.40	2.10
200µ - 2 mm %	7	6
50µ - 200µ %	73	63
20µ - 50µ %	9	10
2µ - 20µ %	3	6
<2µ %	7	13
$CaCO_3$ Equivalent %	nd	nd
Loss on Ignition %	8	3.2
Organic Carbon %	0.3	nd
Total Nitrogen %	0.04	nd
C/N Ratio	1.8	nd
pH in water (1:2.5)	6.3	7.1
pH in M/100 $CaCl_2$	5.7	6.2
Exchangeable Calcium meq %	4.9	9.5
Exchangeable Magnesium meq %	2.3	4.8
Exchangeable Potassium meq %	0.19	0.14
Exchangeable Sodium meq %	0.10	0.13
Total Exchangeable Bases meq %	7.5	14.6
Exchangeable Hydrogen meq %	1.7	2.0
Cation Exchange Capacity meq % (by addition)	9.2	16.6
Base Saturation %	82	88

nd = no determination or no sample; tr = trace; - = nil

PROFILE B **JUVENILE SOIL ON RIVERINE ALLUVIUM**

LOCATION:	Close to river bank, by Phuthiatsana road bridge Teyateyaneng district.
CLIMATE:	About 760-875 mm (30-35 in) annual rainfall.
SITE:	Very gentle reverse slope of a river terrace.
PARENT MATERIAL:	Developed from riverine alluvium.
VEGETATION:	Poor grass at edge of ploughed land.
SOIL DRAINAGE:	Free, permeability moderately rapid.

HORIZON	DEPTH cm (in)	DESCRIPTION
1	0 - 20 (0 -8)	Dark greyish brown, 10 YR 4/2, very slightly moist; fine sandy loam; very weak fine blocky structure; friable consistence, moist; smooth, clear boundary to:
2	20 - 46 (8 - 18)	very dark brown, 10 YR 2/2, moist; fine sandy loam; weak coarse blocky structure, breaking to medium blocky; friable to firm consistence, moist; smooth, gradual boundary to:
3	46 - 88 (18 - 35)	very dark brown, 10 YR 2/2, moist; fine sandy clay loam; weak medium blocky structure; firm to friable consistence, moist, slightly, plastic, slightly sticky; consistence, wet; slightly wavy, clear boundary to:
4	88 - 152 (35 - 60) plus	dark yellowish brown, 10 YR 4/4, almost dry; fine sand; structureless; loose consistence, dry.

PROFILE B

HORIZON DEPTH cm	1 0-15	2 25-38	3 64-76
Moisture 100-105°C %	3.54	3.48	4.28
200μ - 2 mm %	4	5	6
50μ - 200μ %	54	52	51
20μ - 50μ %	13	6	20
2μ - 20μ %	8	14	3
<2μ %	18	20	17
$CaCO_3$ Equivalent %	tr	tr	-
Loss on Ignition %	4.6	4.7	5.2
Organic Carbon %	1.1	nd	nd
Total Nitrogen %	0.09	nd	nd
C/N Ratio	12	nd	nd
pH in water (1:2.5)	6.9	7.2	7.5
pH in M/100 $CaCl_2$	6.2	6.4	6.7
Exchangeable Calcium meq %	11.2	13.0	15.5
Exchangeable Magnesium meq %	8.3	6.4	9.6
Exchangeable Potassium meq %	0.27	0.19	0.17
Exchangeable Sodium meq %	0.13	0.18	0.20
Total Exchangeable Bases meq %	19.9	19.8	25.5
Exchangeable Hydrogen meq %	2.9	2.7	2.2
Cation Exchange Capacity meq % (by addition)	22.8	22.5	27.7
Base Saturation %	87	88	92

nd = no determination or no sample; tr = trace; - = nil

PROFILE C **CALCIMORPHIC SOIL, MOKHOTLONG SET**

LOCATION:	Above Bushman Pass, Mountain Road, about 2250 m (7,500 feet) elevation.
CLIMATE:	About 875 mm (35 in) annual rainfall.
SITE:	Slightly convex slope (about 11°) southern aspect.
PARENT MATERIAL:	Developed from basaltic lava.
VEGETATION:	Poor *Themeda* veld.
SOIL DRAINAGE:	Free, permeability moderately slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 23 (0 - 9)	Very dark greyish brown, 10 YR 3/2, moist; loamy sand; structureless; loose consistence, dry; smooth, clear boundary to:
A12	23 - 46 (9 - 18)	black, 10 YR 2/1, moist; gritty clay loam; strong fine and medium granular structure; firm consistence, moist, sticky, plastic consistence, wet; smooth, clear boundary to:
C1	46 - 53 (18 - 21)	brown, 10 YR 3/3, moist; gritty sandy loam; weak fine subangular blocky structure; friable consistence, moist; smooth, diffuse boundary to:
C2	54 - 76 (21 - 30)	soil like the preceding horizon, but containing much stony weathering material.

PROFILE C

HORIZON	A12
DEPTH cm	31-43
Moisture 100-105°C %	7.24
200μ - 2 mm %	13
50μ - 200μ %	26
20μ - 50μ %	9
2μ - 20μ %	15
<2μ %	22
$CaCO_3$ Equivalent %	nd
Loss on Ignition %	17.3
Organic Carbon %	4.2
Total Nitrogen %	0.43
C/N Ratio	10
pH in water (1:2.5)	6.0
pH in M/100 $CaCl_2$	5.1
Exchangeable Calcium meq %	25.5
Exchangeable Magnesium meq %	10.3
Exchangeable Potassium meq %	0.45
Exchangeable Sodium meq %	0.01
Total Exchangeable Bases meq %	36.3
Exchangeable Hydrogen meq %	13.3
Cation Exchange Capacity meq % (by addition)	49.6
Base Saturation %	73

nd = no determination or no sample; tr = trace; - = nil

PROFILE D **CALCIMORPHIC SOIL, MOKHOTLONG SET**

LOCATION:	By Blue Mountain Pass, Mountain Road about 2,670 m (8,900 feet) elevation.
CLIMATE:	About 1,000 mm (40 in) annual rainfall.
SITE:	Straight slope (about 9°) southern aspect.
PARENT MATERIAL:	Developed from basaltic material.
VEGETATION:	Poor *Themeda-Festuca* Alpine Veld.
SOIL DRAINAGE:	Free, permeability moderately slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 5 (0 - 2)	Thin colluvial topsoil - dark grey brown loamy sand.
A12	5 - 25 (2 - 10)	black, 10 YR 2/1, moist; stony loam; moderate fine granular structure; firm consistence, moist; slightly wavy, clear boundary to:
C	25 - 40 (10 - 16)	very dark grey, 10 YR 3/1, moist; gritty sandy loam; structureless; friable consistence, moist; wavy, abrupt boundary to:
R	at 40 (16)	hard basalt lava.

PROFILE D

HORIZON	A12
DEPTH cm	8-21
Moisture 100-105°C %	8.37
200μ - 2 mm %	21
50μ - 200μ %	29
20μ - 50μ %	16
2μ - 20μ %	13
<2μ %	4
$CaCO_3$ Equivalent %	nd
Loss on Ignition %	17.4
Organic Carbon %	5.5
Total Nitrogen %	0.48
C/N Ratio	12
pH in water (1:2.5)	6.1
pH in M/100 $CaCl_2$	5.2
Exchangeable Calcium meq %	11.8
Exchangeable Magnesium meq %	2.5
Exchangeable Potassium meq %	0.87
Exchangeable Sodium meq %	0.06
Total Exchangeable Bases meq %	15.2
Exchangeable Hydrogen meq %	17.7
Cation Exchange Capacity meq % (by addition)	32.9
Base Saturation %	46

nd = no determination or no sample; tr = trace; - = nil

PROFILE E **VERTISOL OF LITHOMORPHIC ORIGIN, PHECHELA SET**

LOCATION: By Mapotu village, Mafeteng district.

CLIMATE: About 500-630 mm (20-25 in) annual rainfall.

SITE: Colluvial apron to a large sill (slope about 4°).

PARENT MATERIAL: Developed from dolerite and doleritic drift material.

VEGETATION: *Cymbopogon - Themeda* veld.

SOIL DRAINAGE: Imperfect to poor, permeability slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 20 (0 - 8)	Black, 10 YR 2/1, dry; clay; moderate medium prismatic structure, breaking to blocks and granules; firm consistence, moist, hard consistence, dry, rare small carbonate concretions; smooth, diffuse boundary to:
A12	20 - 40 (8 - 16)	black, 2.5 Y 2/0, dry; clay; moderate medium blocky structure; firm consistence, moist; very hard consistence, dry; common carbonate concretions and some hard doleritic stones; smooth, gradual boundary to:
A13	40 - 61 (16 - 24)	very dark grey, ped exterior, 10 YR 3/1, dry or very dark greyish brown, ped interior, 2.5 Y 3/2, dry; gritty clay; moderate coarse blocky structure; very hard consistence, dry; sparse manganese shot and abundant carbonate concretions; some doleritic stones; slightly wavy, clear boundary to:
C	61 - 107 (24 - 42)	grey brown; mottled with variegated weathering colours; sandy; weathering dolerite.
R	At 107 (42)	hard, only partially weathered dolerite.

Note: Surface soil self-mulching. Cracks not well developed in this profile, but common elsewhere to base of A horizon. Some slickensides.

PROFILE E

HORIZON DEPTH cm	A11 0-13	A12 23-36	A13 51-61
Moisture 100-105°C %	5.64	5.40	5.15
200μ - 2 mm %	6	16	17
50μ - 200μ %	30	26	29
20μ - 50μ %	8	8	9
2μ - 20μ %	13	11	9
<2μ %	39	36	35
$CaCO_3$ Equivalent %	tr	5.6	4.8
Loss on Ignition %	7.7	6.2	4.5
Organic Carbon %	1.1	nd	nd
Total Nitrogen %	0.09	nd	nd
C/N Ratio	12	nd	nd
pH in water (1:2.5)	8.5	8.9	9.1
pH in M/100 $CaCl_2$	7.4	8.0	8.2
Exchangeable Calcium meq %	10.8	33.0	16.9
Exchangeable Magnesium meq %	29	27	27
Exchangeable Potassium meq %	0.73	0.34	0.21
Exchangeable Sodium meq %	1.97	1.95	2.66
Total Exchangeable Bases meq %	42.5	62.3	46.8
Exchangeable Hydrogen meq %	1.7	0.6	0.1
Cation Exchange Capacity meq % (by addition)	44.2	62.9	46.9
Base Saturation %	96	99	100
Soluble Salts meq % (by conductivity)	0.6	1.2	1.3

nd = no determination or no sample; tr = trace; - = nil

PROFILE F **VERTISOL OF LITHOMORPHIC ORIGIN, SEMONKONG SET**

LOCATION:	By stream bank in Upper Makhaleng Valley, Maseru district.
CLIMATE:	About 760 mm (30 in) annual rainfall.
SITE:	Almost flat valley floor.
PARENT MATERIAL:	Developed from basaltic colluvium.
VEGETATION:	Poor *Themeda* veld.
SOIL DRAINAGE:	Imperfect, permeability moderately slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 23 (0 - 9)	Dark brown, 10 YR 4/3, dry, or very dark greyish brown 10 YR 3/2, moist; fine sandy clay loam; structureless; friable consistence, moist; smooth clear boundary to:
A12	23 - 86 (9 - 34)	very dark brown, 10 YR 2/2, dry; clay loam; moderate to strong medium prismatic structure; firm consistence, moist, sticky, plastic consistence, wet; much iron staining along structure separations; slightly wavy, gradual boundary to:
C1	86 - 109 (34 - 43)	dark brown; faintly grey mottled; massive, gritty clay colluvium.
C2	109 - 123 (43 - 48)	Stone-line horizon of sub-angular basaltic pebbles and stones of varying size in dark brown clay matrix.
C3	123 - 152 (48 - 60) plus	Horizon similar to C1 but grey mottles replaced by coarse yellowish-brown patches.

PROFILE F

HORIZON DEPTH cm	A11 3-15	A12 25-41	A12 64-76	C1 97-109
Moisture 100-105°C %	4.52	5.65	5.46	6.45
200μ - 2 mm %	7	12	8	3
50μ - 200μ %	35	31	30	28
20μ - 50μ %	10	12	12	8
2μ - 20μ %	18	18	19	23
$<2\mu$ %	21	13	18	30
$CaCO_3$ Equivalent %	nd	nd	nd	nd
Loss on Ignition %	11.3	15.2	15.0	11.0
Organic Carbon %	3.0	nd	nd	nd
Total Nitrogen %	0.26	nd	nd	nd
C/N Ratio	12	nd	nd	nd
pH in water (1:2.5)	6.0	6.3	6.6	6.8
pH in M/100 $CaCl_2$	5.0	5.5	5.8	5.9
Exchangeable Calcium meq %	16.5	32.0	33.8	22.4
Exchangeable Magnesium meq %	8.6	14	12	9.3
Exchangeable Potassium meq %	0.60	0.20	0.20	0.20
Exchangeable Sodium meq %	0.13	0.18	0.18	0.21
Total Exchangeable Bases meq %	25.8	46.4	46.2	32.1
Exchangeable Hydrogen meq %	11.0	13.0	10.5	7.6
Cation Exchange Capacity meq % (by addition)	36.8	59.4	56.7	39.7
Base Saturation %	70	78	81	81

nd = no determination or no sample; tr = trace; - = nil

PROFILE G VERTISOL OF LITHOMORPHIC ORIGIN, SEMONKONG SET

LOCATION: By Kubutu Store, Maseru district.

CLIMATE: About 760-875 mm (30-35 in) annual rainfall.

SITE: Broad, straight slope on about 2° of a pediplain. A slightly accumulating position.

PARENT MATERIAL: Developed from colluvial drift of basaltic origin.

LAND USE: On edge of maize field.

SOIL DRAINAGE: Imperfect, permeability slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
Ap/A12	0 - 48 (0 - 19)	Black, 10 YR 2/1, moist; clay; moderate medium blocky structure; firm consistence, moist; plastic consistence, wet; surface self-mulching; cracks to horizon base; slickensides common; smooth, gradual boundary to:
C1	48 - 76 (19 - 30)	very dark grey, 2.5 Y 3/1, moist; clay; coarsly mottled with grey brown and manganese stained; massive; firm consistence, moist; sticky, plastic consistence, wet; smooth, gradual boundary to:
C2	76 - 130 (30 - 51) plus	dark greyish brown, 2.5 Y 4/2, moist; clay; massive; firm consistence, moist; sticky, plastic consistence, wet; some small manganese shot.

PROFILE G

HORIZON	Ap	A12	C1
DEPTH cm	0-13	18-31	51-64
Moisture 100-105°C %	5.93	7.83	7.89
200μ - 2 mm %	2	2	1
50μ - 200μ %	29	29	20
20μ - 50μ %	10	7	4
2μ - 20μ %	19	17	11
< 2μ %	32	37	61
$CaCO_3$ Equivalent %	-	-	-
Loss on Ignition %	10.9	11.9	8.7
Organic Carbon %	3.1	nd	nd
Total Nitrogen %	0.22	nd	nd
C/N Ratio	14	nd	nd
pH in water (1:2.5)	6.5	6.9	7.5
pH in M/100 $CaCl_2$	5.3	5.9	6.6
Exchangeable Calcium meq %	26.9	33.3	32.1
Exchangeable Magnesium meq %	10.5	13	15
Exchangeable Potassium meq %	0.51	0.40	0.55
Exchangeable Sodium meq %	0.14	0.20	0.33
Total Exchangeable Bases meq %	38.1	46.9	48.0
Exchangeable Hydrogen meq %	8.4	6.4	3.4
Cation Exchange Capacity meq % (by addition)	46.5	53.3	51.4
Base Saturation %	82	88	93

nd = no determination or no sample; tr = trace; - = nil

PROFILE H VERTISOL OF TOPOGRAPHIC DEPRESSIONS, THULO SET

LOCATION: By stream at Palama, near fork to Morija.

CLIMATE: About 760 mm (30 in) annual rainfall.

SITE: Developed from a deep pedisediment on the straight, broad lower erosion slope (about 2°) of a dissected peneplain.

PARENT MATERIAL: Pedisediments.

LAND USE: Maize field.

SOIL DRAINAGE: Imperfect to poor, permeability slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
Ap	0 - 18 (0 - 7)	Black 10 YR 2/1, moist; clay; weak medium prismatic structure, breaking to fine blocky; very firm consistence, moist, sticky, plastic consistence, wet; surface crusty; smooth, diffuse boundary to:
A12	18 - 46 (7 - 18)	very dark grey, 10 YR 3/1, moist; clay; moderate medium blocky structure; very firm consistence, moist; very sticky, very plastic consistence, wet; cracks to base of horizon; rare, small, black manganese shot; smooth, diffuse boundary to:
C1ca	46 - 73 (18 - 29)	very dark grey, 5 Y/1, moist; clay; distinctly mottled with yellowish brown; moderate medium blocky structure; firm consistence, moist; sticky, plastic consistency, wet; some manganese shot and fine carbonate segregations and rare carbonate concretions; slightly wavy, gradual boundary to:
C2ca	73 - 99 (29 - 39)	intimate intermottle of grey, 5 Y 5/1, moist and yellowish brown, 10 YR 5/6, moist, with also some streaks and pockets of very dark grey, 5Y hue; sandy clay; almost massive; firm consistence, moist; plastic, consistence, wet; frequent small, hard carbonate concretions; slightly wavy, gradual boundary to:
C3ca	99 - 147 (39 - 58) plus	yellowish brown, hard and dry pedisediment.

PROFILE H

HORIZON DEPTH cm	Ap 0-13	A12 23-36	Clca 51-64
Moisture 100-105°C %	3.48	5.98	3.96
200μ - 2 mm %	3	5	6
50μ - 200μ %	23	15	28
20μ - 50μ %	4	4	3
2μ - 20μ %	22	22	18
<2μ %	44	51	44
$CaCO_3$ Equivalent %	nd	-	21.3
Loss on Ignition %	8.0	8.2	5.6
Organic Carbon %	1.8	nd	nd
Total Nitrogen %	0.23	nd	nd
C/N Ratio	12	nd	nd
pH in water (1:2.5)	6.2	7.2	8.5
pH in M/100 $CaCl_2$	5.5	6.1	7.7
Exchangeable Calcium meq %	17.1	22.1	47.4
Exchangeable Magnesium meq %	7.6	12	13
Exchangeable Potassium meq %	0.85	0.91	0.73
Exchangeable Sodium meq %	0.25	0.46	0.59
Total Exchangeable Bases meq %	25.8	35.5	61.7
Exchangeable Hydrogen meq %	5.6	3.5	nd
Cation Exchange Capacity meq % (by addition)	31.4	39.0	61.7
Base Saturation %	82	91	100

nd = no determination or no sample; tr = trace; - = nil

PROFILE I **VERTISOL OF TOPOGRAPHIC DEPRESSIONS, KHABOS SET**

LOCATION:	800 m (½ mile) upstream from ford, Thaba Phatsoa area, Leribe district.
CLIMATE:	About 760-875 mm (30-35 in) annual rainfall.
SITE:	Almost flat stream terrace.
PARENT MATERIAL:	Developed from riverine alluvium.
VEGETATION:	Poor grass, on edge of cultivated land.
SOIL DRAINAGE:	Imperfect, permeability slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 23 (0 - 9)	Very dark greyish brown, 10 YR 3/2, moist; fine sandy clay loam; weak fine and medium blocky structure; friable consistence, moist; slightly sticky, slightly plastic consistence, wet; surface crusty; slightly wavy, clear boundary to:
A12	23 - 70 (9 - 28)	very dark grey, 10 YR 3/1, moist; clay loam; weak coarse blocky, breaking to medium blocky structure; firm consistence, moist; sticky, plastic consistency, wet; cracks to 18 in; smooth, diffuse boundary to:
C1	70 - 131 (28 - 52) plus	complex mixture of very dark greyish brown, 10 YR 3/2, moist, with some very dark grey, 10 YR 3/1, moist; clay; massive; firm consistence, moist; sticky, plastic consistence, wet.

PROFILE I

HORIZON	A11	A12	A12	C1
DEPTH cm	3-15	25-38	51-64	79-97
Moisture 100-105°C %	2.81	5.80	5.56	3.77
200μ - 2 mm %	5	2	3	4
50μ - 200μ %	49	40	37	42
20μ - 50μ %	9	12	15	16
2μ - 20μ %	12	18	16	11
<2μ %	20	21	23	24
$CaCO_3$ Equivalent %	nd	nd	nd	nd
Loss on Ignition %	7.1	9.2	8.3	5.7
Organic Carbon %	2.0	nd	nd	nd
Total Nitrogen %	0.19	nd	nd	nd
C/N Ratio	11	nd	nd	nd
pH in water (1:2.5)	5.4	5.2	5.7	6.4
pH in M/100 $CaCl_2$	4.7	4.4	4.8	5.4
Exchangeable Calcium meq %	10.1	13.5	19.3	15.8
Exchangeable Magnesium meq %	3.9	5.5	7.4	7.3
Exchangeable Potassium meq %	1.47	0.64	0.34	0.33
Exchangeable Sodium meq %	0.06	0.13	0.17	0.19
Total Exchangeable Bases meq %	15.5	19.8	27.2	23.6
Exchangeable Hydrogen meq %	7.9	14.5	9.9	4.5
Cation Exchange Capacity meq % (by addition)	23.4	34.3	37.1	28.1
Base Saturation %	66	58	73	84

nd = no determination or no sample; tr = trace; - = nil

PROFILE J — CLAYPAN SOIL, MASERU SET

LOCATION:	By deep erosion gulley, Agricultural Experimental Station, Maseru.
CLIMATE:	About 760 mm (30 in) annual rainfall.
SITE:	Lower erosion slope of about 3° of a dissected peneplain.
PARENT MATERIAL:	Developed from deep pedisediment over Red Beds sandstone.
VEGETATION:	Poor grass.
SOIL DRAINAGE:	Imperfect, permeability slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
A1	0 - 23 (0 - 9)	Brown, 10 YR 5/3, dry, (brown, 10 YR 4/3, moist) fine sandy loam; almost structureless; loose consistence, dry; smooth, diffuse boundary to:
A2	23 - 35 (9 - 14)	light grey, 10 YR 7/2, almost dry; fine sandy loam, with fine, faint, yellowish brown mottles; structureless; loose consistence, dry; rare small shot-like Fe concretions; slightly wavy, abrupt boundary to:
IIB21t	35 - 48 (14 - 19)	greyish brown, 2.5 Y 5/2, dry; clay loam, with smooth and continuous very dark greyish brown, clay skins on ped exterior; strong coarse prismatic structure; hard consistence, dry, firm consistence, moist; common Fe concretions; smooth, gradual boundary to:
IIB22t	48 - 76 (19 - 30)	greyish brown, 2.5 Y 5/2; dry; clay loam; clay skins less well developed than in preceding horizon; strong medium blocky structure; very hard consistence, dry; very firm consistence, moist; abundant rounded Fe concretions of all sizes; slightly wavy, clear boundary to:
IIC1	76 - 131 (30 - 52)	light grey; mottled with yellowish brown; hard dry pedisediment; abundant iron and lime concretions.
IIC2	131 - 186 (52 - 73) plus	Yellow pedisediment; mottled in shades of brown; abundant Fe concretions and some calcium concretions; black manganese stains along cracks. At 215 cm in donga, a grit bed, mostly pea-shaped iron concretions with larger, more angular pieces of sandstone, agate and more rarely, weathering dolerite.

PROFILE J

HORIZON DEPTH cm	A1 0-13	A2 25-34	IIB21t 41-48	IIB22t 58-71	IIC1 97-109
Moisture 100-105°C %	0.99	1.26	2.11	3.51	2.66
200μ - 2 mm %	7	5	4	4	3
50μ - 200μ %	51	43	40	35	47
20μ - 50μ %	20	24	18	16	12
2μ - 20μ %	12	16	15	17	16
<2μ %	9	11	23	28	22
$CaCO_3$ Equivalent %	nd	nd	-	tr	-
Loss on Ignition %	2.0	2.0	2.5	2.9	2.3
Organic Carbon %	0.6	0.2	0.3	nd	nd
Total Nitrogen %	0.06	0.03	0.04	nd	nd
C/N Ratio	10	7	8	nd	nd
pH in water (1:2.5)	5.9	6.0	8.1	9.0	8.5
pH in M/100 $CaCl_2$	5.2	5.3	6.7	7.4	6.9
Exchangeable Calcium meq %	1.5	1.5	4.6	6.7	4.6
Exchangeable Magnesium meq %	0.75	0.64	4.2	5.7	3.7
Exchangeable Potassium meq %	0.18	0.05	0.25	0.40	0.26
Exchangeable Sodium meq %	0.09	0.16	1.69	2.94	1.97
Total Exchangeable Bases meq %	2.5	2.4	10.7	15.7	10.5
Exchangeable Hydrogen meq %	2.3	1.0	1.2	0.7	0.9
Cation Exchange Capacity meq % (by addition)	4.8	3.4	11.9	16.4	11.4
Base Saturation %	52	71	90	96	92
Soluble Salts meq/100g (by conductivity)	0.2	0.1	0.3	0.4	0.3
Exchangeable Sodium %	1.9	4.7	14.2	17.8	17.3

nd = no determination or no sample; tr = trace; - = nil

PROFILE K **CLAYPAN SOIL, MASERU SET**

LOCATION:	Near Mokhele village, Mafeteng district.
CLIMATE:	About 500-630 mm (20-25 in) annual rainfall.
SITE:	Broad, straight lower erosion slope of about 4° of a dissected peneplain.
PARENT MATERIAL:	Developed from pedisediment overlying Beaufort sandy shales.
LAND USE:	On verge of maize field.
SOIL DRAINAGE:	Imperfect, permeability slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
AP	0 - 38 (0 - 15)	Brown, 10 YR 5/3, dry, (dark brown, 10 YR 4/3, moist) fine sandy loam; structureless; loose consistence, dry; some FeMn concretions at horizon base; smooth, clear boundary to:
IIB21t	38 - 50 (15 - 20)	greyish brown, 2.5 Y 5/2, moist; clay; weak medium blocky structure; firm consistence, moist; smooth, diffuse boundary to:
IIB22t	50 - 68 (20 - 27)	dark greyish brown, 2.5 Y 4/2, moist; clay; moderate medium blocky structure; very firm consistence, moist; smooth, clear boundary to:
IIC	68 - 112 (27 - 44)	yellowish brown, 10 YR 5/4, slightly moist; clay; slightly mottled with olive brown; coarse blocky structure, almost massive; very firm consistence dry.

PROFILE K

HORIZON DEPTH cm	Ap 0-13	Ap 25-38	IIB21t 39-50	IIc 68-81
Moisture 100-105°C %	1.61	2.06	5.46	5.14
200μ - 2 mm %	8	7	4	3
50μ - 200μ %	38	42	35	23
20μ - 50μ %	16	10	3	8
2μ - 20μ %	15	20	12	22
<2μ %	21	20	44	44
$CaCO_3$ Equivalent %	nd	nd	-	1.3
Loss on Ignition %	4.0	3.5	6.4	4.6
Organic Carbon %	1.0	1.1	0.9	nd
Total Nitrogen %	0.13	0.13	0.13	nd
C/N Ratio	8	9	7	nd
pH in water (1:2.5)	5.2	5.2	6.7	9.0
pH in M/100 $CaCl_2$	4.3	4.4	5.4	7.9
Exchangeable Calcium meq %	2.2	2.6	7.2	27.9
Exchangeable Magnesium meq %	2.2	2.2	8.8	13
Exchangeable Potassium meq %	0.43	0.23	0.47	0.67
Exchangeable Sodium meq %	0.35	1.16	3.10	4.71
Total Exchangeable Bases meq %	5.2	6.2	19.6	46.3
Exchangeable Hydrogen meq %	6.0	5.9	4.9	0.3
Cation Exchange Capacity meq % (by addition)	11.2	12.1	24.5	46.6
Base Saturation %	46	51	80	99
Soluble Salts meq/100g (by conductivity)	0.3	1.0	1.1	1.5

nd = no determination or no sample; tr = trace; - = nil

PROFILE L **CLAYPAN SOIL, SEPHULA SET**

LOCATION:	800 m (½ mile) from Sephula village, Mafeteng district, by track to main road.
CLIMATE:	About 630 mm (25 in) annual rainfall.
SITE:	A broad, flattish-topped slope crest, sloping about 1°.
PARENT MATERIAL:	Developed from colluvial drift over Molteno sandstone.
LAND USE:	Field fallow, after wheat.
SOIL DRAINAGE:	Imperfect, permeability slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
Ap	0 - 31 (0 - 12)	Brown, 10 YR 5/3, dry (dark brown, 10 YR 4/3, moist) loamy fine sand; structureless; loose consistence, moist; some rounded FeMn concretions; smooth, gradual boundary to:
A12	31 - 40 (12 - 16)	soil similar to horizon Ap, but containing abundant hard and rounded small FeMn concretions; smooth, clear boundary to:
IIB21t	40 - 70 (16 - 28)	strong brown, 7.5 YR 5/6, moist; clay, with olive brown mottles; weak, fine and medium blocky structure; firm consistence, moist; rare FeMn concretions; smooth, clear boundary to:
IIB22t	70 - 102 (28 - 40)	greyish brown, 2.5 Y 5/2, moist; clay; coarsly mottled with yellowish brown and manganese stained; moderate medium blocky structure; very firm consistence, moist; smooth gradual boundary to:
IIC	102 - 134 (40 - 53) plus	massive light olive brown clay.

PROFILE L

HORIZON DEPTH cm	Ap 0-13	Ap 18-31	IIB21t 46-56	IIB22t 74-86
Moisture 100-105°C %	0.69	1.23	9.49	6.89
200μ - 2 mm %	20	11	6	3
50μ - 200μ %	63	57	26	16
20μ - 50μ %	5	10	3	4
2μ - 20μ %	3	8	4	18
<2μ %	8	13	60	56
$CaCO_3$ Equivalent %	nd	nd	nd	-
Loss on Ignition %	1.4	2.3	7.4	8.9
Organic Carbon %	0.3	0.4	0.5	nd
Total Nitrogen %	0.03	0.05	0.10	nd
C/N Ratio	10	8	5	nd
pH in water (1:2.5)	6.0	6.0	6.3	7.5
pH in M/100 $CaCl_2$	4.9	4.8	5.1	6.2
Exchangeable Calcium meq %	0.7	1.5	7.5	11.0
Exchangeable Magnesium meq %	0.19	0.56	5.2	7.7
Exchangeable Potassium meq %	0.21	0.22	2.12	3.29
Exchangeable Sodium meq %	0.07	0.09	0.23	0.98
Total Exchangeable Bases meq %	1.2	2.4	15.1	23.0
Exchangeable Hydrogen meq %	1.7	2.8	4.9	3.3
Cation Exchange Capacity meq % (by addition)	2.9	5.2	20.0	26.3
Base Saturation %	41	46	76	87
Soluble Salts meq/100g (by conductivity)	0.1	0.1	0.2	0.3

nd = no determination or no sample; tr = trace; - = nil

PROFILE M	**BROWN SOIL OF SEMI-ARID REGIONS, MATS'ABA SET**
LOCATION:	Near fork in the road to Ramapepe, Leribe district.
CLIMATE:	About 760-875 mm (30-35 in) annual rainfall.
SITE:	On the level top of a small dolerite sill.
PARENT MATERIAL:	Developed from weathering dolerite and some colluvial drift of similar origin.
VEGETATION:	*Themeda* veld.
SOIL DRAINAGE:	Free, permeability moderately rapid.

HORIZON	DEPTH cm (in)	DESCRIPTION
A1	0 - 25 (0 - 10)	Reddish brown, 5 YR 4/4, moist; fine sandy loam; structureless; friable consistence, moist; smooth, gradual boundary to:
B1	25 - 43 (10 - 17)	yellowish red, 5 YR 4/6, moist; fine sandy clay loam; weak fine blocky structure; friable consistence, moist; rare small angular dolerite stones; smooth, gradual boundary to:
B2	43 - 58 (17 - 23)	yellowish red, 5 YR 4/8, moist; fine sandy clay loam; weak fine blocky structure; friable consistence, moist; sticky, slightly plastic consistence, wet; very rare rounded Fe concretions and some small dolerite stones; slightly wavy, gradual boundary to:
C	58 - 81 (23 - 32)	brownish yellow, 10 YR 6/6, moist; gritty, fine sandy loam; structureless; friable consistence, moist; frequent angular fragments of dolerite of varying sizes and some soft black manganese concretions and stains; wavy, abrupt boundary to
R	at 81 (32)	hard, but partially weathered, doleritic rock.

PROFILE M

HORIZON DEPTH cm	A1 3-15 ?	B1 28-41 ?	C 61-76 ?
Moisture 100-105°C %	1.05	1.78	2.87
200μ - 2 mm %	7	4	14
50μ - 200μ %	59	51	48
20μ - 50μ %	12	9	8
2μ - 20μ %	7	11	11
< 2μ %	13	23	16
$CaCO_3$ Equivalent %	nd	nd	nd
Loss on Ignition %	3.0	4.0	5.0
Organic Carbon %	0.7	nd	nd
Total Nitrogen %	0.08	nd	nd
C/N Ratio	9	nd	nd
pH in water (1:2.5)	4.6	5.2	5.3
pH in M/100 $CaCl_2$	4.0	4.1	4.1
Exchangeable Calcium meq %	1.3	1.5	2.4
Exchangeable Magnesium meq %	0.70	1.1	2.2
Exchangeable Potassium meq %	0.43	0.17	0.19
Exchangeable Sodium meq %	0.08	0.13	0.22
Total Exchangeable Bases meq %	2.5	2.9	5.0
Exchangeable Hydrogen meq %	4.3	5.6	6.1
Cation Exchange Capacity meq % (by addition)	6.8	8.5	11.1
Base Saturation %	37	34	45

nd = no determination or no sample; tr = trace; - = nil

PROFILE N **EUTROPHIC BROWN SOIL, MACHACHE SET**

LOCATION:	By road, 400m (¼ mile) west of Ntsi village, Maseru district.
CLIMATE:	About 760-875 mm (30-35 in) annual rainfall.
SITE:	Broad pediment slope of about 4°.
PARENT MATERIAL:	Developed from colluvial drift of basaltic origin.
LAND USE:	Poor grass, cultivated land.
SOIL DRAINAGE:	Free, permeability moderate.

HORIZON	DEPTH cm (in)	DESCRIPTION
Ap	0 - 13 (0 - 5)	Reddish brown, 5 YR 4/3, moist; clay loam; weak fine granular structure; friable consistence, moist; smooth, gradual boundary to:
B11	13 - 38 (5 - 15)	reddish brown, 5 YR 4/4, moist; clay; almost structureless; friable consistence, moist; smooth, gradual boundary to:
B12	38 - 63 (15 - 25)	yellowish red, 5 YR 4/6, moist; clay; weak fine sub-angular blocky structure; friable consistence, moist; smooth, diffuse boundary to:
IIB2	63 - 127 (25 - 50)	red, 2.5 YR 4/8; clay; weak fine sub-angular blocky structure; friable consistence, moist. A thin stone line of angular fragments of weathering basalt occurs in the upper part of this horizon.

PROFILE N

HORIZON DEPTH cm	Ap 3-13	B11 21-33	B12 46-58	IIB2 76-89
Moisture 100-105°C %	2.32	4.11	5.38	7.33
200μ - 2 mm %	2	4	2	8
50μ - 200μ %	35	31	32	22
20μ - 50μ %	12	8	16	11
2μ - 20μ %	14	12	14	15
< 2μ %	31	42	30	37
$CaCO_3$ Equivalent %	nd	nd	nd	nd
Loss on Ignition %	8.9	7.3	9.1	10.7
Organic Carbon %	2.0	nd	nd	nd
Total Nitrogen %	0.19	nd	nd	nd
C/N Ratio	11	nd	nd	nd
pH in water (1:2.5)	5.4	5.6	5.3	5.6
pH in M/100 $CaCl_2$	4.3	4.5	4.3	4.6
Exchangeable Calcium meq %	2.9	1.6	2.9	5.4
Exchangeable Magnesium meq %	1.6	2.1	2.2	7.4
Exchangeable Potassium meq %	0.86	0.17	0.25	0.24
Exchangeable Sodium meq %	0.11	0.18	0.17	0.24
Total Exchangeable Bases meq %	5.5	4.1	5.5	13.3
Exchangeable Hydrogen meq %	10.3	6.8	8.8	8.0
Cation Exchange Capacity meq % (by addition)	15.8	10.9	14.3	21.3
Base Saturation %	35	38	38	62

nd = no determination or no sample; tr = trace; - = nil

PROFILE O **FERSIALLITIC SOIL, LERIBE SET**

LOCATION: By camp, Tsiu's Dam, Maseru district.

CLIMATE: About 760 mm (30 in) annual rainfall.

SITE: Stable, slightly convex, broad slope of about 3° below a slope crest.

PARENT MATERIAL: Developed from colluvial drift over Red Beds sandstone.

VEGETATION: Overgrazed *Cymbopogon-Themeda* veld.

SOIL DRAINAGE: Free, permeability moderate.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 13 (0 - 5)	Reddish brown, 5 YR 4/4, dry (brown, 7.5 YR 4/4, moist) fine sandy loam; very weak fine blocky structure-almost structureless; friable consistence, moist; smooth, gradual boundary to:
A12	13 - 35 (5 - 14)	reddish brown, 5 YR 4/4, moist; fine sandy loam; structureless; friable consistence, moist; smooth, gradual boundary to:
IIB21	35 - 70 (14 - 28)	red, 2.5 YR 4/6, moist; fine sandy clay loam; structureless; friable consistence, moist; slightly sticky, slightly plastic consistence, wet; some small shot-like FeMn concretions; smooth, diffuse boundary to:
IIB22	70 - 127 (28 - 50)	red, 2.5 YR 4/8, moist; fine sandy clay; very weak fine to medium blocky structure; friable consistence, moist; smooth, gradual boundary to:
IIC	127 - 165 (50 - 65) plus	dark reddish brown, 5 YR hue; clay; firm, compact consistence, moist; much manganese stained and containing frequent rounded FeMn concretions.

PROFILE O

HORIZON DEPTH cm	A11 0-13	A12 14-25	IIB21 36-46	IIB22 71-81
Moisture 100-105°C %	0.92	1.55	2.72	4.04
200μ - 2 mm %	8	7	7	5
50μ - 200μ %	54	51	46	39
20μ - 50μ %	14	16	12	8
2μ - 20μ %	8	8	4	4
2μ %	15	17	30	42
$CaCO_3$ Equivalent %	nd	nd	nd	nd
Loss on Ignition %	2.3	2.7	4.3	5.9
Organic Carbon %	0.4	nd	nd	nd
Total Nitrogen %	0.05	nd	nd	nd
C/N Ratio	8	nd	nd	nd
pH in water (1:2.5)	5.3	5.7	5.3	6.0
pH in M/100 $CaCl_2$	4.5	4.8	4.7	5.2
Exchangeable Calcium meq %	1.3	1.7	2.3	2.8
Exchangeable Magnesium meq %	0.63	0.78	1.5	2.8
Exchangeable Potassium meq %	0.42	0.33	0.21	0.27
Exchangeable Sodium meq %	0.10	0.09	0.09	0.15
Total Exchangeable Bases meq %	2.5	2.9	4.1	6.0
Exchangeable Hydrogen meq %	2.6	2.7	3.3	3.6
Cation Exchange Capacity meq % (by addition)	5.1	5.6	7.4	9.6
Base Saturation %	49	52	55	63

nd = no determination or no sample; tr = trace; - = nil

PROFILE P **FERSIALLITIC SOIL, LERIBE SET**

LOCATION:	By main road 800 m (½ mile) west of St. Monica Mission, Leribe district.
CLIMATE:	About 760-875 mm (30-35 in) annual rainfall.
SITE:	Crest of a hill of Red Beds sandstone with a slope of about 2°.
PARENT MATERIAL:	Developed from colluvial drift.
LAND USE:	Old cropland, now rough grass.
SOIL DRAINAGE:	Free, permeability moderate.

HORIZON	DEPTH cm (in)	DESCRIPTION
Ap	0 - 13 (0 - 5)	Reddish brown, 5 YR 4/3, moist; fine sandy loam; structureless; friable consistence, moist; smooth, gradual boundary to:
A12	13 - 25 (5 - 10)	reddish brown, 5 YR 4/4, moist; fine sandy loam; friable consistence, moist; smooth, gradual boundary to:
B1	25 - 40 (10 - 16)	yellowish red, 5 YR 4/6, moist; fine sandy clay loam; structureless; friable consistence, moist; smooth, gradual boundary to:
IIB21	40 - 73 (16 - 29)	red, 2.5 YR 4/6, moist; fine sandy clay loam; very weak fine sub-angular blocky structure; friable consistence, moist; slightly sticky, very slightly plastic consistence, wet; smooth, diffuse boundary to:
IIB22	73 - 137 (29 - 54) plus	red, 2.5 YR 4/8, moist; fine sandy clay loam; very weak fine sub-angular blocky structure; firm to friable consistence, moist; slightly sticky, slightly plastic consistence, wet.

PROFILE P

HORIZON **DEPTH** cm	Ap 3-13	A12 15-25	IIB21 43-54	IIB21 61-74
Moisture 100-105°C %	1.02	1.51	2.21	3.95
200μ - 2 mm %	4	3	4	3
50μ - 200μ %	54	47	51	42
20μ - 50μ %	17	19	12	14
2μ - 20μ %	9	13	9	7
<2μ %	14	16	24	33
$CaCO_3$ Equivalent %	nd	nd	nd	nd
Loss on Ignition %	3.0	3.9	3.8	4.3
Organic Carbon %	0.5	nd	nd	nd
Total Nitrogen %	0.06	nd	nd	nd
C/N Ratio	8	nd	nd	nd
pH in water (1:2.5)	5.1	5.8	5.6	5.9
pH in M/100 $CaCl_2$	4.3	4.8	4.8	5.1
Exchangeable Calcium meq %	1.3	2.5	1.8	1.6
Exchangeable Magnesium meq %	0.59	1.0	1.1	2.0
Exchangeable Potassium meq %	0.37	0.23	0.18	0.21
Exchangeable Sodium meq %	0.10	1.10	1.12	0.11
Total Exchangeable Bases meq %	2.4	3.8	3.2	3.9
Exchangeable Hydrogen meq %	3.6	3.2	3.4	3.2
Cation Exchange Capacity meq % (by addition)	6.0	7.0	6.6	7.1
Base Saturation %	40	54	48	55

nd = no determination or no sample; tr = trace; - = nil

PROFILE Q — FERSIALLITIC SOIL, BEREA SET

LOCATION:	About 400 m (¼ mile) from Maqalika Village, Maseru district.
CLIMATE:	About 760 mm (30 in) annual rainfall.
SITE:	Stable, straight slope of about 4° immediately below a slope crest.
PARENT MATERIAL:	Derived from drift material overlying dull yellow coloured Red Beds sandstone.
VEGETATION:	Overgrazed *Cymbopogon-Themeda* veld.
SOIL DRAINAGE:	Free, permeability moderate.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 15 (0 - 6)	Light yellowish brown, 10 YR 6/4, very slightly moist; loamy fine sand; very weak fine and medium granular structure; very friable consistence, moist; smooth, diffuse boundary to:
A12	15 - 40 (6 - 16)	yellowish brown, 10 YR 5/4, moist; loamy fine sand; structureless; friable consistence, moist; common rounded FeMn concretions; smooth, gradual boundary to:
B1	40 - 58 (16 - 23)	yellowish brown, 10 YR 5/6, moist; fine sandy loam, finely and faintly mottled with strong brown; structureless; friable consistence, moist; very common rounded FeMn concretions; smooth, gradual boundary to:
B2	58 - 76 (23 - 30)	yellowish brown, 10 YR 5/8, moist; fine sandy loam; distinct, common, coarse red-brown mottles; very weak fine blocky structure; friable consistence, moist; common FeMn concretions; smooth gradual boundary to:
C1	76 - 102 (30 - 40)	yellowish brown, 10 YR 5/4, moist; fine sandy clay with variegated weathering colours; weak medium blocky structure; firm consistence, moist; slightly sticky, slightly plastic consistence, wet; sparse FeMn concretions; slightly wavy, clear boundary to:
C2	102 (40) plus	yellow; gritty sand with much black manganese staining.

PROFILE Q

HORIZON	A11	A12	B1	B2	C1
DEPTH cm	3-13	23-36	43-56	66-76	86-100
Moisture 100-105°C %	0.81	0.49	0.82	1.35	2.11
200μ - 2 mm %	14	18	19	14	20
50μ - 200μ %	47	61	54	55	41
20μ - 50μ %	17	8	8	8	6
2μ - 20μ %	10	4	5	3	6
<2μ%	11	9	13	19	26
$CaCO_3$ Equivalent %	nd	nd	nd	nd	nd
Loss on Ignition %	2.2	1.4	1.9	2.7	4.0
Organic Carbon %	0.5	0.2	nd	nd	nd
Total Nitrogen %	0.05	0.03	nd	nd	nd
C/N Ratio	10	7	nd	nd	nd
pH in water (1:2.5)	5.8	5.7	5.8	5.5	5.3
pH in M/100 $CaCl_2$	4.7	4.7	4.8	4.5	4.3
Exchangeable Calcium meq %	1.7	1.2	1.3	1.3	2.0
Exchangeable Magnesium meq %	0.57	0.59	0.82	1.3	1.8
Exchangeable Potassium meq %	0.28	0.12	0.13	0.12	0.17
Exchangeable Sodium meq %	0.09	0.10	0.12	0.09	0.12
Total Exchangeable Bases meq %	2.6	2.0	2.4	2.8	4.1
Exchangeable Hydrogen meq %	2.9	1.5	1.7	2.6	4.2
Cation Exchange Capacity meq % (by addition)	5.5	3.5	4.1	5.4	8.3
Base Saturation %	47	57	59	52	49

nd = no determination or no sample; tr = trace; - = nil

PROFILE R **FERRALLITIC SOIL, THEBE SET**

LOCATION:	On Berea Plateau, by end of motorable track from Lancers' Gap.
CLIMATE:	About 760-875 mm (30-35 in) annual rainfall.
SITE:	Near the foot of a straight slope of about 2° on a pediplain. A slightly accumulating site.
PARENT MATERIAL:	Developed from colluvial drift over Cave Sandstone.
VEGETATION:	Overgrazed *Cymbopogon-Themeda* veld.
SOIL DRAINAGE:	Free, permeability moderate.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 23 (0 - 9)	Dark brown, 10 YR 4/3, dry, (dark brown, 10 YR 3/3, moist) fine sandy loam; almost structureless; loose consistence, moist; smooth, gradual boundary to:
A12	23 - 38 (9 - 15)	brown, 10 YR 5/3, dry (dark brown, 10 YR 4/3, moist) fine sandy loam; structureless; loose to friable consistence, moist; smooth, gradual boundary to:
B1	38 - 50 (15 - 20)	yellowish brown, 10 YR 5/6, moist; fine sandy loam; structureless; friable consistence, moist; smooth, diffuse boundary to:
B21	50 - 88 (20 - 35)	brownish yellow, 10 YR 6/6, moist; fine sandy clay loam; structureless; friable consistence, moist; sparse, hard and rounded iron concretions; smooth, diffuse boundary to:
B22	88 - 131 (35 - 52) plus	brownish yellow, 10 YR 6/6, moist; fine sandy clay; very weak, fine and medium blocky structure; firm to friable consistence, moist; slightly plastic, slightly sticky consistence, wet; some hard iron concretions increasing in amount with depth.

PROFILE R

HORIZON DEPTH cm	A11 0-13	A12 23-36	B1 38-50	B21 61-74
Moisture 100-105° C %	1.87	1.72	1.66	2.55
200μ - 2mm %	1	2	2	2
50μ - 200μ %	50	52	45	50
20μ - 50μ %	15	14	18	13
2μ - 20μ %	13	13	13	6
<2μ %	18	17	21	28
$CaCO_3$ Equivalent %	nd	nd	nd	nd
Loss on Ignition %	4.7	4.1	3.5	3.6
Organic Carbon %	1.2	nd	nd	nd
Total Nitrogen %	0.12	nd	nd	nd
C/N Ratio	10	nd	nd	nd
pH in water (1:2.5)	4.1	4.5	4.7	4.7
pH in M/100 $CaCl_2$	3.6	3.7	3.9	4.0
Exchangeable Calcium meq %	0.5	0.5	0.3	0.3
Exchangeable Magnesium meq %	0.15	0.14	0.18	0.23
Exchangeable Potassium meq %	0.47	0.13	0.10	0.12
Exchangeable Sodium meq %	0.08	0.10	0.10	0.10
Total Exchangeable Bases meq %	1.2	0.9	0.7	0.8
Exchangeable Hydrogen meq %	8.6	6.9	5.5	5.0
Cation Exchange Capacity meq % (by addition)	9.8	7.8	6.2	5.8
Base Saturation %	12	12	11	14

nd = no determination or no sample; tr = trace; - = nil

PROFILE S **CLAYPAN SOIL INTERGRADE**

LOCATION:	800 m (½ mile) from Tsoinyane River, near Mohobong track, Leribe district.
CLIMATE:	About 760-875 mm (30-35 in) annual rainfall.
SITE:	Towards the foot of a broad convex slope of about 3°. A slightly accumulating position.
PARENT MATERIAL:	Developed from colluvial drift over Molteno Sandstone.
LAND USE:	Rough grass, cultivated land.
SOIL DRAINAGE:	Free, permeability moderately slow.

HORIZON	DEPTH cm (in)	DESCRIPTION
Ap	0 - 8 (0 - 3)	Dark brown, 10 YR 3/3, moist; fine sandy clay loam; weak to moderate fine blocky structure; friable to firm consistence, moist; smooth, clear boundary to:
B2	8 - 33 (3 - 13)	dark yellowish brown, 10 YR 3/4, moist; fine sandy clay; moderate medium blocky structure; firm consistence, moist; sticky, plastic consistence, wet; smooth, diffuse boundary to:
C	33 - 125 (13 - 49)	dark yellowish brown, 10 YR 4/4, moist, tending to dark brown or dark greyish brown; fine sandy clay; structureless; firm consistence, moist.

PROFILE S

HORIZON DEPTH cm	Ap 0-8	B2 21-33	C 51-64
Moisture 100-105° C %	3.91	7.28	7.42
200µ - 2mm %	4	2	3
50µ - 200µ %	44	36	39
20µ - 50µ %	11	10	9
2µ - 20µ %	10	13	18
<2µ %	27	33	26
$CaCO_3$ Equivalent %	nd	nd	-
Loss on Ignition %	7.1	9.6	7.9
Organic Carbon %	1.3	nd	nd
Total Nitrogen %	0.14	nd	nd
C/N Ratio	9	nd	nd
pH in water (1:2.5)	5.7	6.3	6.7
pH in M/100 $CaCl_2$	4.9	5.5	5.9
Exchangeable Calcium meq %	11.1	17.8	21.6
Exchangeable Magnesium meq %	8.1	11	13
Exchangeable Potassium meq %	0.50	0.31	0.26
Exchangeable Sodium meq %	0.14	0.23	0.41
Total Exchangeable Bases meq %	19.8	29.3	35.3
Exchangeable Hydrogen meq %	6.2	6.1	4.4
Cation Exchange Capacity meq % (by addition)	26.0	35.4	39.7
Base Saturation %	76	83	89

nd = no determination or no sample; tr = trace; - = nil

PROFILE T **CALCIMORPHIC SOIL INTERGRADE**

LOCATION:	By Fusi Village, Mountain Road, about 2,070 m (6,900 feet) elevation.
CLIMATE:	About 760-875 mm (30-35 in) annual rainfall.
SITE:	Northern aspect, on a broad, straight slope about 12°.
PARENT MATERIAL:	Developed from weathering basaltic rocks.
VEGETATION:	Poor *Themeda* veld.
SOIL DRAINAGE:	Free, permeability moderate.

HORIZON	DEPTH cm (in)	DESCRIPTION
A11	0 - 15 (0 - 6)	Dark brown, 10 YR 3/3, moist; loamy sand; structureless; loose consistence, dry; smooth, clear boundary to:
A12	15 - 35 (6 - 14)	dark reddish brown, 5 YR 3/4, moist; clay loam; strong medium sub-angular blocky (breaking to granular) structure; firm consistence, moist; slightly sticky, slightly plastic consistence, wet; smooth, clear boundary to:
C	35 - 70 (14 - 28)	reddish brown, 5 YR 4/4, moist; sandy loam; much weathering basaltic material; weak coarse blocky structure; wavy, abrupt boundary to:
R	at 70 (28)	solid basalt lava.

PROFILE T

HORIZON	A12
DEPTH cm	18-31
Moisture 100-105° C %	7.18
200μ - 2mm %	5
50μ - 200μ %	30
20μ - 50μ %	9
2μ - 20μ %	15
<2μ %	31
$CaCO_3$ Equivalent %	nd
Loss on Ignition %	13.0
Organic Carbon %	1.1
Total Nitrogen %	0.16
C/N Ratio	7
pH in water (1:2.5)	5.7
pH in M/100 $CaCl_2$	6.3
Exchangeable Calcium meq %	11.0
Exchangeable Magnesium meq %	20
Exchangeable Potassium meq %	0.36
Exchangeable Sodium meq %	0.06
Total Exchangeable Bases meq %	31.4
Exchangeable Hydrogen meq %	7.4
Cation Exchange Capacity meq % (by addition)	38.8
Base Saturation %	81

nd = no determination or no sample; tr = trace;- = nil

METHODS OF ANALYSIS

Preparation of sample: the soil taken from the field is air dried and hand ground to pass a 2 mm screen. A sub-sample is ground in a Morrice mechanical pestle and mortar (agate) to pass a 0.5 mm sieve. The 2 mm sample is used for all determinations except carbon, nitrogen and calcium carbonate equivalent which are made on the 0.5 mm sample.

Mechanical analysis: the sample is dispersed using sodium hexa-metaphosphate (*Calgon*) and sodium hypochlorite. Calcium carbonate is not dissolved. Coarse sand (200μ - 2 mm) is retained on a suitable sieve; the fractions $<2\mu$, 2-20μ and 20-50μ are obtained by sedimentation analysis using an hydrometer (Bouyoucos, 1951). The 50-200μ fraction is calculated by difference, after making allowance for the organic matter present. The fractions separated are:

International coarse sand	200μ - 2 mm	
International fine sand	50μ - 200μ	
	20μ - 50μ	U.S. Soils Bureau silt
International silt	2μ - 20μ	U.S. Soils Bureau silt
International clay	$<2\mu$	

Loss on ignition: this value is determined using a muffle furnace maintained at 850°C and is corrected for decomposition of calcium carbonate, when this is present.

Calcium carbonate equivalent: a calcimeter (Bascomb, 1961) is used to measure the volume of carbon dioxide evolved from the sample on treatment with 1:3 hydrochloric acid. This is calculated to the equivalent amount of calcium carbonate irrespective of whether other carbonates contribute.

Organic carbon: Tinsley's procedure (Tinsley, 1950) of wet oxidation under reflux with a mixture of 0.4N sodium dichromate, 15N sulphuric acid and 3N phosphoric acid, at 140°C for 2 hours, is used. The excess of dichromate is titrated against ferrous ammonium sulphate using barium diphenylamine sulphonate as indicator.

Total Nitrogen: a Kjeldahl digestion is followed by steam distillation of an aliquot using a Hoskins apparatus (Hoskins, 1944) the distillate is absorbed in boric acid and titrated with 0.01N hydrochloric acid.

pH measurements: these are made electometrically in a 1:2.5 suspension of soil (a) in water (b) in 0.01M calcium chloride (Schofield and Taylor, 1955).

Exchangeable bases: the soil is leached with neutral normal ammonium acetate. Sodium and potassium in the leachate are determined directly using an Eel flame photometer, while calcium is determined in the same apparatus after the addition of magnesium as release agent (Rowe, 1963). Magnesium is determined spectrographically using a porous cup technique (Scott and Ure, 1958).

Exchangeable hydrogen: a modification of the method of Mados (1943) is used. The soil is equilibrated with 0.2N ammonium hydroxide and formaldehyde is added. After shaking, the formaldehyde is centrifuged off, 2.5N barium chloride is added and the mixture again shaken and centrifuged. The supernatant liquid is then titrated with 0.1N sodium hydroxide.

Soluble salts: these are determined by conductivity measurement on a 1:5 water extract. The results are recalculated in terms of meq per 100 g soil. (United States Department of Agriculture 1954).

APPENDIX II - X-RAY ANALYSIS DATA

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APPENDIX II X-RAY ANALYSIS

(Surface horizons)

SAMPLE NO.	LOCALITY	SOIL TYPE	KAOLIN	MICA	VERMICULITE	MONTMORILLONITE	FELSPAR	QUARTZ	GOETHITE	HAEMATITE
X 983	Leribe	Red-Brown Fersiallitic	Moderate	Dominant	-	-	Present	Much	-	Present
X 984	Berea	Yellow-Brown Fersiallitic	Moderate	Dominant	-	-	Present	Present	-	Present
X 985	Matsieng	Red-Brown Fersiallitic	Moderate	Dominant	-	-	Present	Much	-	Present
X 986	Mafeteng	Claypan	Moderate	Dominant	-	-	Present	Much	-	-
X 987	Machache	Eutrophic Brown	Dominant	Moderate	-	-	-	Present	Present	Present
X 988	Maseru	Claypan	Moderate	Dominant	-	-	Present	Much	-	-
X 989	Mokhotlong	Calcimorphic	Very little	-	Very little	Dominant	Present	Present	-	Present

Dominant >75%, Moderate 26-50%, Very little 5-10%. Present, Much, refer to non-clay minerals, percentages of which could not be determined in these samples.

APPENDIX III - AREAS OF THE DIFFERENT SOIL MAPPING UNITS

APPENDIX III AREAS OF THE DIFFERENT SOIL MAPPING UNITS

SOIL MAPPING UNIT		AREA: SQUARE KILOMETRES	AREA: SQUARE MILES
1	Lithosols on lava	4317.51	1667.0
2	Lithosols on lava/Basalt rock debris	3449.87	1332.0
3	Lithosols on lava/Calcimorphic soils	6570.01	3695.0
4	Lithosols on rocks rich in ferromagnesian minerals	166.54	64.3
5	Lithosols on rocks rich in ferromagnesian minerals/Eutrophic brown soils	209.53	467.0
6	Lithosols on sedimentary rocks/Sedimentary rock debris	4314.92	1666.0
7	Lithosols on sedimentary rocks/Fersiallitic soils	10.36	4.0
8	Lithosols on sedimentary rocks/Ferrallitic soils	20.72	8.0
9	Juvenile soils on recent riverine alluvium	39.11	15.1
10	Calcimorphic soils/Lithosols on lava	2362.07	912.0
11	Calcimorphic soils/Vertisols	88.06	34.0
12	Vertisols of lithomorphic origin	44.03	17.0
13	Vertisols of lithomorphic origin/ Calcimorphic soils	196.84	76.0
14	Vertisols of topographic depressions	202.02	78.0
15	Claypan soils (Maseru set)	2444.95	944.0
16	Claypan soils/Vertisols	5.70	2.2
17	Claypan soils (Maseru set/Sephula set)	1.56	0.6
18	Claypan soils/Fersiallitic soils	76.41	29.5
19	Claypan soils (Sephula set)	202.02	78.0
20	Claypan soils (Sephula set/Maseru set)	1.56	0.6
21	Eutrophic brown soils/Vertisols	898.73	347.0
22	Fersiallitic soils	738.15	285.0
23	Fersiallitic soils/Lithosols	33.67	13.0
24	Fersiallitic soils/Claypan soils	91.69	35.4
25	Fersiallitic - Lithosol intergrades	31.08	12.0
26	Ferrallitic soils/Lithosols	70.19	27.1

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