SOIL CLASSIFICATION

A BINOMIAL SYSTEM FOR SOUTH AFRICA

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A Report on a Research Project conducted under the Auspices of

The Soil and Irrigation Research Institute

DEPARTMENT OF AGRICULTURAL TECHNICAL SERVICES

1977

First published in 1977 by
THE DEPARTMENT OF AGRICULTURAL TECHNICAL SERVICES
REPUBLIC OF SOUTH AFRICA

Science Bulletin 390

Price R7,50 Other Countries R9,50

ISBN 0 621 03831 8

Obtainable from
Director, Division of Agricultural Information
Private Bag X144, Pretoria 0001
Republic of South Africa

Preface

THE OBJECT of this book is to present a simple, definitive statement of the first detailed system for classifying the soils of South Africa. The system has evolved over a period of years and is now being formally released for general use after extensive performance-testing by a wide variety of individuals and organizations. Its general acceptability in the agricultural sphere has been established and its implementation as a national system approved by the Department of Agricultural Technical Services. Publication of a definitive edition at this juncture is thus appropriate. This is a first edition; it is certain that the system as presented here is not the final word. It will continue to develop in step with expanding knowledge of the soils of this country; future changes will reflect refinements in the appreciation of the soil both as a natural phenomenon and as an essential life support.

Because there exist many popular misconceptions regarding the nature and purpose of soil classification, it is important that those who would wish to use this system develop an early appreciation both of its possibilities and its limitations. Soil properties – visible as well as non-visible (but measurable) – form the basis of the classification. Since properties, individually and collectively, determine the intrinsic behaviour and capability of soils, a vast amount of information that is potentially relevant to land use and management is contained in and can be conveyed by the language of classification. Those, therefore, who see soil classification as a theoretical or academic exercise – something for the experts only – deprive themselves of sharing in the practical benefits that result from its use. On the other hand, it must not be thought that classification will, in itself, provide answers to all questions. It must be coupled to soil mapping for it to yield any information on the geographical distribution of soils. It must be coupled to information on other resources such as climate, topography and management before it will have any specific meaning in terms of land use and agricultural production. As part of an integrated information system it has immense utility; alone it has limited value.

This soil classification has as its primary aim the identification and naming of soils according to an orderly system of defined classes, whereby the inter-relationships between soil properties are clearly revealed and communication about soils in an accurate and consistent way is made possible. It also has secondary and more practical aims relating to land utilization and management; these it achieves by pointing up similarities and differences between soils that are pertinent to land use, and by giving clarity and meaning to map legends. However, none of these secondary aims is achieved without additional inputs of information and interpretation. A clear distinction must therefore be made between the classification of soils, and interpretations based on the classification. The former is dealt with here, the latter not. And for very good reasons. In the first place, land use interpretations must be preceded by a statement of objective, and so great is the number of potential objectives involving the soil that it is impossible in a work of this nature to anticipate, leave alone discuss them. Secondly, only a part of the information required to make interpretations is contained in the classification; other non-soil information, and not infrequently other soil information, is invariably also required, and about this the soil classification has nothing to say. Local climatic, topographic, engineering, socio-economic and many other factors must normally be considered and integrated with the soil factor when making interpretations for a specified objective. It is thus beyond the scope of this book to venture any statements, however simple or generalized, on the ability of soils to fulfil certain functions or on their behaviour when put to a particular form of use. Such statements are more appropriately made at the level of local land capability studies.

This book is intended then to serve as a ***vade mecum*** for soils identification in South Africa. It does not include a discussion of the theory of soil classification, nor does it purport to be a manual for soil survey or a treatise on soil genesis. However, to enable those who might not be well-versed in the technicalities of soil science to use the system independently of other sources of information, to promote insight into the significance for land use of soil classes and to facilitate interpretation of maps and reports relating to the quality of soil, explanatory notes on various terms and concepts are included in the glossary.

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Conveners: Soil Classification Working Group

Pretoria, 1977

Acknowledgements

THE APPEARANCE of this book is due in large measure to the Secretary, Department of Agricultural Technical Services who sanctioned its publication, and to the Director, Soil and Irrigation Research Institute under whose auspices the Soil Classification Working Group was convened and whose support was unfailing.

Several colleagues in the Department of Agricultural Technical Services generously gave their assistance. Mr J.L. Hutson and Mr H.M. du Plessis helped in compiling the glossary of terms. Photographs to illustrate soil forms were provided by Mr R.P.V. Haug (6), Mr F. Ellis and Mr B.H.A. Schloms (3), Mr T.E. Dohse (1) and Mr J.F. Eloff (1). Mr A.T.P. Bennie, Mr R.W. Bruce, Mr J.A.V. Dietrichsen, Mr F. Ellis, Dr M.V. Fey, Mr R.W. Fitzpatrick, Dr P.F. Fuls, Mr B.C. Geers, Dr P.J. Gous, Dr H.C.H. Hahne, Mr J.L. Schoeman, Mr J.A. Smit and Mr K.P. Taylor gave helpful comment or located sites in the field that yielded photographs to illustrate some of the soil forms.

Finally, the Soil Classification Working Group is indebted to many un-named colleagues who, over a long period of time, have provided useful information and given helpful criticism.

Contents

Abstract

THE BOOK sets out a natural, two-category or binomial system for classifying the soils of South Africa designed to permit easy identification. The higher category contains 41 soil forms, each made up of a vertical sequence of diagnostic horizons or materials (not more than four in number) that are generally easy to identify in the field. Altogether there are five topsoil and fifteen subsoil diagnostic horizons, each clearly defined in terms of soil properties and briefly discussed in terms of genesis. Soil series (504 in all) within the forms constitute the lower category and are differentiated according to a variety of criteria (texture, base status etc). The series are referred to by geographic names (no two series have the same name), which are labels with no intrinsic significance, and the form takes its name from one of its constituent series. Each form is illustrated by a colour plate. A glossary of terms and an index are included.

Résumé

LE LIVRE présente un système naturel binômial, ou à deux catégories, pour la classification des sols d'Afrique du Sud. Ce système a été élaboré dans le but de permettre une identification aisée. La catégorie supérieure comprend 41 différentes sortes ("formes") de sols, dont chacune est constituée d'une séquence verticale d'horizons de diagnostic, ou de matériaux (pas plus de 4 en tout), qui sont généralement facilement identifiables sur le terrain. En tout il y a cinq horizons de diagnostic de surface, et 15 de sous-sol, dont chacun est défini en fonction des propriétés du sol, et brièvement discuté en fonction de sa genèse. Les séries de sols (504 en tout) comprises dans les différentes "formes", constituent la catégorie inférieure et sont différenciées d'après toute une gamme de critères (texture, saturation en bases, etc). Les séries sont dénommées par des noms géographiques (deux séries ne portant jamais le même nom). Ces noms sont des désignations sans signification intrinsèque, et les formes de sols prennent leur nom d'une de leurs séries constituantes. Chaque forme est illustrée par une planche en couleur. L'analyse comprend également, un lexique de termes et un répertoire alphabétique.

Historical Background

THE FIRST edition of a new soil classification system for South Africa is presented in response to a widely-felt need for some means of identifying and naming soils in a consistent way and for distinguishing between those whose properties and behaviour demand that they be set apart. This need has arisen notwithstanding the meritorious contributions of earlier South African soil scientists. For a time the broad groupings of Van der Merwe[1], together with those made in terms of the CCTA/SPI legend for the soil map of Africa[2] and its early drafts, provided an adequate perspective of the general nature of the soil mantle and permitted orientation at an atlas scale. But as objectives became more practical in terms of agricultural and other kinds of land utilization and attention consequently became focused on individual landscapes, individual farms, and individual fields, these groupings proved to be inadequate. They were not sufficiently rigorous in definition, nor were they sufficiently specific in differentiation, for the purpose of detailed soil identification and mapping.

The past fifteen years have seen a dramatic increase in the tempo of soil mapping in South Africa and inevitably the problem of selecting or developing a classification had to be faced. Without a generally accepted classification system soil mapping programmes lack continuity in time and space and the resulting maps lose much of their interpretability. There was no intention, initially, of developing a new system. On the contrary, considerable effort was devoted to examining the applicability of available systems, notably that of the USDA Soil Survey Staff[3]. However, as information accumulated it became evident that there was no factual, logical and, above all,

1 Van der Merwe, C.R., 1941. Soil groups and sub-groups of South Africa. Dept. Agric. and Forestry. Science Bulletin 231. Revised 1962 as Science Bulletin 356. Pretoria: Government Printer.

2 D'Hoore, J.L. (Co-ordinator), 1964. Soils Map of Africa. Commission for Technical Co-operation in Africa (CCTA) and Interafrica Pedological Service (SPI) Joint Project No. 11.

3 Soil Survey Staff, 1960. Soil classification – a comprehensive system (7th Approximation). US Dept. Agric. Washington: US Govt. Printing Office.

simple system which would satisfactorily accommodate the soils of South Africa.

It is of interest to reflect on the stimuli which gave rise to the period of heightened enquiry into the nature and distribution of the soils of this country. Foremost was probably a growing realization that existing information on soil and other land resources was grossly inadequate to serve a variety of needs. Impending intensification in land use, coupled with increasing world-wide concern over population trends and dwindling natural resources, undoubtedly did much to precipitate this realization. It was predictable that planning, in all its aspects, would be needed in order to optimize land utilization and fully develop the natural resources potential of the country. But such planning demands a complex information infrastructure which is not developed overnight. Soils information was in a parlous state and there seemed thus to be compelling reasons why a systematic study of the soil resources of the nation should be initiated.

The inadequacies were highlighted by agricultural research in various spheres. For example, the question arose as to whether the problems that were being addressed by agronomic research and field experimentation were sufficiently widespread to justify the effort and, once results were obtained, where were they applicable? The much discussed gap between research and the extension of its results could be traced largely to the absence of a secure basis for extrapolation.

Little was known about unique yield ceilings and response patterns of individual soils and soil-climate interactions. Consequently, fertilizer advisory work developed upon fairly standard recommendations which, even though they were guided by soil analysis, inescapably under-exploited the inherent production potential in some situations and probably overestimated it in others.

Most disturbing of all, perhaps, was the fact that scant attention was being given to the nature of the soil during farm planning. Ideally, farm planning involves the integration of all available agricultural information and the application of that which is relevant to a particular site or situation. Increasing demands upon the agricultural industry cause farming to become more intensive and specialized. This in turn brings about an increase in the proportion of technology that must be applied vertically, that is, selectively to the sites and situations to which it is appropriate. Consequently, site and situation, of which soil is a vital component, need to be more and more closely circumscribed.

Various surveys were carried out in response, we believe, to these stimuli. Among the early field studies to be undertaken was that in the Tugela Basin of Natal. As part of its efforts to establish an adequate planning base, the Natal Town and Regional Planning Commission initiated, in 1956, a soil survey of the Basin in conjunction with the University of Natal and the Department of Agricultural Technical Services. In many respects this major undertaking laid the foundations of the new classification. The survey report[4] contained a prototype of the system, and a summary of the underlying *rationale* which had been presented elsewhere[5].

Numerous other surveys provided a growing base of experience which made possible the evolution of the system to the stage where it now approaches comprehensive, country-wide applicability. The Experiment Station of the South African Sugar Association at Mount Edgecombe had accumulated much information on the soils of the Natal Coast Lowlands. This was incorporated into a first list of soil series definitions[6]. The Soil and Irrigation Research Institute launched a programme of key-area surveys which yielded much valuable information in previously unexplored regions[7]. Considerable momentum was added to the data gathering when the fertilizer industry and the Government of the Republic commissioned extensive soil surveys in various parts of the country[8]. Several university departments also ran field survey programmes in conjunction with post-graduate training and, more significantly, the teaching of soil science in this country underwent something of a renaissance.

This was an exciting time pervaded by an atmosphere of experimentation and improvisation. In the United States, the USDA Soil Survey Staff was developing an imaginative new system[9] through a concerted application of talent and experience that is unique in contemporary soil science. This was happening in full view of world attention. The logic of the new approach was refreshing and, although it may not have presented everyone with a classification to suit his needs, it loosened the shackles of traditionalism and stimulated re-thinking on soil classification. The appearance in recent years of several new classification schemes bears testimony to this.

Being man-made contrivances, classification systems take on different forms depending on circumstances and the background, philosophy, and terms of reference of the persons responsible for developing them. Two requirements in particular have guided the development of this system. The first was that the classification had to be easy to understand and to use. It was clear at an early stage that the manpower situation was inadequate for the soil survey task that confronted us even if we thought only in terms of the more intensively utilized, higher rainfall areas of the country. Detailed mapping by soil scientists as a means of

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4 Van der Eyk, J.J., MacVicar, C.N. & de Villiers, J.M., 1969. Soils of the Tugela Basin. A study in subtropical Africa. Natal Town and Regional Planning Reports, Vol. 15. Pietermaritzburg: Natal Town and Regional Planning Commission.

5 MacVicar, C.N., 1969. A basis for the classification of soil. J. Soil Sci. 20: 141–152.

6 MacVicar, C.N., Loxton, R.F. & van der Eyk, J.J., 1965. South African soil series. Report Nos. 107–108/64. Soil Research Institute. Pretoria: Department of Agricultural Technical Services (mimeo).

7 Contained in various Technical Communications published by and available from the Department of Agricultural Technical Services, Pretoria.

8 R.F. Loxton, Hunting and Associates, Johannesburg.

9 *Loc. cit.*

extending information about soil behaviour to individual users of land was not feasible in the short and medium term as a general procedure (except in the case of highly capitalized forms of land use) and an alternative approach had to be found. Experience that was accumulating at the time suggested that the most likely solution to the *impasse* lay in reconnaissance mapping backed up by a classification system that would be acceptable to, and could be used by, non-soil scientists for accurate soil identification in the field. Class definitions had to be factual statements of soil properties, preferably those that can be seen and easily measured. To be avoided were criteria which are not always measurable and involve speculation (such as genetic history). This imposed distinct and obvious restraints on the subsequent development of the system and has been the main influence in its evolution up to the present.

The second requirement which applied was that the classification should be comprehensive and should be capable of accommodating all of the soils to be found in the Republic. Parochial classifications of a farm, a district, or a region can serve a useful purpose for a time, but because of their restricted vision they do not serve the needs of soil users on a country-wide basis. A national perspective is required directly by many agriculturists, ecologists and resource scientists and, indirectly, by all. The real objectives of soil classification are largely defeated by a proliferation of *ad hoc* classification schemes.

There is reason to believe that events have justified the particular course of action taken and the precepts upon which that action was based. In providing a generally acceptable means for the identification of soils in terms of the classes which it sets up, and the consequent rationalization of map legends, the classification has accomplished its minimum objectives. But it has accomplished far more than this. By drawing attention to the similarities and differences between soils and by permitting accurate communication about them, the classification has promoted a better understanding of the relationships that exist among soils, and between them and the environment. It has given to non-specialist users in many spheres the confidence and perspective to exploit soils information more fully, and there is increasing evidence that it is permitting the development of a sound basis for predicting soil behaviour and management responses under defined conditions.

CHAPTER 2

Structure of the Classification System

INTRODUCTION

IN ESSENCE the system is a very simple one which employs only two categories or levels of classes – an upper or general level containing SOIL FORMS, and a lower, more specific one containing SOIL SERIES. Each of the soil forms in the classification is a class at the upper level, defined by a unique vertical sequence of diagnostic horizons. Each form, except Dundee, is subdivided into a number of series (varying from two to 30 or more) which have in common the properties of the form (that is, the prescribed horizon sequence) but are differentiated within the form on the basis of other defined properties. The range of variation permitted within a class at the series level is thus narrower than that at the form level and the series is a far more specific concept than the form.

Soils (in practice, soil. profiles) are classified with reference to this system, being allocated first to a soil form and then to a series on the basis of the relevant soil properties which define the classes. Identification (and communication) is accomplished by means of names, and all classes at both levels are given place names in accordance with convention. The system is thus a two-name one. In this respect it parallels the binomial Linnaean system of classifying plants and animals, form being analogous to the genus of that system and series corresponding to species. No two series in the classification system have the same name. Consequently reference can be made to a series without using its form name. However, as the number of series is fairly large, communication may be made easier by using the form name or its abbreviation: for example, Valsrivier arniston or Va arniston.

The procedure to be followed in the identification of a soil by means of this system involves:

(i) demarcating the master horizons present in the profile (O, A, E, B, C, G and R),
(ii) identifying diagnostic horizons,
(iii) establishing the soil form,
(iv) identifying series differentiae, and
(v) establishing the soil series.

The definitions and criteria needed to apply this procedure of identification are discussed in the pages which follow and lead up to a presentation of the classification itself.

MASTER HORIZONS

Development of genetic horizons, as distinct from depositional or inherited stratifications, has been traditionally accepted as the quintessence of soil formation. Processes which form soil have a net tendency to differentiate the materials on which they act (rocks and loose sediments of various kinds) into horizons. The importance of these horizons to the classifier is that they are reproduced over and over under the same genetic conditions. Soils, therefore, are unique in that they consist of horizons. This is the starting point.

If one regards this attribute of soils as the norm, then the absence or minimal development of genetic horizons in materials which, for practical purposes, are regarded as soil becomes significant and is usually traceable to youthfulness or processes which work against horizonation. Although they represent the exception rather than the rule, provision is nevertheless made for the inclusion of certain undifferentiated materials in the system (young alluvia, deposits of raw sand).

The organization and re-organization of material as a result of soil formation follows a pattern which can be generalized by recognizing a small number of ***master horizons*** as shown in Fig 1. Standard letter symbols are used to denote the master horizons as follows:

O – An horizon forming the upper part of the soil and consisting of fresh and/or partly decomposed organic matter accumulated under marshy conditions.

A – An horizon at or adjacent to the surface and consisting predominantly of mineral particles intimately mixed with a greater or lesser amount of humified organic matter.

B – An horizon lying between the A and the C or R horizons which is characterized by a concentration of silicate clay (by illuviation or alteration), sesquioxides (by illuviation or residual accumulation) or organic matter (by illuviation), alone or in combination.

C – An horizon consisting of unconsolidated material (including weathered rock) which does not show properties of the other master horizons.

R – Consolidated bedrock and strictly, therefore, not an horizon.

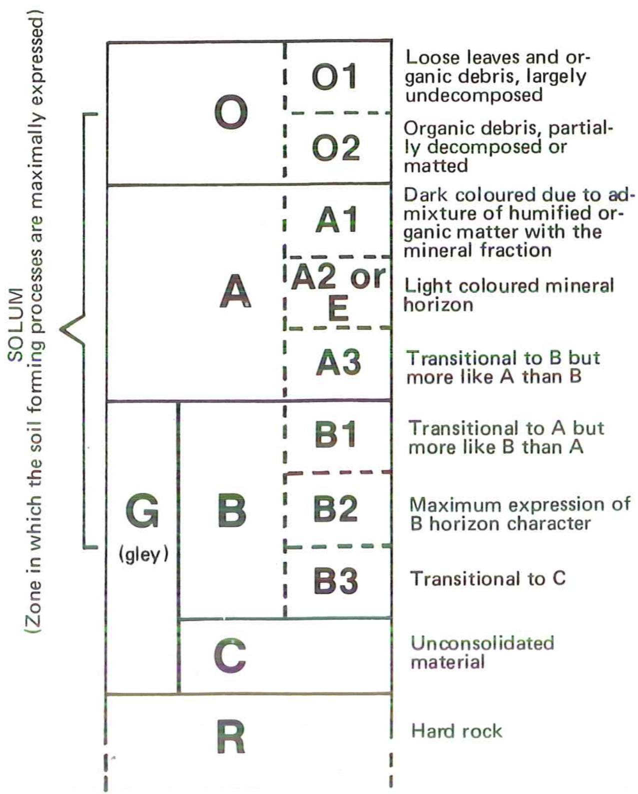

Fig 1 Arrangement of master horizons

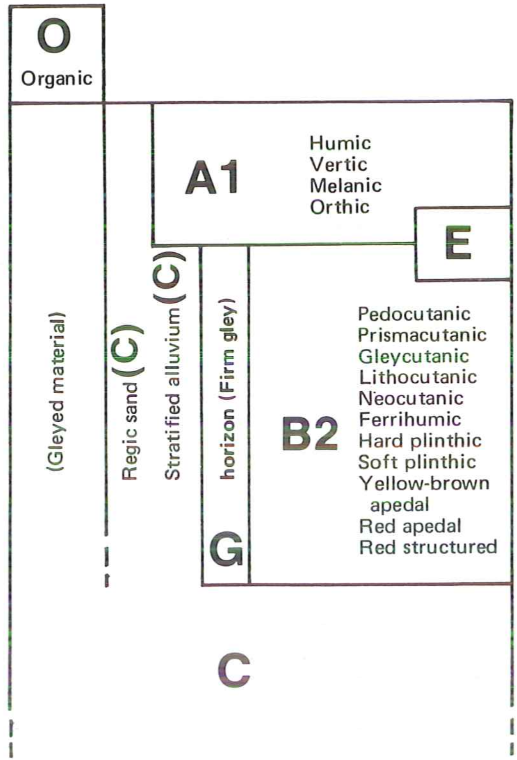

Fig 2 Diagnostic horizons

These conventions are observed more or less universally. In recent years there have been proposals to add two further master horizons, namely:

E – An horizon underlying the O or A horizon (if present), having a lower content of organic matter and/or sesquioxides and/or clay than the immediately underlying horizon, usually reflected by a pale colour and a relative accumulation of quartz and/or other resistant minerals of sand or silt sizes.

G – An horizon showing features of strong reduction under anaerobic conditions, usually with bluish, greenish or greyish colours or combinations of these, and having subordinate expression of properties diagnostic of A, E or B horizons.

Few soils contain all of these horizons, but all soils contain some of them, and in a majority of cases they are quite easily identifiable in vertical exposure such as is provided by the face of a soil pit.

DIAGNOSTIC HORIZONS

Recognition of master horizons is the first step in examining, describing and identifying soils in the field. However, it will be appreciated that the master horizons only really contain or convey information relating to position in the profile (a B horizon, for example, occurs below an A and above a C or R material) and the general nature of the processes which have taken place (for example, accumulation of organic matter, development of soil structure, weathering). B horizons, for example, are found which have such widely contrasting properties as to be entirely different from one another in all respects except those which determine that they are B horizons. These more specific properties of the master horizons are as, or more important than the master horizons themselves when it comes to identifying (and utilizing) soils. Subscripts have been used as a device for specifying some of the more outstanding properties of master horizons: Bca, for example, signifies a B horizon having an accumulation of calcium carbonate. However, this device has limitations. Recently there has been a trend towards defining, more completely, specific kinds of master horizons. Unfortunately there is as yet no general agreement on a standard set of such diagnostic horizons nor on the criteria that should be used for their definition. This classification system defines in fairly rigorous terms a number of diagnostic horizons (Fig 2) that are tailored to fit the soils of South Africa. These definitions are presented in Chapter 3. For two reasons a short discussion of the underlying concept of the horizon follows its definition. Firstly, definitions of horizons have been worked out with the object of including certain things and excluding others. They are phrased in terms of soil properties and are as concise as possible. Each gives expression to a concept but, because the definitions eventually can become complicated (they describe a complex system), the underlying concepts tend to become obscured and the meaning behind the definition somewhat unintelligible. It is not very satisfying to apply a definition more or less slavishly without some appreciation of what is intended by it. Secondly, although correct identification will be achieved by literal application of the definitions in the vast majority of soils, there will always be anomalous cases which are not accommodated altogether comfortably in all respects. It is probably impossible to formulate definitions that will take care of all eventualities. In such instances the user is at a disadvantage if he cannot fall back on personal judgement and common sense, backed by an understanding of the concepts and intentions behind the definitions of diagnostic horizons.

In addition to meeting specified requirements in terms of properties, soil horizons should also occur wholly or in part within 1 200 mm of the surface in order to be diagnostic for the purposes of classification. A depth limit is necessary and that chosen, although arbitrary, is convenient in that it coincides with the depth to which soils are normally investigated during systematic surveys (using a hand auger), and acceptable insofar as the importance of soil for a majority of agricultural purposes diminishes rapidly beyond this depth. This limit is a guideline in that an element of common sense is needed in its application. Clearly material at a depth of 20 m is of little importance to most land users and is excluded by this guideline. However, a soil form comprizing say three horizons may occur in a landscape in such a way that in some places the third horizon occurs partly or wholly within 1 200 mm depth, and in other places it is below, often not by far, the 1 200 mm mark. In these instances, and even when the third horizon just misses the 1 200 mm mark throughout the landscape, it would be wrong to ignore it on such an arbitrary basis. Excluding it in these cases would frequently mean ignoring properties and processes, such as hydromorphy, important to land use as well as to an appreciation of genesis.

SOIL FORMS

Recognition of horizons as definable entities amounts to dissection of the soil profile into a number of discrete, component parts. This analytical step is essential in the classification procedure but it should not be misinterpreted. Soils are not random combinations of horizons – they are unique integrated wholes. The horizons of a soil do not form independently of one another but are produced by the operation of a set of processes which affect the entire soil, albeit to different degrees in different parts of the depth profile. Diagnostic horizons have been abstracted and defined by studying whole soils as they occur in the field.

Because one is classifying whole soils and not horizons, it is necessary to reconstitute the soil after identifying master and diagnostic horizons. This is accomplished by means of the SOIL FORM which is a specification of the kind and sequence of diagnostic horizons present and, in some cases, also of the general nature of the underlying material.

Forty-one different horizon sequences, and thus soil forms, have been encountered in South Africa to date. These are arranged systematically for easy reference and as an aid to profile identification in the KEY TO THE SOIL FORMS. Each form is referred to by means of a geographic name (for example Swartland, Estcourt) which serves as a tag or label and has no further intrinsic significance.

The soil forms are illustrated by means of colour plates of selected profiles that have been included with the FORM-SERIES SCHEDULES in a later section. These profiles are representative examples of soils which belong in each particular form, chosen to show as clearly as possible the horizon sequence that defines the form. They do not illustrate the range of variation that occurs or that is possible within the form. This must be deduced from the horizon definitions and from the series specifications.

The soil form with its range of variation has provided the basis upon which correlations have been made between the classes of this system and those of the USDA Comprehensive System[1] and the FAO World Soil Map Legend[2] at an approximately equivalent level of abstraction. The correlations, which appear with the profile photographs, are of somewhat academic interest and should not concern the majority of local users. They should, however, provide foreign readers with a means of access to the system and will, it is hoped, facilitate orientation. It should be pointed out that the correlations are not exhaustive but relate to more or less modal concepts of the taxa of this system. The impression might be gained from the correlations that the forms have a very broad spectrum of properties since they are seen to span across suborders and even orders of the USDA system, for example. This impression would be mistaken; the forms are, in a majority of cases, rather specific morphological concepts in terms of the criteria used at this level of abstraction and in most cases represent a narrow slice out of the taxa with which they have been correlated. In other words, had the correlation been performed in the reverse direction, the result would have been very similar: taxa of the international systems also cut widely across the forms. The breadth of correlation arises from the use of different class

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1 Soil Survey Staff, 1960. Soil classification — a comprehensive system (7th approximation). US Dept. Agriculture. Washington: US Govt. Printing Office, together with supplements to the system dated March 1967 and September 1968.

2 Dudal, R., 1968. Definitions of soil units for the soil map of the world. World Soil Resources Reports No. 33. Rome: World Soil Resources Office, FAO.

limits for differentiating criteria as well as different criteria at the several levels in the respective systems. For example, base status and other criteria which permit the recognition of climatic zonality are given prominence at a high level in the USDA system, whereas this operates in general only at the series level in the South African system.

SOIL SERIES

Soil forms are conceptual generalizations based on selected soil properties (those used to define diagnostic horizons) with fairly wide permissible variations. To make the classification useful for a variety of objectives, it is necessary to classify further in order to narrow down such wide variations as still exist. For narrower definition, use is made of two kinds of properties: firstly, narrower ranges of properties used to define the diagnostic horizons of the form, and secondly, properties that are not used to define diagnostic horizons. Subdivision of forms into series is the means whereby this further refinement is achieved and expressed. Each series is referred to by a geographic name (for example, Estcourt and Uitvlugt). The form takes its name from one of its constituent series (for example, Estcourt form contains an Estcourt series).

In many respects, this situation has a parallel in the classification of plants. Genera (cf forms) are recognized and defined in terms of a few prescribed attributes, namely the morphology of flowers and fruits (cf diagnostic horizon sequences). Individuals belonging to a genus can vary widely as regards other properties. For example, the genus *Acacia* includes plants as different as the *gomdoring* (*A. borleae*), a thorn tree with mature height of two to three metres, the *apiesdoring* (*A. galpinii*) which also has thorns but attains a normal height of some 20–25 m, and the black wattle (*A. mearnsii*) which is devoid of thorns. *Cenchrus* is a genus of grass plants, *C. ciliaris* (*bloubuffelsgras*) being a valuable pasture grass in the northern parts of the country, whereas *C. brownii* (fine bristle burgrass) is a proclaimed weed. These and other variations are accounted for by subdivision of the genus into a number of species (cf series).

Criteria used for series differentiation within forms include, most importantly: soil texture in terms of clay content and size grading of the sand fraction (coarse, medium, fine); base status in terms of dystrophic (highly leached), mesotrophic (intermediate), eutrophic (minimally leached or unleached); calcareousness; soil colour where this is not a criterion for the diagnostic horizon; soil reaction; the nature of the C or underlying material. The application of the series criteria is set out in the FORM-SERIES SCHEDULES. Details of standard class limits of certain criteria (base status and sand grades, for example) are provided in the glossary.

It should be noted that certain soil properties, notably soil depth and salinity, are not used in the classification. This does not mean that they are unimportant. On the contrary, a property such as soil depth is often critically important in practice. However, it is difficult to set limits that will be consistently relevant for all soils and all purposes. Practical distinctions which have a variable significance but which are needed to interpret the classification in terms of soil behaviour are introduced (for example during mapping) as phases of soil series. Analogous is the position regarding plant species. Knowledge of the species may sometimes suffice; on the other hand differentiation within the species is frequently necessary.

CHAPTER 3

Definitions and Concepts of Diagnostic Horizons

TOPSOIL HORIZONS

FIVE SPECIAL surface horizons (*organic, humic, vertic, melanic* and *orthic*) have been defined as diagnostic by virtue of the presence of such distinctive features or combinations of features as abnormally high organic carbon, thickness, dark colour, strongly developed structure and expansive properties – or their absence (in the orthic horizon).

Organic O horizon

(i) *has sufficient organic carbon to ensure an average content of at least 10% throughout a vertical distance of 300 mm;*

(ii) *overlies gleyed material.*

Except where vegetation is totally absent as under extreme desert conditions, natural topsoils contain accumulations of organic material. Amounts vary between wide extremes. Unusually large surface accumulations which result from a slow rate of decomposition of plant residues due to ponding of water are distinguished by means of the diagnostic organic horizon. Differentiation of organic from other topsoil horizons is based on amount of organic material present (measured and expressed as organic carbon) and the presence of a gleyed subsoil. These horizons are found in and around coast as well as inland swamps, but it should be noted that not all swamps and marshes produce organic horizons. Colour is normally black or dark brown and the state of degradation of the plant residues may vary from predominantly finely divided in certain situations to predominantly coarse fibrous in others. They invariably overlie a strongly gleyed horizon. Organic horizons are not widely distributed in South Africa and have not been intensively investigated. The definition is thus somewhat tentative and it is likely that it, as well as the classification of soils possessing organic horizons, may undergo future refinements.

Humic A horizon

(i) *contains more than 2% organic carbon throughout a depth of at least 450 mm;*
(ii) *contains less than 0,28 milli-equivalents of exchangeable metal cations (Ca, Mg, Na, K) for each 1% of clay present;*
(iii) *does not directly overlie an horizon or material which is subject to gleying.*

The humic horizon has been defined to accommodate very distinctive topsoils which have been encountered on certain apparently old land surfaces in humid, cool, mistbelt regions. Although they occur on well drained upland sites, they are both thick and rich in humified organic matter. A minimum thickness of 450 mm containing more than 2% organic carbon is specified in the definition; however, it is not uncommon for humic horizons to extend to a depth of 1 000 mm and more. They differ from thick organic horizons in that drainage, both external and internal, is good and there is no hydromorphy. The humic horizon is a humid climate phenomenon and as such must be distinguished from thick, dark coloured topsoil horizons (melanic and vertic) that are found typically under drier climates where less leaching of soluble constituents occurs. Some melanic horizons may closely resemble humic horizons in morphology. The distinction is made by introducing base status limits in the respective definitions; this also differentiates vertic horizons.

Melanic A horizon

(i) *has dark colours such that both value and chroma are 3 or less in the dry state but with the exclusion of 10YR3/3; a value of 4 and a chroma of 1 or less in the dry state is permitted if the horizon is more than 300 mm thick; dusky red colours of hues 5YR and redder are not permitted;*
(ii) *lacks slickensides, lacks a self-mulching habit and lacks cracks that are diagnostic of vertic horizons;*
(iii) *has blocky structure;*
(iv) *contains at least 15% clay;*
(v) *contains at least 0,28 milli-equivalents of exchangeable metal cations (Ca, Mg, Na, K) for each 1% of clay present;*
(vi) *has less organic carbon than that required for a diagnostic organic horizon;*
(vii) *is at least 300 mm thick if it overlies a B horizon with a red or yellow colour.*

A fairly wide range of dark coloured, usually well structured topsoils develops under semi-arid to subhumid climates from parent materials which are basic or intermediate as regards base reserve, or in landscape positions (usually footslopes) which receive additions of bases via lateral drainage of water. Part of this range is made up by soils with vertic properties, that is with slickensides, extensive cracks when dry, or a self-mulching surface. But many dark, structured topsoils do not show such evidence of extreme expansiveness. These are catered for and distinguished by the melanic concept. Absence of vertic properties is usually attributable to either a lower clay content or, if clay content is high, a predominance of micaceous, vermiculitic or even kaolinitic rather than highly expansive smectitic clay minerals. Melanic horizons do not have sufficient organic carbon to qualify as diagnostic organic (despite dark colours, carbon content is normally low), and are distinguished from humic A horizons by their higher base status. Measurements to date show that air-water permeability ratios are usually less than 100 and can be less than 10.

Vertic A horizon

(i) *has blocky structure at least moderately developed;*

(ii) *has one or more of the following:*

clearly visible slickensides in some part of the horizon or in the transition to an underlying layer, OR cracks wider than 25 mm throughout at least half the thickness of the horizon when dry, OR self-mulching properties in the surface material.

A horizons that have both a high clay content and a predominance of smectitic minerals possess the capacity to swell and shrink markedly in response to moisture changes. Such expansive materials have a characteristic appearance: structure is strongly developed, ped faces are shiny, and consistence is highly plastic when moist and sticky when wet. Swell-shrink potential is manifested typically by the formation of conspicuous vertical cracks in the dry state or the presence, at some depth, of slickensides (polished or grooved glideplanes produced by internal movement), or both. Cracks and slickensides are definitive features. However, development of these is apparently also a function of vertical thickness, being dependent on the total volume of the material which swells and shrinks. Shallow vertic horizons may lack these features. They are then recognized by a third diagnostic feature, namely a surface which, either naturally or after disturbance (for example by ploughing), breaks down to a loose mulch of very fine peds. Most typically, vertic horizons are black or very dark coloured. However, examples are known of grey, yellow-brown and red vertic horizons. Colour is thus not diagnostic for the horizon but is used to differentiate at the series level. Measurements to date show that air-water permeability ratios are above 60 and usually above 100.

Orthic A horizon

(i) *A surface horizon that does not qualify as an organic, humic, melanic or vertic topsoil although it may have been darkened by organic matter.*

A majority of soils in South Africa have topsoils which do not show organic, humic, vertic or melanic character and may be regarded as "ordinary" or "normal". They are defined, by exclusion, as orthic. Occurring as they do over virtually the full range of soil forming conditions encountered in South Africa, orthic topsoils will obviously vary widely in organic carbon content, colour, texture, structure, base status, mineral composition, etc. Because there is normally a natural genetic relationship between topsoils and subsoils, there tends to be marked covariance between many of their properties. Consequently, although the classification does not take direct account of the variation in properties of orthic topsoils, it does, through covariance, go a long way towards implying the nature of these topsoils. For example, the orthic topsoils of Katspruit series (Katspruit form), Hutton series (Hutton form) and Shigalo series (Hutton form) differ widely in all or some of their physical and chemical properties, and in moisture regime. However, the nature of the topsoil can, in each case, be deduced from the classification. Hutton and Shigalo will have medium textured, reddish coloured, weakly structured topsoils, free from water-logging, very acid in the case of Hutton and neutral to alkaline in the case of Shigalo. Katspruit form on the other hand is characterized by waterlogging and anaerobic conditions; its orthic topsoil will therefore be grey or dark grey, weakly structured and subject to wetness.

SUBSOIL HORIZONS

Fifteen subsoil horizons have been defined as diagnostic for the classification. The bleached ***E horizon*** is the result of eluviation and intermittent gleying by a watertable either perched upon a diagnostic subsoil horizon or originating beneath the classified soil body. The ***G horizon*** is a strong, firm gley. Uniformity of colour is the main distinguishing feature of ***red apedal, yellow-brown apedal*** and ***red structured*** B horizons. Recognition of two plinthic horizons, namely ***soft plinthic*** and ***hard plinthic,*** takes account of the important processes of mobilization and segregation of iron into loose concretions (soft or hard; a layer of loose, hard iron concretions is referred to in other disciplines as gravel ferricrete) and continuous ironpan (hardpan or honeycomb ferricrete), respectively. Five cutanic horizons have been defined. Colour variegations in the material constituting these horizons is the main distinguishing feature. In the case of ***gleycutanic, prismacutanic*** and ***pedocutanic*** horizons, movement and redistribution of clay-size material (including, in some cases, organic matter) has been chiefly responsible for the non-uniform colour. The ***lithocutanic*** B horizon owes its colour variegations to differential weathering in a largely saprolitic matrix, staining by highly coloured weathering products and illuvial material, often as tongues, in a generally youthful weathering situation. The ***neocutanic*** B caters for minimal cutanic development in the early stages of soil formation on unconsolidated materials.

The *ferrihumic* B accommodates the classical concept of the podzol B, namely that of a subsoil horizon enriched in humified organic matter in combination with free iron oxides as a result of the downward movement of these materials. Finally, two important kinds of undeveloped or juvenile materials (strictly speaking, C horizons) have been recognized as diagnostic. These are *regic sand* and *stratified alluvium.*

E horizon

(i) *occurs immediately beneath a diagnostic topsoil horizon except where mixing (for example by ploughing) or topsoil erosion has occurred, in which case it may occur at the surface;*

(ii) *has a Munsell colour value that, typically, is at least one unit higher than that of a topsoil horizon;*

(iii) *has, in either the moist or the dry state, one or more of the following "grey" matrix colours:*

- *if hue is 2.5Y, then values of 5 or more and chromas of 2 or less; or values of 6 or more and chromas of 4 or less;*
- *if hue is 10YR, then values of 4 and chromas of 2 or less; or values of 5 or more and chromas of 3 or less; or values of 6 or more with a chroma of 4;*
- *if hue is 7.5YR, then values of 5 or more with a chroma of 2 or less; or values of 6 or more with a chroma of 4 or less;*
- *if hue is 5YR, then values of 5 or more and chromas of 2 or less; or values of 6 or more with chromas of 3 to 4;*
- *if colour is neutral, then values of 5 or more;*

(iv) *overlies a gleycutanic, prismacutanic, lithocutanic, neocutanic, plinthic, ferrihumic, yellow-brown apedal or red apedal B horizon;*

(v) *may contain discernible mottling or streaking with a higher chroma than that of the matrix — the result of periodic saturation with water;*

(vi) *is not firmer than slightly firm in the moist state, is non-plastic, but may set hard when dry.*

This is essentially a greyish horizon which is usually paler in colour than the overlying topsoil or the horizon which underlies it. Thus, when present, it occurs as the second in a vertical sequence of diagnostic horizons, except where it has been exposed at the surface as a result of erosion of the topsoil, or mixed with the A horizon by ploughing. E horizons overlie diagnostic B horizons of various kinds. The genesis of this horizon has not been the same everywhere. In many cases (Estcourt, Kroonstad, Cartref, Wasbank and some members of the Shepstone, Constantia and Vilafontes forms) it lies abruptly on a B which is very much less permeable. Here a temporary build-up of water above the B horizon takes place after rain, and discharge occurs in a predominantly lateral direction. Reduction, together with lateral flow of water through the E horizon, has resulted in a loss of colouring materials such as iron and organic matter, as well as clay particles, producing the characteristic bleached appearance and a coarser texture. It may have lamellae. Rusty markings (flecks, streaks, faint mottles) are common, and testify to the temporary presence of a perched watertable. Coarse materials require relatively mild reducing conditions to develop this bleached appearance. In some cases where a deep, porous material overlies a slowly permeable clay or rock and there is a fluctuating watertable and deposition of ferric oxides, a soft plinthic B horizon has developed in the lower part of what would otherwise have been a thick E horizon. This is the situation in Longlands form. When the plinthic material is so extensive as to leave no trace of an E, the form is Westleigh. E horizons are also found where there has not been an impediment to the downward movement of water. In such cases (eg podzolization) there has been vertical eluviation of organic matter, iron and aluminium out of the A and E horizons. Clearly the E horizon can be found in a wide range of situations, and is a component horizon of what, in other classifications, are termed podzols, solonetzic soils and pseudogleys. Not included is regic sand, the colour of which is often due to the original nature of the sand. In some cases there has been loss of colouring materials from regic sand by eluviation or reduction, but these are often difficult to tell apart from raw, unaltered sands. A decision in this regard often involves an undesirable degree of subjectivity and therefore all deep grey sands are included in regic. The reader is referred to the discussion of the yellow-brown apedal B for guidelines on the classification of Cartref and Kroonstad profiles with non-diagnostic yellow-brown apedal horizons, and Pinedene profiles with non-diagnostic E horizons.

G horizon

(i) *has "grey" matrix colours as defined for the E horizon, often with blue or green tints, with or without mottling; mottles may be yellowish brown, olive brown, red or black; dark grey matrix colours are also permitted;*
(ii) *is saturated with water for a greater part of most years unless the landscape has been drained;*
(iii) *directly underlies a diagnostic topsoil horizon;*
(iv) *has firm or plastic consistence;*
(v) *is at least 250 mm thick;*
(vi) *does not overlie a diagnostic gleycutanic, prisma-cutanic, plinthic, lithocutanic or neocutanic B horizon.*

The concept of the G horizon is one of a strong gley saturated with water for long periods in most years unless drained artificially or by erosion. The diagnostic G horizon occurs immediately beneath a topsoil diagnostic horizon. The presence of a more or less permanent watertable results in the development of matrix colours having low chromas, with or without mottles. G horizons normally develop in bottomland positions. Many materials may qualify, on the basis of colour, as either E or G horizons. Apart from the requirement of a relatively permanent watertable (as opposed to a sporadic, perched watertable in the E horizon), the G horizon is distinguished from the E horizon by the absence of an underlying diagnostic B (cutanic, plinthic, ferrihumic). G horizons are, as a rule, substantially thicker than E horizons. Included in the definition of the G horizon is the condition that consistence must be firm or plastic. In other words, a certain minimum clay percentage is required (in the region of 15%) and grey, hydromorphic sands are excluded. Irrespective of whether or not a watertable is present, these grey sands are regarded either as regic sands (if deep) or as E horizons and are excluded from the G horizon. G horizons commonly show evidence of clay illuviation, but the gleying takes precedence over cutanic character for purposes of classification.

Red apedal B horizon

(i) *has one or more of the following "red" colours in both the moist and dry states unless otherwise specified:*

- *if hue is 5YR, then values of 3 to 5 and chromas of 4 or more; or values of 3 to 4 and a chroma of 3; or 5YR 5/3 in the dry state only;*
- *if hue is 2.5YR, then values of 3 or more and chromas of 6 or more; or values of 2 to 4 and a chroma of 4;*
- *if hue is 10R, then values of 3 or more and chromas of 4 or more; or values of 3 to 4 with chroma of 3;*
- *if hue is 7.5R, then values of 3 or more and chromas of 6 or more; or values of 2 to 4 and a chroma of 4; or 7.5R 3/2;*
- *although colour must be substantially uniform, a slight variability is permitted, for example red mottles in a red matrix;*

(ii) ***has structure that is weaker than moderate blocky or prismatic in the moist state;***

(iii) ***directly underlies a diagnostic topsoil horizon, a yellow-brown apedal B horizon or an E horizon.***

B horizons that have more or less uniform colours falling within the range defined (above) as "red" and that, in the moist state, lack well formed peds other than porous micro-aggregates, qualify as red apedal. Typically, the material of red apedal B horizons, although coherent, is macroscopically structureless. The concept embraces that kind of weathering that takes place in a well drained oxidizing environment to produce coatings of iron oxides on individual soil particles (hence the diagnostic red colours) and clay mineral suites dominated by non-swelling 1:1 types (hence the lack of structural development). 2:1 layer clays, even smectites, can be found in the coarser textured red apedal horizons, but in fine textured horizons 1:1 layer clays and/or amorphous compounds dominate the clay fraction. Red apedal B horizons are easy to identify and occur extensively under the full range of climatic conditions experienced in South Africa. Where they have developed from basic parent materials (for example, basalt, norite, diabase) an advanced degree of weathering and leaching is indicated. On the other hand, they appear to develop rather easily under a wider range of climatic conditions from siliceous parent materials such as granite, schist, gneiss, quartzite, sandstone and sands which have a lower content of weatherable minerals and thus a lower clay-forming potential. In view of the wide climatic spread, the full range of base status is encountered: from highly acid and unsaturated to calcareous and salty soils. Colour is usually remarkably uniform within the horizon. However, there are permissible colour variegations: evidence of faunal activity (for example, dark coloured worm casts); low contrast mottling (red mottles in the red matrix); dark coloured illuvial material which does not constitute a distinct horizon essentially different from the red apedal horizon. Due to the stabilizing effects of iron oxide coatings, and possibly also free aluminium, there is little textural differentiation through physical movement of clay. Consequently, macroscopically visible clayskins tend to be rare or absent. There is some evidence, however, that certain red apedal sands in the more humid zones have lost considerable amounts of clay from the entire solum.

Yellow-brown apedal B horizon

(i) *has one or more of the following colours in both the moist and dry states unless otherwise specified:*

- *if hue is 2.5Y, then values of 5 or more with chromas of 6 or more; or 2.5Y 4/4; or 2.5Y 5/4 in the dry state only;*
- *if hue is 10YR, then a value of 3 and chroma of 3 or more, or value and chroma of 4; or a value of 5 to 6 with a chroma of 6 or more; 10YR 4/3, 5/4, 7/6, 7/8, 8/6 and 8/8 are permitted when they refer to the colour of dry but not moist soil;*
- *if hue is 7.5YR, then a value of 4 with a chroma of 2 or more; or a value of 5 or more with a chroma of 6 or more; 7.5YR 5/4 and 8/6 are permitted when they refer to the colour of dry but not moist soil;*
- *if hue is 5YR, then a value and chroma of 6 or more;*
- *although colour must be substantially uniform, some variability is permitted, for example mottles or concretions which are insufficient to qualify the horizon as a diagnostic plinthic B; faunal reworking may also result in acceptable colour variegations;*

(ii) *has structure as defined for the red apedal B;*

(iii) *directly underlies a diagnostic topsoil horizon or an E horizon.*

This diagnostic horizon is the analogue of the red apedal B, being differentiated from it only on the basis of colour which instead of red, is yellow or brown as defined above. Yellow-brown apedal horizons occur over approximately the same climatic spread as their red counterparts, and so are also very widely distributed throughout the country. They may be found on all types of parent material, but less commonly on basic rocks. Remarks made about the clay minerals, structure and colour uniformity of the red apedal B horizon apply equally here. As in the case of uniformly red materials, individual particles are coated with free sesquioxides. However, the mineralo-chemical nature of these coatings is different, a fact which is attributable to either the composition of the parent material (primarily a lower ferrous iron reserve) or a higher average moisture status of the horizon, or both. A very moist (but non-gleying) soil regime is needed to produce a yellow soil on a parent material such as basalt which has a large reserve of ferrous iron. It is more easily formed in sands, sandstones, quartzites, shales and granite on account of their lower ferrous iron reserve. The average moisture status will be higher where the soil is shallow on impervious rock, in the horizon above a fluctuating watertable and in humid climates, particularly cool humid climates. The occurrence of a yellow horizon between the topsoil and a red apedal horizon in Griffin and Kranskop forms suggests that, in some instances, organic matter and its soluble products could well play a role in the development of yellow horizons. The yellow-brown apedal B may contain mottles and iron concretions, provided it does not fulfil the requirements, particularly with respect to the grey gley colours, of a diagnostic soft plinthic B horizon. A transition from Pinedene to Kroonstad form occurs when the orthic plus yellow-brown apedal horizons becomes less than half the thickness of the material overlying the gleycutanic B. A transition from Clovelly to Cartref form occurs when an E horizon extends upwards to within 900 mm of the surface.

Red structured B horizon

(i) *has "red" colours as defined for the red apedal B; colour must be substantially uniform;*

(ii) *has structure more strongly developed than defined for the red apedal B;*

(iii) *directly underlies a diagnostic orthic horizon; a transition from the A which is abrupt with respect to structure or texture is a disqualification.*

This diagnostic horizon is recognized in uniformly red subsoil materials which have developed pedality, that is, a strong rather than moderate blocky structure in the dry state. In concept, the interface between the red structured and red apedal B horizons is defined solely in terms of degree of structural development. Pedality is the result, primarily, of the presence of a substantial amount of 2:1 layer clay minerals, especially smectites. This, in turn, reflects a less advanced weathering stage than that attained in red apedal B horizons. Basic rocks normally provide the parent materials for this horizon. Red structured B horizons are often enriched in clay relative to an overlying topsoil, but the transition typically is gradual rather than abrupt, and clayskins or cutans that may be present tend to be inconspicuous, having a colour that is similar to that of the soil mass. Markedly contrasting non-red colours that contribute to a distinct horizon disqualify a material as red structured. The interface between red structured and pedocutanic is thus defined in terms of colour uniformity. Red structured B horizons are overlain by orthic topsoils which are usually red but may be dark coloured. If the orthic has a grey colour, a red subsoil is normally disqualified as a red structured B on account of distinct cutanic character.

Soft plinthic B horizon

(i) *has mottling and/or concretions which have resulted from the accumulation and localization of iron and manganese oxides and which form a vesicular pattern or impart a concretionary character to the material; the mottle colours are usually red, yellow, dark grey and black, and the matrix colours always include grey due to the gleying process;*

(ii) *is non-indurated and can be cut with a spade when wet even though individual mottles may have hardened irreversibly into concretions;*

(iii) ***occurs as the second or third of a vertical sequence of diagnostic horizons, provided that when it is the third, the second horizon is an E horizon, yellow-brown apedal B or red apedal B; soft plinthic material is non-diagnostic when it occurs beneath the third diagnostic horizon in a profile.***

Accumulation of iron (and frequently also manganese) oxides and hydrates, and localization in the form of high-chroma mottles and concretions (often with black centres) is the predominating feature of this horizon. This takes place in a zone of periodic saturation with water, for example between the limits of fluctuation of a watertable. A vesicular pattern of mottles or concretions is characteristic and the latter have the effect of imparting a firmer consistence and greater coherence to friable materials on the one hand, and degrading the pedality of well structured materials on the other. Grey matrix colours associated with the gleying process are essential. Accumulation of iron and manganese may have progressed from soft mottles to the formation of discrete concretions in all stages of hardening (also known as gravel ferricrete). The latter have, however, not coalesced to the extent of forming the continuous indurated sheet that constitutes hard plinthite. The soft plinthite/hard plinthite interface is defined in terms of whether or not the material can be cut away with a spade when wet. The soft plinthic B normally merges to a non-diagnostic gley with depth. The interface between the soft plinthic and G horizons is defined by a lesser degree of hydromorphy in the former, and mottles (with or without concretions) sufficient to impart a vesicular pattern or concretionary character in the case of the soft plinthic B. There is an interface with wet regic sand marked by the disappearance of prominent iron-manganese concretions. The soft plinthic B horizon interfaces with uniformly chromatic horizons where the colour contrast between matrix (red or yellow-brown as defined) and diagnostic soft plinthic mottling disappears. Soft plinthic B horizons often underlie an E horizon; so do gleycutanic B horizons. This gleycutanic/soft plinthic interface is defined in terms of the nature of the transition with the overlying E horizon and in terms of the degree of development of vesicular character. When vesicular character is poorly defined, an abrupt (with respect to any two of structure, texture or consistence) transition from the E horizon indicates gleycutanic. Moderately well developed vesicular or concretionary character indicates soft plinthic, irrespective of the nature of the transition from the E horizon. Soft plinthic B horizons usually display cutanic character.

Hard plinthic B horizon

(i) *consists of an indurated zone of accumulation of iron and manganese oxides which cannot be cut with a spade even when wet;*

(ii) *occurs as the third in a vertical sequence of diagnostic horizons provided that the second horizon is an E horizon or a yellow-brown apedal B horizon; hard plinthic material is not diagnostic when it occurs at the surface, immediately beneath a topsoil diagnostic horizon or beneath the third diagnostic horizon in a profile.*

The processes that give rise to the soft plinthic B eventually, if they continue for a long enough period, form a continuous, indurated ironpan (also known as hardpan ferricrete, "ouklip"). Ironpans are pedologic materials and as such deserve consideration in a soil classification. Many ironpan horizons are obviously relict. Others are part of the genetically developed soil. Ideally, the concept of hard plinthic B as a diagnostic horizon and as part of the solum embraces the latter but excludes the former. However, it is often very difficult to distinguish between the two and even more difficult to set simple rules for recognising plinthic B horizons which belong genetically in a profile. Consequently the diagnostic hard plinthic B horizon is restricted to those occurrences of ironpan that occupy a position where it could have been expected to develop as an integral part of the genetic profile: beneath either an E horizon or a yellow-brown apedal B horizon. This method of including ironpan in the classification appears to cater for most of the instances where it is part of the genetic profile. Unavoidably it also causes horizon sequences that are not such genetic profiles to be included (a relict ironpan covered by sediment may, by virtue of its presence, induce the formation of a yellow-brown apedal B horizon or E horizon above it). The distribution of ironpan, whether diagnostic or not, has geomorphological, agricultural and other economic significance, and it is important that its occurrence be shown on soil maps. Where this is not achieved through the classification (note that ironpan is used as a series differentiating criterion within the Mispah form), phase qualifications should be introduced during mapping to indicate its presence and extent.

Gleycutanic B horizon

(i) *directly underlies an E horizon or a yellow-brown apedal B horizon;*

(ii) *has colour variegation in a random pattern comprising grey, low chroma colours as defined for the E horizon, high chroma mottling and contrasting, usually dark colouration due to cutans;*

(iii) *has any type or degree of development of structure except well developed permanent prismatic or columnar with uniformly coloured dark ped exteriors.*

The basic concept of this horizon is that of a material, beneath an E horizon or yellow-brown apedal B, which has cutanic character superimposed on marked evidence of gleying. Typically, though not necessarily, the coarse textured overburden in the case of profiles with an E horizon is thick (in excess of 500 mm). Colour variegation arises from interruption of gleyed, low chroma matrix colours by dark colours of clayskins and clayey infillings (for example, along root and other channels) in a dendritic or more often random pattern. Organic matter associated with the clay contributes to these dark colours. In addition, diffuse mottling and streaking by higher chroma yellows and reds is typical. Well developed structure is not mandatory but is common. It is not a G horizon because, by definition, the G must occur directly beneath a diagnostic topsoil horizon. The gleycutanic – soft plinthic interface is defined under the description of the latter. The interface between the gleycutanic and pedocutanic B is defined in terms of gleying and the nature of the overlying horizon. A pedocutanic horizon occurs directly beneath a diagnostic topsoil horizon and lacks such evidence of gleying as to qualify as a G horizon. The gleycutanic interfaces more directly with the prismacutanic B when these horizons are overlain by an E horizon and this contact is more difficult to define. Ideally, the prismacutanic B has strongly developed prismatic or columnar structure with little or no evidence of wetness in the B or C. Distinction is then easy. However, prismacutanic B horizons often underlie an E horizon, and there may then be marked evidence of wetness in the B and C horizons, in the form of mottles (usually fine) in ped interiors or even some low chroma colouring of clayskins. The criterion which is then applied to distinguish the prismacutanic is that prismatic or columnar structure be well developed and permanent as indicated by uninterrupted distinct clayskins on vertical ped faces which give the horizon an outwardly uniform colour, darker than the underlying material. Many gleycutanic horizons tend to exhibit a false prismatic structure within a few days of exposure and drying; observations should therefore be made on fresh exposures. The transition with the overlying horizon is often clear or abrupt.

Prismacutanic B horizon

(i) *has an abrupt transition with an overlying E or A horizon with respect to at least two of the following three properties —*

Texture: if the clay content of the material above the abrupt transition is less than 20%, then the clay content below it must be at least twice as high (for example 15% increasing abruptly to at least 30%); if the material above the transition has more than 20% clay, then the material below must show an absolute increase of at least 20% clay (for example, 25% increasing abruptly to at least 45%);
Structure: at least one grade stronger than that of the overlying horizon;
Consistence: at least two grades harder or firmer than that of the overlying horizon;
(in the case of structure and consistence, the abrupt change should take place over a very small vertical distance to give a line along which a knife can be run; textural requirements should be met if sampling is done within 100 mm above and below the transition);

(ii) *has prismatic or columnar structure (usually coarse); occasionally primary blocky structure is more pronounced than the secondary prismatic or columnar structure;*

(iii) *lacks evidence of wetness in the form of low chromas, or if it has signs of wetness, then the vertical faces of prisms have continuous clay coatings of uniform dark colour;*

(iv) *exhibits colour contrast between clayskins and ped interiors.*

This horizon accommodates the classical concept of the solodized solonetz B in which prismatic or columnar structure has developed under an abrupt transition and cutanic character is conspicuous as colour differences between ped interiors and exteriors. Certain chemical peculiarities, namely a high exchangeable sodium or magnesium percentage, are fairly regularly associated with this morphology although there are exceptions. The upper surface of the prismacutanic B is normally found within 500 mm of the soil surface. It appears that when the overburden is excessively thick and particularly when it is coarse textured, a gleycutanic rather than prismacutanic B develops on account of increased hydromorphy. The distinction between these two horizons has already been drawn (see gleycutanic B horizon). Where wetness occurs in the prismacutanic B, the characteristic structure from which it takes its name must be well developed. Where wetness is absent, some relaxation of the structural requirement is permitted: provided the upper boundary is abrupt, primary blocky structure may be more pronounced than the secondary prismatic or columnar structure, particularly if the exchangeable sodium percentage exceeds 8. Accordingly, a pedocutanic horizon may have an abrupt upper boundary if its structure is not prismatic or columnar, and is permitted to have prismatic structure if its upper boundary is not abrupt. Field evidence indicates that the lower the clay content of the B horizon, the coarser and weaker its structure tends to be. It is common in these sandier horizons for the bleached caps of prisms or columns to extend as tongues between the peds.

Pedocutanic B horizon

(i) *underlies a diagnostic topsoil horizon either directly or via a stone-line;*

(ii) *has a transition with the overlying horizon which is non-abrupt, except that an abrupt transition is permitted where there is no indication of prismatic or columnar structure;*

(iii) *has structure more strongly developed than defined for the red apedal B; when its upper boundary is not abrupt, a prismatic tendency is permitted;*

(iv) *has clearly expressed cutanic character resulting from illuviation of fine material and manifested as prominent cutans on most ped surfaces;*

(v) *does not qualify as a diagnostic G horizon (because it lacks sufficient evidence of wetness), as a gleycutanic or prismacutanic B, as a plinthic B (because it fails to meet the required degree of accumulation of iron and manganese oxides), or as a red structured B horizon (because colour is either non-diagnostic, or if diagnostic is not sufficiently uniform), all of which horizons may have cutanic character to a greater or lesser degree.*

The concept embraces B horizons that have become enriched in clay, presumably by illuviation (an important pedogenic process which involves downward movement of fine materials by, and deposition from water to give rise to cutanic character), and that have developed moderate (when moist) or strong (when dry) structure, but which do not qualify as a diagnostic soft plinthic B horizon, a G horizon, a prismacutanic or gleycutanic B horizon, or a red structured B.

Lithocutanic B horizon

(i) *underlies a diagnostic topsoil horizon either directly or via a stone-line, or an E horizon;*

(ii) *merges into underlying weathering rock;*

(iii) *has characteristics at least 50% of which are attributable to material in various stages of alteration between hard rock and completely homogenized soil;*

(iv) *has cutanic character expressed usually as tongues or prominent colour variegations resulting from residual soil formation or illuviation and localization of one or* *more of clay, iron and manganese oxides and organic matter in a non-homogenized matrix of geological material (saprolite) in a variable but generally youthful stage of weathering.*

The concept is one of minimal development of an illuvial B horizon in weathered rock. With the exception of its presence beneath an E horizon in Cartref form, the lithocutanic B occurs beneath a diagnostic topsoil horizon. Weathering of rock *in situ* under a topsoil has produced a heterogeneous and, typically, a highly variegated zone consisting of soil material (relatively well homogenized without traces of weathering rock) interspersed with saprolite or weathering rock in various stages of breakdown. The latter is recognised by its general organization with respect to structure, colour or consistence which still has distinct affinities with the parent rock. Furthermore, this zone grades into relatively unaffected and eventually fresh rock, often at fairly shallow depth. The soil component of this zone is either discontinuous laterally and consists of tongues penetrating downwards into the saprolite or, if it is continuous, has not the structure to qualify as pedocutanic, with or without a tonguing lower boundary. The cutanic pattern is very characteristic especially where tongues are present. Hard, impervious rock and flat-lying shaly sediments are not conducive to the formation of lithocutanic B horizons. However, tilted, shattered sediments with differential weathering and soil material between bedding planes normally qualify as lithocutanic. The lithocutanic B interfaces with the pedocutanic B since the latter may also contain traces of saprolite in the form of incompletely weathered cores of peds. The distinction is made in terms of degree of development of soil structure. An horizon with strongly developed structure and subordinate saprolitic character (not apparent unless peds are broken) will qualify as pedocutanic. Where saprolitic character is dominant, soil structure is weakly or, at best, moderately developed and a lithocutanic B is recognised. The lithocutanic B differs from the neocutanic by being gradational to underlying rock via saprolite, whereas the neocutanic B contains no evidence of saprolite and typically grades to unconsolidated materials that are not saprolitic. Lithic material which underlies an E horizon is included in lithocutanic even although cutanic character may be very weakly expressed.

Neocutanic B horizon

(i) *directly underlies a diagnostic topsoil or E horizon;*

(ii) *has formed in recent sediments or other unconsolidated material and has one or more of the following indications of incipient pedogenesis:*

- *aggregation of soil particles to the extent that it is no longer loose;*
- *structural development as defined for the red apedal B horizon;*

- *a clay increase relative to the topsoil horizon and/or the C material if present;*
- *the presence of cutans;*
- *disappearance of fine stratifications in a deposit which presumably was initially stratified (contrast with an underlying stratified C);*

(iii) *has a non-uniform colour by virtue of the presence of cutans and channel infillings except if the colour is a uniform dark brown which does not qualify as diagnostic red, yellow or grey as defined; colour variegation may then be absent;*

(iv) *lacks evidence of wetness (low chromas) that would qualify it as a diagnostic G horizon, regic sand, gleycutanic or soft plinthic horizon;*

(v) *has no evidence of saprolite in the B2 or B3 horizons.*

Recent sediments and other unconsolidated materials provide the parent material of many soils. Depending upon the nature and age of the material and on environmental conditions (such as climate and relief), virtually any kind of diagnostic horizon may develop: for example, a red or yellow-brown apedal B in aeolian sands; a G horizon or melanic and vertic horizons in alluvial valley-fills. Neocutanic character is recognized when soil formation in unconsolidated materials has not progressed sufficiently far to produce one or another distinctive diagnostic horizon but has brought about a certain amount of reorganization of the material (most frequently there is evidence of an incipient illuvial horizon), and obliterated any depositional stratifications that may originally have been present (see diagnostic stratified alluvium). The materials in which neocutanic horizons form are usually of alluvial or colluvial origin and the horizon is thus typically, but not always, found in certain landscape positions, for example river terraces. Soil formation has been minimal and the horizon is marked by rather weak structural development, the presence of cutans indicating pedogenic reorganization of materials such as clay, aggregation of particles to the extent that the material is no longer single grained (presumably its condition at the time of deposition), or cementation by weathering products and the development of hardness or massiveness. As a result of weathering or illuviation, or both, the horizon may contain more clay than the A and C horizons, but because there is often inherited textural differentiation in depositional materials, this is not a prerequisite for the recognition of the horizon.

Ferrihumic B horizon

(i) *directly underlies an E horizon;*

(ii) *has dark colours relative to the horizons above and below it and a Munsell colour value of 3 or less;*

(iii) *has a thickness of 100 mm or more; it is sometimes discontinuous when underlain by saprolite;*

(iv) *contains more pyrophosphate extractable C + Fe + Al than the overlying E horizon;*

(v) *lacks clayskins on ped faces or in pores.*

The best examples of podzols in South Africa are found on sandy materials under ***fynbos*** vegetation (it has marked affinities with heath, macchia and chaparral), and a winter (mediterranean) or year-round mean annual rainfall in excess of 350 mm. Such conditions obtain along the south and south-western coast areas of the country. In these soils, the B horizon underlies an E horizon and has become enriched in organic matter and sesquioxides by illuviation. It is important to note that this B horizon, termed ferrihumic, does not show marked textural differentiation; in other words, little or no clay has moved down into it with the organic matter and sesquioxides (as happens in some cutanic B horizons). Should a marked clay increase be present, it occurs below the ferrihumic B. Examples of this horizon have only very recently been encountered in South Africa. Consequently, the definition of the horizon is tentative at this stage and has been patterned on the definition of the podzol B horizon as developed elsewhere. However, three variants, with intergrades, of the horizon have been observed in deep loose sediments: a soft, very dark grey horizon with little sesquioxic hardening, often wet, and apparently associated with low-lying parts of the landscape; a dark coloured, vesicular ortstein hardpan that can normally be broken by hand, and occurring either intimately with a fluctuating watertable regime or in positions apparently relict; and a soft, dark coloured horizon of slightly reddish hue, with little sesquioxic hardening, and found in well drained situations. A fourth variant, which is usually soft, overlies saprolite.

Regic sand

(i) *is coarse textured (usually sand or loamy sand) and has little or no structure; it may be massive or single grained;*

(ii) *lacks fine stratifications of depositional origin but may have clay fibres or lamellae;*

(iii) *usually has "grey" colours as defined for the E horizon; does not have uniform red or yellow colours;*

(iv) *has consistence that is loose, friable, soft, or slightly hard;*

(v) *directly underlies a diagnostic topsoil horizon or, if this is absent, occurs at the surface; does not overlie any other diagnostic horizon within 1 200 mm of the soil surface but may overlie hard rock;*

(vi) *is at least 250 mm thick.*

The term regic (from Greek, ***rhegos*** = blanket) is used here to convey the idea of cover sands in which, by virtue of their youth, environment or low clay forming potential, little or no profile development has taken place. The purpose of defining this class of materials as diagnostic is to provide a place in the classification for young sands that are chiefly, though not exclusively, of aeolian origin. Such materials often represent an important geographic entity in desertic and littoral regions. The colours exhibited by these materials are generally pale and are related either to the lithological character of source rocks (for example, light pinkish sands from certain granites) or to their moisture regime (for example, gleyed sands). Where soil development has resulted in iron oxide coatings on the sand grains, and thus red or yellow colours, or in localization of iron oxides, and thus plinthic character, the materials are no longer regic sands. Pale sandy materials occurring under a topsoil and overlying one or another diagnostic B horizon (for example, cutanic or plinthic) qualify as E horizons. Under arid and semi-arid conditions, regic sand may rest on hard rock within 1 200 mm of the surface. In moister climates, rock occurring within this depth limit will almost invariably have developed some features of a lithocutanic B and the sandy material, provided that it complies with the colour requirements of the E horizon, is regarded as such. When the rock is deeper than 1 200 mm, however, the sandy material is regic sand provided it does not qualify as one of the other diagnostic subsoil horizons. The moisture regime of deep regic sands varies widely from dry regic sands of deserts and semi-deserts through moist regic sands of humid coast habitats to wet regic sands of topographic depressions. Both soil climate and overhead climate are important factors in land use, and must be highlighted in some way (for example, by the use of phases) during mapping if the series classification is not sufficient. Regic sands are commonly but not necessarily deep. They normally underlie a distinguishable topsoil but under extreme conditions (for example, where shifting desert sands occur) a topsoil may be absent. There may be some problem in distinguishing shallow regic sands on rock from sandy orthic A horizons in some areas. Here the presence of organic matter and distinguishable topsoils in deeper sandy deposits in the vicinity becomes an important consideration. If shallower than 250 mm it is orthic by definition. Deep regic sands which have gley colours are distinguished from G horizons on the basis of consistence; it is not possible to set a textural limit that would consistently separate the two, but in most cases the regic sands would contain less than 15% clay.

Stratified alluvium

(i) *is unconsolidated and contains fine stratifications due to deposition;*

(ii) *directly underlies a diagnostic topsoil horizon or occurs at the surface.*

Unlike soil horizons that have developed by pedogenetic processes, stratified (young) alluvium owes its distinguishing characteristics to a depositional process and is thus not a sequence of so-called genetic horizons. Pedogenetic changes have been minimal and it is, properly, a C horizon or parent material. The rare occurrences of stratified colluvium are also accommodated in this concept. Given time, homogenizing processes of soil formation will destroy the evidence of deposition: stratifications will disappear and be replaced by true genetic soil horizons, their kind depending upon the character of the particular material, the particular site and the particular external environment. However, alluvium is commonly utilized very intensively for crop production under irrigation. For this practical reason, it has been regarded as highly desirable to recognize stratified alluvium as a diagnostic subsoil material. The classification reflects this importance of young alluvium by making provision, through a diagnostic horizon, for its easy inclusion. Other diagnostic subsoil horizons cater for the pedogenetic changes which affect alluvium with time.

Definitions of Forms and Series

KEY TO THE SOIL FORMS (page references in brackets)

UNDERLYING DIAGNOSTIC HORIZONS AND MATERIALS	DIAGNOSTIC TOPSOIL HORIZONS				
	Organic	Humic	Vertic	Melanic	Orthic
Gleyed material	CHAMPAGNE (34)				
G horizon			RENSBURG (44)	WILLOWBROOK (48)	KATSPRUIT (60)
Pedocutanic B/saprolite[1]					SWARTLAND (62)
Pedocutanic B/unconsolidated material[2]					VALSRIVIER (64)
Pedocutanic B/not specified				BONHEIM (50)	
Prismacutanic B					STERKSPRUIT (66)
E horizon/prismacutanic B					ESTCOURT (68)
E horizon/gleycutanic B					KROONSTAD (70)
E horizon/yellow-brown apedal B					CONSTANTIA (72)
E horizon/red apedal B					SHEPSTONE (74)
E horizon/neocutanic B					VILAFONTES (76)
E horizon/ferrihumic B/saprolite[1]					HOUWHOEK (78)
E horizon/ferrihumic B/unconsolidated material[2]					LAMOTTE (80)
E horizon/lithocutanic B					CARTREF (82)

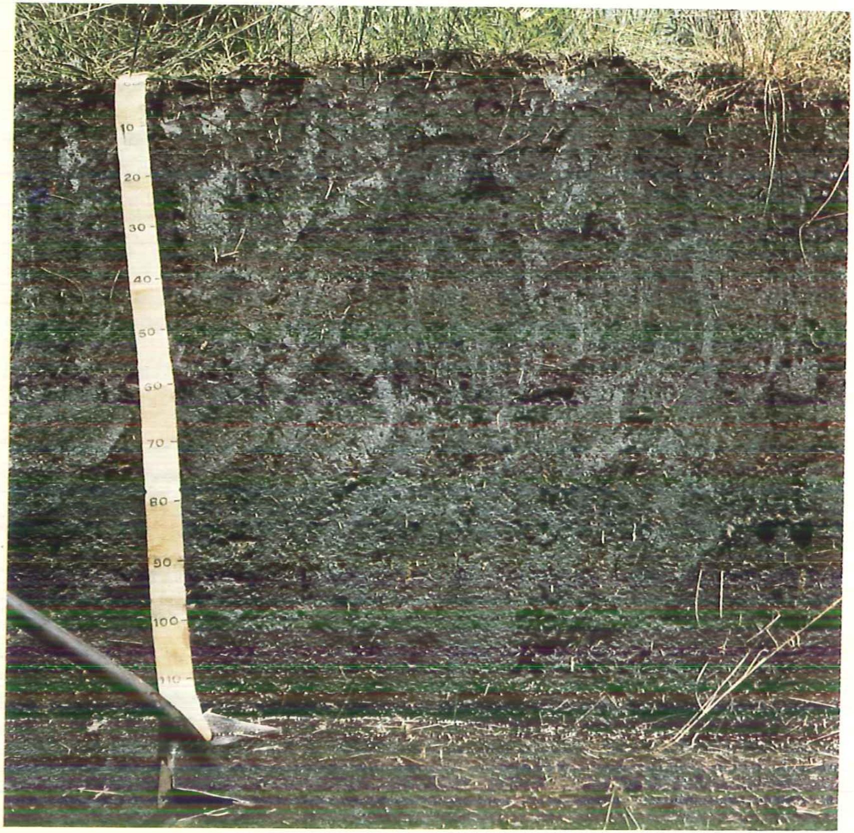
KEY – (continued)

UNDERLYING DIAGNOSTIC HORIZONS AND MATERIALS	DIAGNOSTIC TOPSOIL HORIZONS				
	Organic	Humic	Vertic	Melanic	Orthic
E horizon/hard plinthic B					WASBANK (84)
E horizon/soft plinthic B					LONGLANDS (86)
Soft plinthic B				TAMBANKULU (52)	WESTLEIGH (88)
Yellow-brown apedal B/ soft plinthic B					AVALON (90)
Yellow-brown apedal B/ hard plinthic B					GLENCOE (92)
Yellow-brown apedal B/ gleycutanic B					PINEDENE (94)
Yellow-brown apedal B/ red apedal B		KRANSKOP (36)			GRIFFIN (96)
Yellow-brown apedal B		MAGWA (38)			CLOVELLY (98)
Red apedal B/soft plinthic B					BAINSVLEI (100)
Red apedal B		INANDA (40)			HUTTON (102)
Red structured B					SHORTLANDS (104)
Neocutanic B				INHOEK (54)	OAKLEAF (106)
Regic sand					FERNWOOD (108)
Stratified alluvium				INHOEK (54)	DUNDEE (110)
Lithocutanic B		NOMANCI (42)		MAYO (56)	GLENROSA (112)
Hard rock, hardpan ferricrete, hardpan calcrete, hardpan silcrete or dorbank				MILKWOOD (58)	MISPAH (114)
Not specified			ARCADIA (46)		

(1) Weathering rock which, although unconsolidated, still has easily visible geogenic character.

(2) Recent sediments or decomposed rock without saprolite character.

CHAMPAGNE FORM – Ch



ORGANIC O

SOIL SERIES

pH of O horizon	Clay content of O horizon			
	below 20%		above 20%	
below 4	MPOSA	10	STRATFORD	20
above 4	CHAMPAGNE	11	IVANHOE	21

Note: pH value is measured in 1 mol/ℓ KCl.

Underlying material is not specified, but is gleyed.

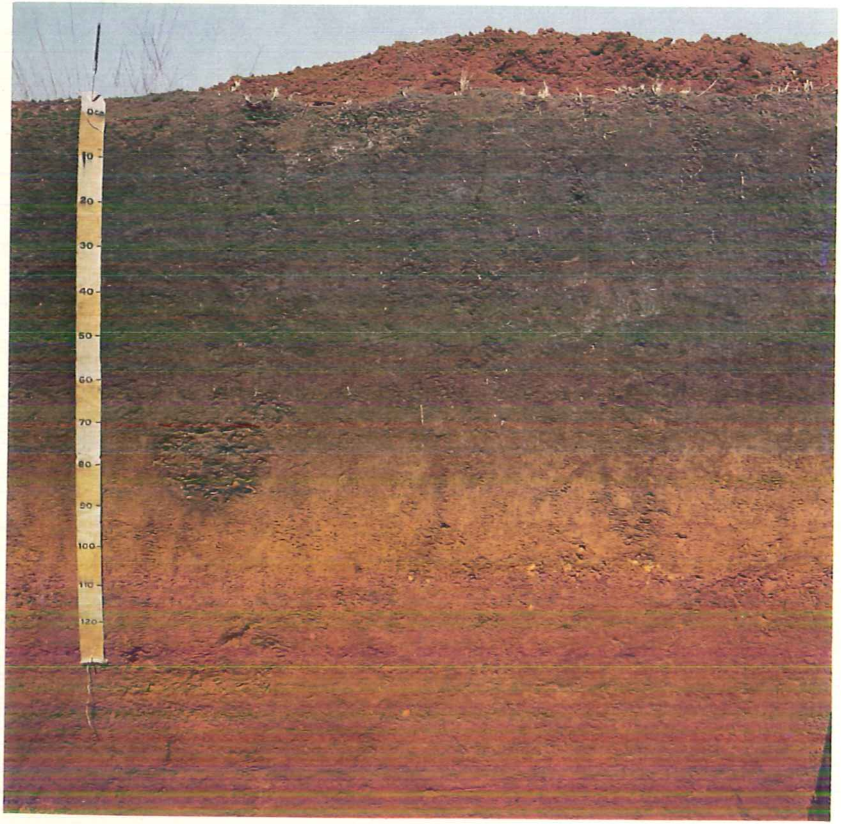
Correlation FAO

HISTIC GLEYSOLS; DYSTRIC and
EUTRIC HISTOSOLS

Correlation USDA

HISTOSOLS – MEDIHEMISTS (various);
MEDISAPRISTS (various)
INCEPTISOLS – HUMAQUEPTS

KRANSKOP FORM – Kp



HUMIC A

YELLOW-BROWN APEDAL B

RED APEDAL B

SOIL SERIES

Clay content of B21 horizon (%)	Usually dystrophic in B21 horizon	
15 – 35	KIPIPIRI	10
35 – 55	KRANSKOP	11
above 55	UMBUMBULU	12

Underlying material is not specified, but is usually saprolite. In this particular example a crotovina in cross section can be seen at left in the yellow-brown horizon. In the background is red soil that was excavated from the soil pit.

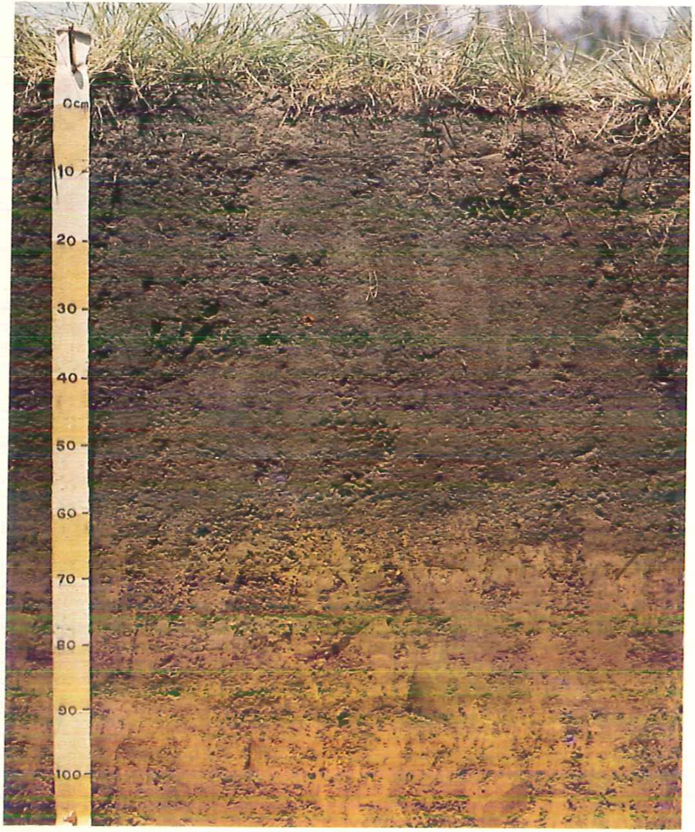
Correlation FAO

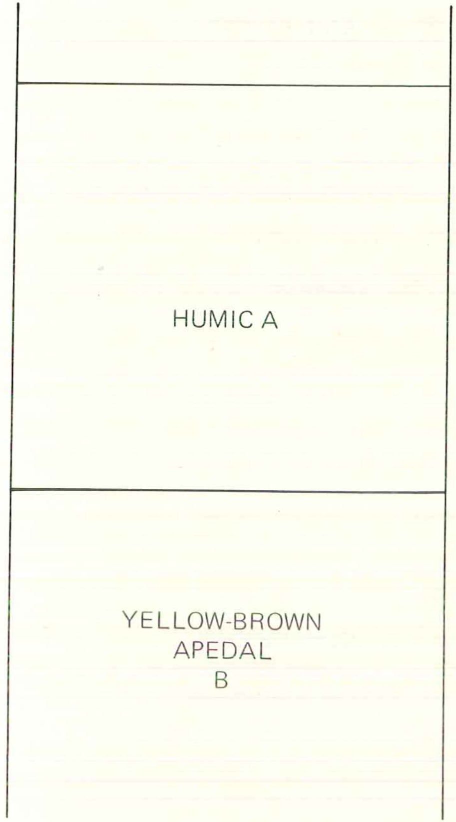
HUMIC ACRISOLS, FERRALSOLS and CAMBISOLS

Correlation USDA

ULTISOLS – PALEHUMULTS (Pachic)
OXISOLS – HAPLOHUMOX (Typic, Pachic, Arenic)

MAGWA FORM – Ma





SOIL SERIES

Clay content of B21 horizon (%)	Usually dystrophic in B21 horizon	
15 – 35	MILFORD	10
35 – 55	MAGWA	11
above 55	FRAZER	12

Underlying material not specified. The yellow-brown apedal B horizon is permitted to have red mottles, but no other signs of gleying such as grey colours. Colour variegation due to faunal activity (earthworm casts, faecal pellets) is also permitted.

Correlation FAO

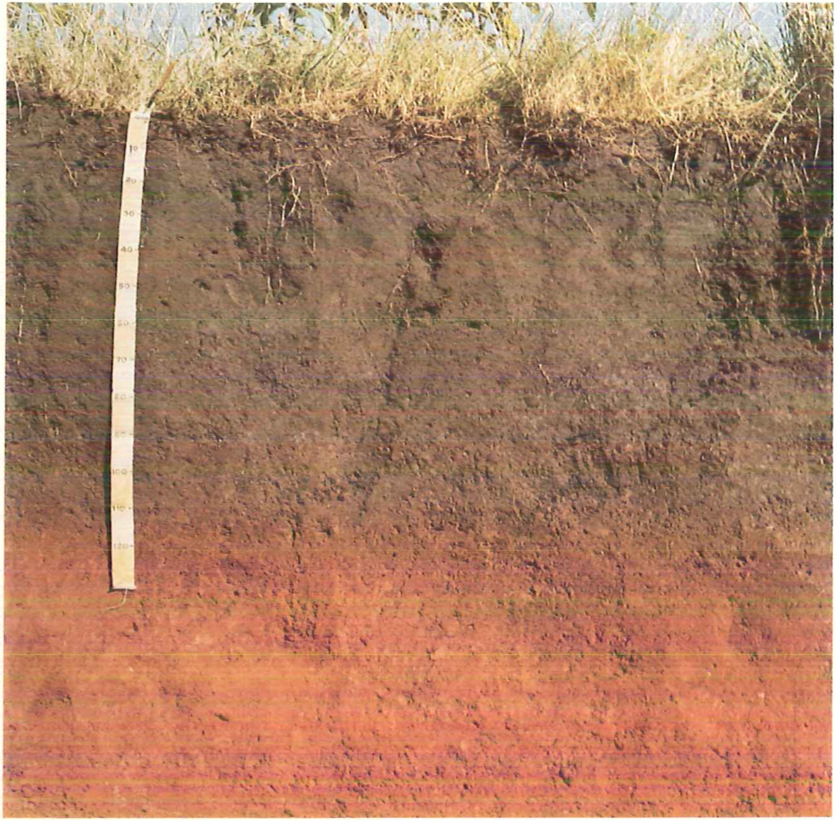
HUMIC (strongly) CAMBISOLS; HUMIC FERRALSOLS; HELVIC ACRISOLS

Correlation USDA

INCEPTISOLS – HAPLUMBREPTS (Pachic); XERUMBREPTS (Pachic)

OXISOLS – HAPLOHUMOX (Typic, Pachic, Arenic)

INANDA FORM – Ia



HUMIC A

RED APEDAL
B

SOIL SERIES

Clay content of B21 horizon (%)		Usually dystrophic in B21 horizon	
15 – 35		FOUNTAINHILL	10
35 – 55		INANDA	11
above 55		SPRINZ	12

Underlying material is not specified, but is usually saprolite.

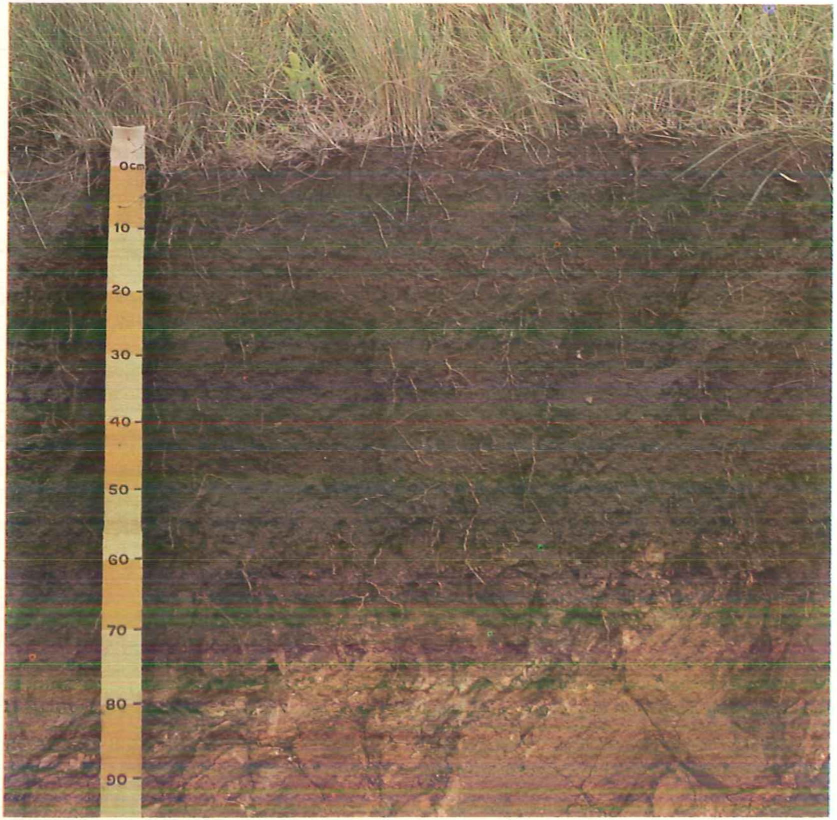
Correlation FAO

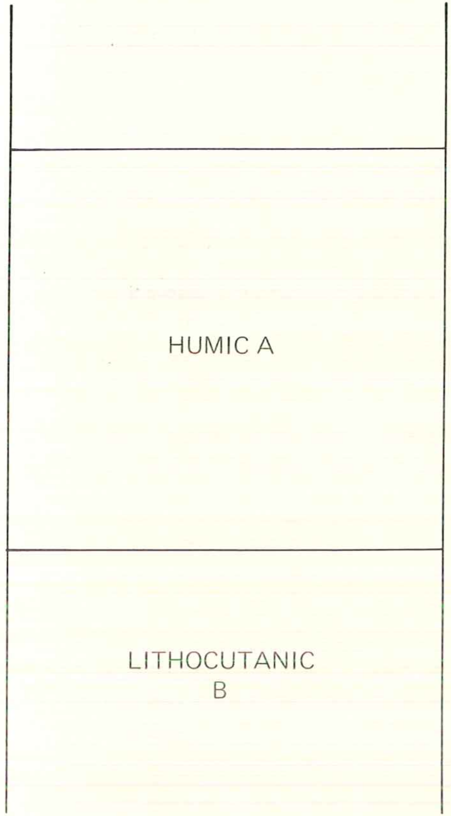
HUMIC FERRALSOLS; HUMIC CAMBISOLS

Correlation USDA

OXISOLS – HAPLOHUMOX (Typic, Pachic, Arenic)

NOMANCI FORM – No





SOIL SERIES

Clay content of A horizon (%)		
below 35	NOMANCI	10
above 35	LUSIKI	11

Underlying material is saprolite grading into rock.

Correlation FAO

RANKERS with thick A horizon;
HUMIC (strongly) CAMBISOLS;
HUMIC ACRISOLS

Correlation USDA

INCEPTISOLS – HAPLUMBREPTS (Pachic);
XERUMBREPTS (Pachic)

RENSBURG FORM – Rg

VERTIC A

G HORIZON

SOIL SERIES

Non-calcareous in upper G		Calcareous in upper G	
PHOENIX	10	RENSBURG	20

Underlying material not specified. In this example lime nodules can be seen in the G horizon.

Correlation FAO

PELLIC and (dark) CHROMIC VERTISOLS (with gleyic horizon)

Correlation USDA

MOLLISOLS – HAPLAQUOLLS (Vertic, Calcic-Vertic); CALCIAQUOLLS (Typic-Vertic)
VERTISOLS – PELLUDERTS; PELLOXERERTS

ARCADIA FORM – Ar

VERTIC A

SOIL SERIES

Colour of vertic A	Strongly crusting surface				Self-mulching or weakly crusting surface			
	Non-calcareous in and immediately below A horizon		Calcareous in or immediately below A horizon		Non-calcareous in and immediately below A horizon		Calcareous in or immediately below A horizon	
Dark	MNGAZI	10	GELYKVLAKTE	20	RYDALVALE	30	ARCADIA	40
Red	BLOUKRANS	11	CLERKNESS	21	ROOIDRAAI	31	EENZAAM	41
Other	NOUKLOOF	12	ZWAARKRYGEN	22	NAGANA	32	WANSTEAD	42

Note 1: Dark colours are such that both value and chroma are 3 or less in the moist state but with the exclusion of 10YR 3/3 and dark reddish brown and dusky red colours of hue 5YR or redder.

Note 2: Red means red or reddish colours of hues 5YR, 2.5YR, 10R and 7.5R.

Underlying material not specified. In this particular example slickensides are prominently displayed in the soil near the boundary to saprolite; the granular, self-mulching topsoil grades in characteristic fashion to a coarser structure at depth. At 1 000 mm depth is a freshly broken fragment of basic igneous rock that is weathering spheroidally.

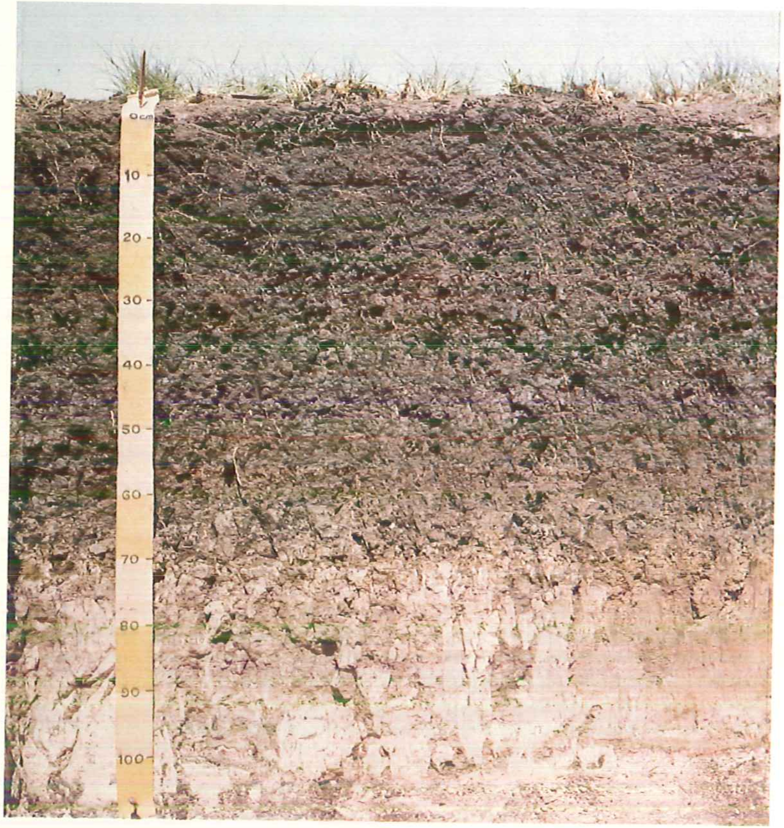
Correlation FAO

PELLIC and (some dark-coloured) CHROMIC VERTISOLS; VERTIC CAMBISOLS

Correlation USDA

VERTISOLS— PELLOXERERTS (Typic, Entic); PELLUSTERTS (Typic, Entic); CHROMOXERERTS (Typic); CHROMUSTERTS (Typic, Paleustollic)

WILLOWBROOK FORM – Wo



MELANIC A

G HORIZON

SOIL SERIES

Clay content of A horizon (%)	Non-calcareous in upper G		Calcareous in upper G	
15 – 35	EMFULENI	10	SARASDALE	20
above 35	WILLOWBROOK	11	CHINYIKA	21

Underlying material not specified.

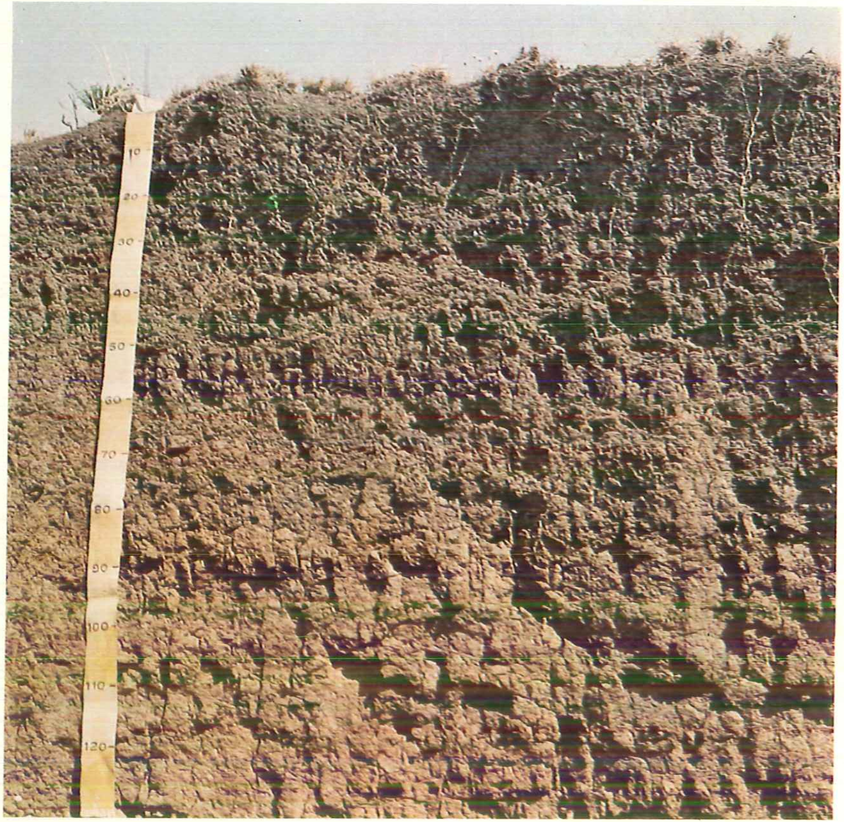
Correlation FAO

GLEYIC PHAEOZEMS; HUMIC GLEYSOLS (with melanic A horizon)

Correlation USDA

MOLLISOLS – HAPLAQUOLLS (Typic, Calcic); CALCIAQUOLLS (Typic)

BONHEIM FORM – Bo



MELANIC A

PEDOCUTANIC
B

SOIL SERIES

Clay content of A horizon (%)	B horizon colour predominantly red				B horizon colour predominantly non-red			
	Non-calcareous in B horizon		Calcareous in B horizon		Non-calcareous in B horizon		Calcareous in B horizon	
15 – 35	KIORA	10	BUSHMAN	20	DUMASI	30	WEENEN	40
above 35	STANGER	11	RASHENI	21	GLENGAZI	31	BONHEIM	41

Underlying material not specified.

Correlation FAO
LUVIC PHAEOZEMS, CASTANOZEMS and possibly CHERNOZEMS

Correlation USDA
MOLLISOLS – ARGIUSTOLLS (Typic, Pachic, Udic); ARGIXEROLLS (Calcic, Pachic, Ultic)

TAMBANKULU FORM – Tk

MELANIC A

SOFT PLINTHIC B

SOIL SERIES

Clay content of A horizon (%)	Non-calcareous in B horizon		Calcareous in B horizon	
15 – 35	FENFIELD	10	LOSHOEK	20
above 35	TAMBANKULU	11	MASALA	21

Underlying material is not specified, but is usually gleyed.

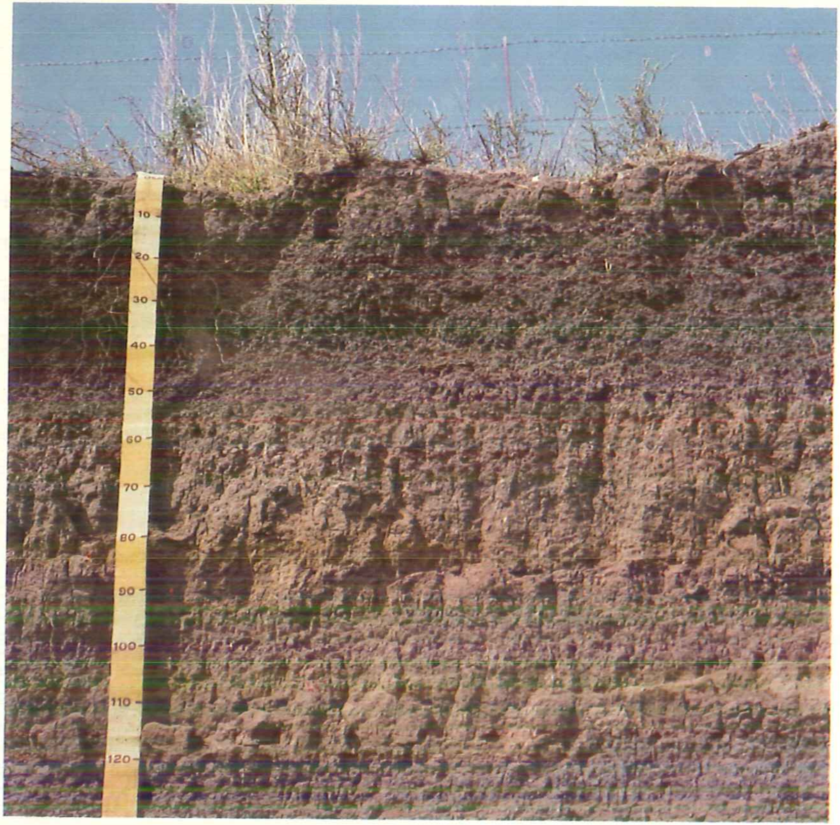
Correlation FAO

PLINTHIC CASTANOZEMS,
PHAEOZEMS and CHERNOZEMS

Correlation USDA

MOLLISOLS – HAPLOXEROLLS (Aquic-Plinthic)

INHOEK FORM – Ik



MELANIC A	
STRATIFIED ALLUVIUM (in this illustration) or NEOCUTANIC B	

SOIL SERIES

Clay content of A horizon (%)	Non-calcareous in and immediately below A horizon		Calcareous in or immediately below A horizon	
below 35	CROMLEY	10	INHOEK	20
above 35	CONISTON	11	DRYDALE	21

Distinguishing a neocutanic B from stratified alluvium is not warranted in this form.

Correlation FAO

HAPLIC PHAEOZEMS, CASTANOZEMS, possibly CHERNOZEMS, all on stratified alluvium

Correlation USDA

MOLLISOLS – HAPLUSTOLLS (Fluventic, Cumulic); HAPLOXEROLLS (Fluventic, Cumulic)

MAYO FORM – My

MELANIC A
LITHOCUTANIC B

SOIL SERIES

Clay content of A horizon (%)	Non-calcareous in B horizon		Calcareous in B horizon	
15 – 35	MAYO	10	TSHIPISE	20
above 35	MSINSINI	11	PAFURI	21

Underlying material is saprolite grading into rock.

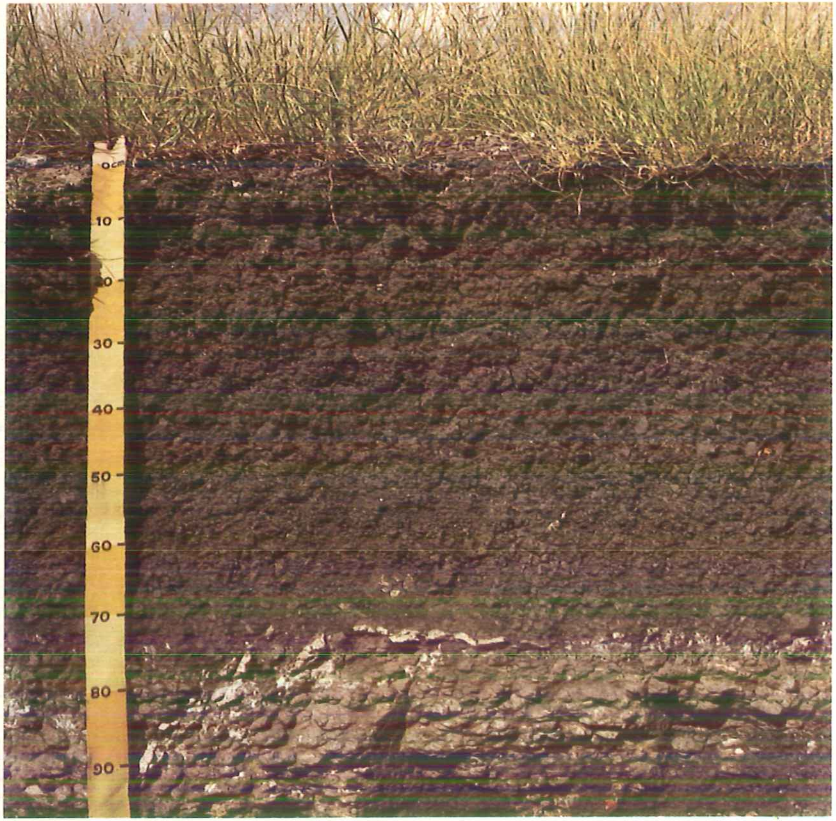
Correlation FAO

HAPLIC PHAEOZEMS,
CASTANOZEMS, possibly
CHERNOZEMS; RENDZINAS

Correlation USDA

MOLLISOLS – HAPLUSTOLLS (Ruptic, Pachic-Ruptic, Udic-Ruptic); HAPLOXEROLLS (Ruptic, Pachic-Ruptic, Calcic-Ruptic)

MILKWOOD FORM – Mw



MELANIC A	
HARD ROCK (in this illustration) HARDPAN FERRICRETE HARDPAN CALCRETE HARDPAN SILCRETE or DORBANK	

SOIL SERIES

Clay content of A horizon (%)	Non-calcareous in A horizon		Calcareous in A horizon	
15 – 35	DANSLAND	10	SUNDAY	20
above 35	MILKWOOD	11	GRAYTHORNE	21

Usually has a clear transition to underlying rock or other consolidated material.

Correlation FAO

HAPLIC PHAEOZEMS; HAPLIC and CALCIC CHERNOZEMS; HAPLIC and CALCIC CASTANOZEMS; RENDZINAS

Correlation USDA

MOLLISOLS – HAPLUSTOLLS (Pachic, Entic, Lithic); CALCIUSTOLLS (Typic, Pachic, Petrocalcic); RENDOLLS (Typic, Lithic); HAPLOXEROLLS (Calcic-Entic, Calcic-Pachic, Calcic-Lithic-Entic, Entic, Lithic, Pachic); CALCIXEROLLS (Typic, Pachic, Lithic)

KATSPRUIT FORM – Ka

ORTHIC A

G HORIZON

SOIL SERIES

Acid		Neutral to alkaline	
KATSPRUIT	10	KILLARNEY	20

Note: Acid means a pH value (measured in 1 mol/ℓ KCl) of less than 6,6 in the upper G horizon.

Underlying material not specified. Yellow mottling in the upper G horizon of this example indicates better aeration.

Correlation FAO

GLEYSOLS (various)

Correlation USDA

INCEPTISOLS – HUMAQUEPTS (Typic); HAPLAQUEPTS (Typic)

ENTISOLS – HAPLAQUENTS (Typic); HYDRAQUENTS

SWARTLAND FORM – Sw

ORTHIC A

PEDOCUTANIC B

SAPROLITE

SOIL SERIES

Clay content of B horizon (%)	B horizon colour predominantly red				B horizon colour predominantly non-red			
	Non-calcareous in B and C horizons		Calcareous in B or C horizons		Non-calcareous in B and C horizons		Calcareous in B or C horizons	
15 – 35	REVEILLIE	10	UITSICHT	20	ROSEHILL	30	MALAKATA	40
35 – 55	SKILDERKRANS	11	BROEKSPRUIT	21	SWARTLAND	31	NYOKA	41
above 55	BREIDBACH	12	PROSPECT	22	HOGSBACK	32	OMDRAAI	42

Note 1: A horizon textural classes should be recognized by means of phase distinctions. Where clay content of the A is below 35%, the textural phase designation should include a reference to the grade of sand present. Textural differentiation in this way will provide some indication of the kind of parent material from which the soil has developed.

Note 2: Windermere series, long recognized in the sugar industry of Natal, is properly Swartland series with a black topsoil.

Saprolite is required to occur under the pedocutanic B in Swartland form to distinguish it from Valsrivier.

Correlation FAO

BRUNIC and CHROMIC LUVISOLS; LUVIC XEROSOLS and ERMOSOLS (A horizons usually hard when dry)

Correlation USDA

ALFISOLS – HAPLUSTALFS (Typic, Udic, Ultic); HAPLOXERALFS (Typic, Ultic); RHODUSTALFS (Typic, Udic); RHODOXERALFS (Typic) (all overlying saprolite)

ARIDISOLS – HAPLARGIDS

VALSRIVIER FORM – Va

ORTHIC A

PEDOCUTANIC
B

UNCONSOLIDATED
MATERIAL

SOIL SERIES

Clay content of B horizon (%)	B horizon colour predominantly red		B horizon colour predominantly non-red	
	Non-calcareous in B and C horizons	Calcareous in B or C horizons	Non-calcareous in B and C horizons	Calcareous in B or C horizons
15 – 35	SUNNYSIDE 10	ZUIDERZEE 20	HERSCHEL 30	VALSRIVIER 40
35 – 55	WATERVAL 11	CRAVEN 21	ARNISTON 31	LINDLEY 41
above 55	LILYDALE 12	MARIENTHAL 22	CHALUMNA 32	SHEPPARDVALE 42

Underlying material is diagnostically unconsolidated. At least 500 mm of a material which shows no geogenic character is interposed between the lower limit of the B horizon and underlying saprolite or hard rock. Dark coloured B horizons can be given a phase distinction. In this particular example powder and nodular lime can be seen in the subsoil.

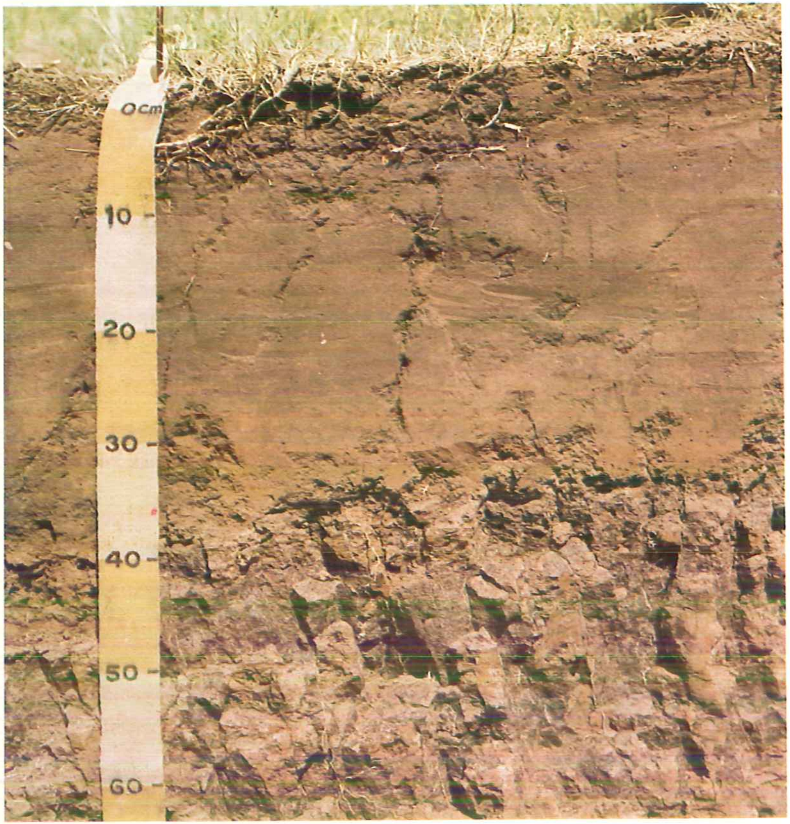
Correlation FAO

As for SWARTLAND form

Correlation USDA

As for SWARTLAND form;
also *ARIDISOLS* – HAPLARGIDS (Typic)

STERKSPRUIT FORM – Ss



ORTHIC A

PRISMACUTANIC
B

SOIL SERIES

Clay content of A horizon (%)	Grade of sand in A horizon	B horizon colour predominantly red		B horizon colour predominantly non-red	
0 – 6	fine	DIEPKLOOF	10	HALSETON	20
	medium	TINA	11	GRAAFWATER	21
	coarse	RUACANA	12	SILWANA	22
6 – 15	fine	BAKKLYSDRIFT	13	STANFORD	23
	medium	TOLENI	14	HARTBEES	24
	coarse	DEHOEK	15	GROOTFONTEIN	25
15 – 35	undifferentiated	SWAERSKLOOF	16	STERKSPRUIT	26
above 35	undifferentiated	DRIEBADEN	17	ANTIOCH	27

Underlying material is not specified, but is usually calcareous. Non-calcareous materials should receive a phase distinction.

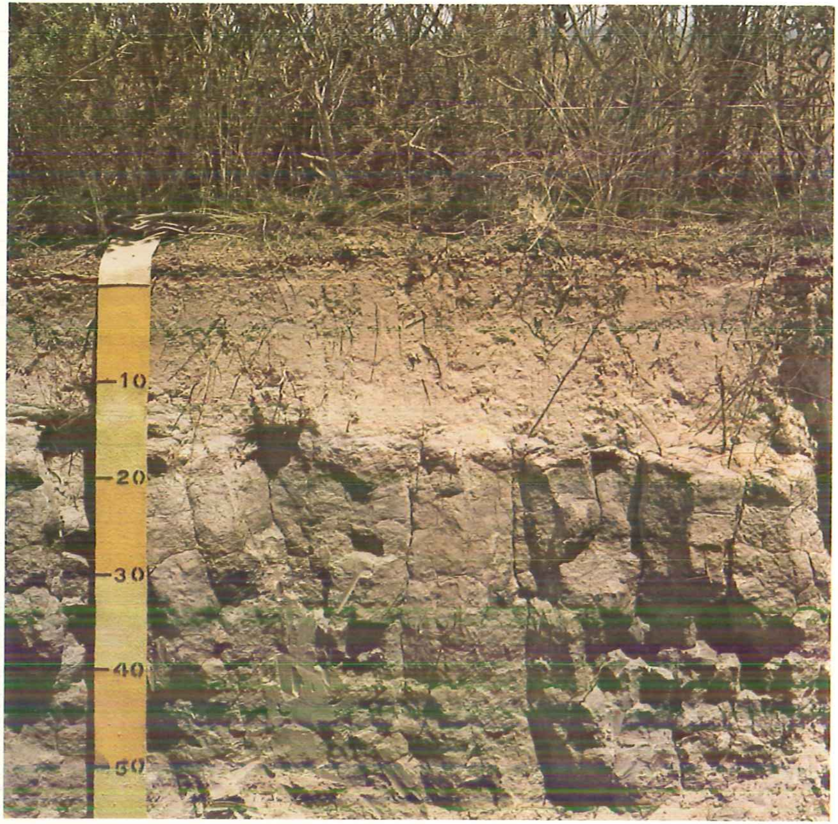
Correlation FAO

OCHRIC SOLONETZ

Correlation USDA

ALFISOLS – NATRIXERALFS (Typic);
NATRUSTALFS (Typic, Salorthidic)
ARIDISOLS – NATRARGIDS (Typic, Lithic)

ESTCOURT FORM – Es



ORTHIC A
E HORIZON
PRISMACUTANIC B

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon	B horizon has continuous black cutans on vertical ped faces		B horizon lacks continuous black cutans	
		Clay content of B less than 25%	Clay content of B above 25%	Clay content of B less than 25%	Clay content of B above 25%
0 – 6	fine	HOUDENBECK 10	ASSEGAAI 20	MOZI 30	BEERLAAGTE 40
	medium	AUCKLAND 11	LANGKLOOF 21	ELIM 31	HEIGHTS 41
	coarse	POTELA 12	AVONTUUR 22	SOLDAATSKRAAL 32	DARLING 42
6 – 15	fine	DOHNE 13		ENKELDOORN 33	
	medium	GRASSLANDS 14		UITVLUGT 34	
	coarse	VREDENHOEK 15		BALFOUR 35	
15 – 35	undifferentiated	ROSEMEAD 16		ESTCOURT 36	
above 35	undifferentiated	ZINTWALA 17		BUFFELSDRIF 37	

Note: The presence of black or very dark coloured cutans as a continuous coating on vertical ped faces in the prismacutanic B has been introduced as a series criterion to distinguish members of the Estcourt form that have a wetter soil climate. Free lime is then usually absent from the C material. When in doubt (ie when unsure whether the B has cutans that qualify as "continuous black") as to the classification of profiles with B and C horizons that are regularly wet (ie that exhibit strong gley character), classes 10 – 22 of Estcourt form are preferred when the coarse textured overburden is less than 500 mm thick and Kroonstad form is preferred when the overburden is thicker than 500 mm.

Underlying material not specified.

Correlation FAO
OCHRIC SOLONETZ (with albic horizon); GLEYIC SOLONETZ; SOLOD; some OCHRIC PLANOSOLS

Correlation USDA
ALFISOLS – NATRIXERALFS (Albaqualfic); NATRUSTALFS (Albaqualfic)

KROONSTAD FORM – Kd

ORTHIC A

E HORIZON

GLEYCUTANIC B

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon	Clay content of gleycutanic B			
		below 25%		above 25%	
0 – 6	fine	ROCKLANDS	10	KOPPIES	20
	medium	VELDDRIF	11	UMTENTWENI	21
	coarse	SWELLENGIFT	12	KATARRA	22
6 – 15	fine	KROONSTAD	13		
	medium	MKAMBATI	14		
	coarse	SLANGKOP	15		
15 – 35	fine	BLUEBANK	16		
	medium	AVOCA	17		
	coarse	UITSPAN	18		
above 35	undifferentiated	VOLKSRUST	19		

Underlying material is not specified, but is usually gleyed.

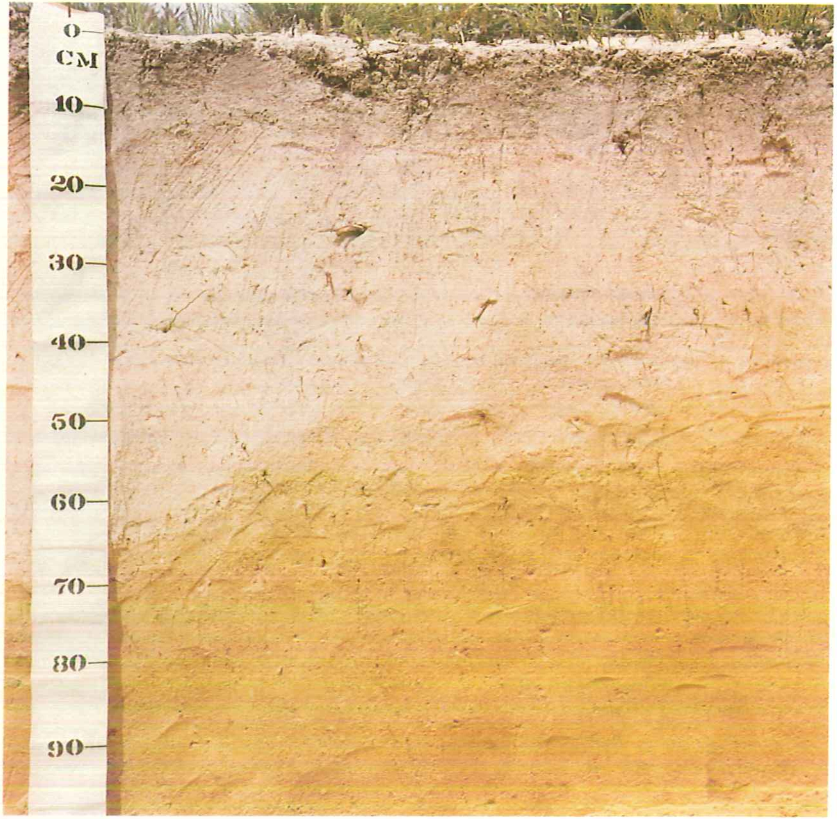
Correlation FAO

OCHRIC PLANOSOLS

Correlation USDA

ALFISOLS – ALBAQUALFS (Typic, Mollic, Aeric, Udollic)

CONSTANTIA FORM – Ct



ORTHIC A

E HORIZON

YELLOW-BROWN
APEDAL
B

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon	Clay content of B less than 15%		Clay content of B above 15%	
0 – 6	fine	STROMBOLIS	10	PALMYRA	20
	medium	TOKAI	11	VLAKFONTEIN	21
	coarse	CONSTANTIA	12	FENCOTE	22
6 – 15	fine	HARKERVILLE	13	DWESA	23
	medium	NOETZIE	14	KROMHOEK	24
	coarse	WYNBERG	15	CINTSA	25

Underlying material not specified.

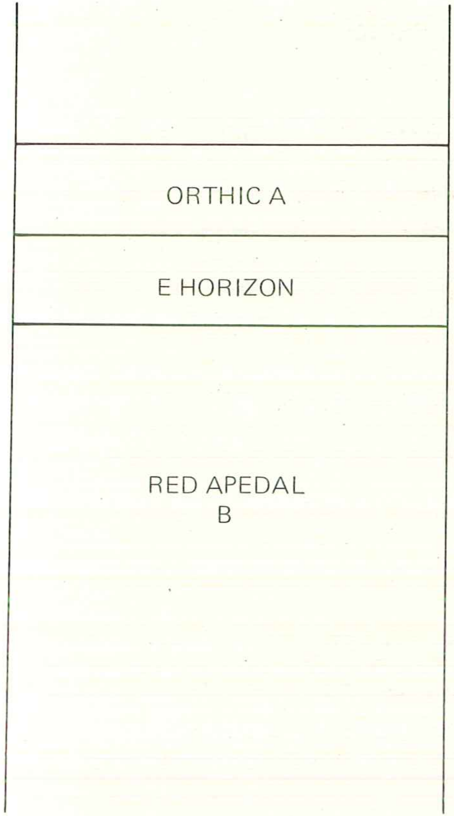
Correlation FAO

ALBISOLS, FERRIC PODZOLS
and RHODIC, HELVIC and
HUMIC ACRISOLS

Correlation USDA

ULTISOLS – UDULTS; USTULTS; HUMULTS
SPODOSOLS – FERRODS
ALFISOLS – GLOSSOBORALFS

SHEPSTONE FORM – Sp



SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon	Clay content of B less than 15%		Clay content of B above 15%	
0 – 6	fine	TERGNIET	10	SOUTHBROOM	20
	medium	BITOU	11	SHEPSTONE	21
	coarse	ADDINGTON	12	KUNJANE	22
6 – 15	fine	GOURITZ	13	PENCARROW	23
	medium	ROBBERG	14	PORTOBELLO	24
	coarse	INHAMINGA	15	PUMULA	25

Underlying material not specified.

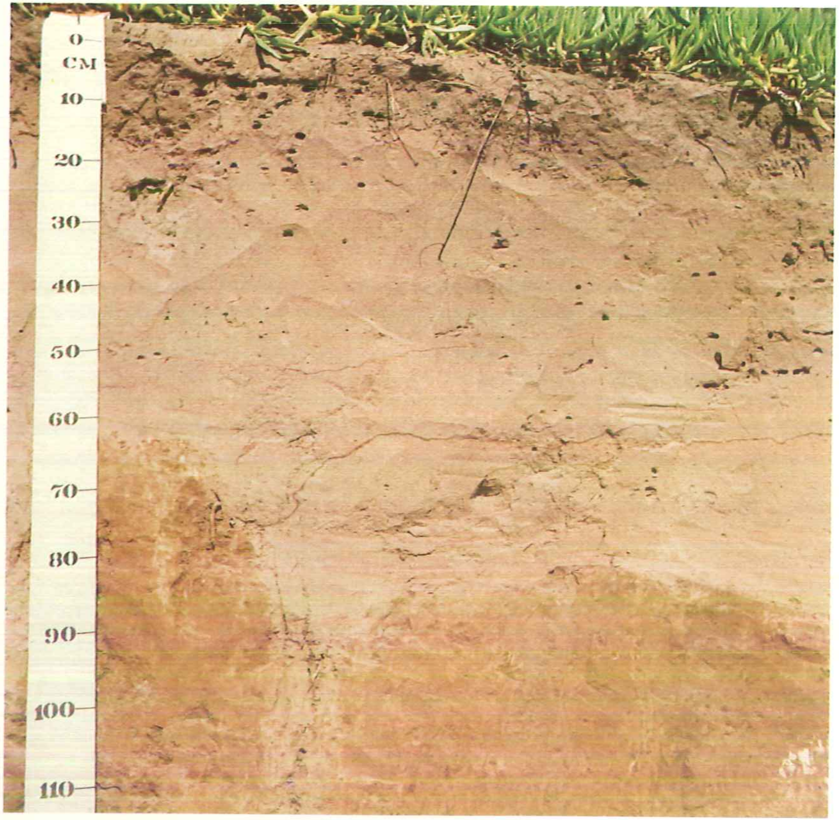
Correlation FAO

ALBISOLS, ALBIC LUVISOLS and HELVIC and HUMIC ACRISOLS

Correlation USDA

ULTISOLS – HAPLUDULTS; HAPLUSTULTS; HUMULTS
SPODOSOLS – FERRODS
ALFISOLS – GLOSSOBORALFS

VILAFONTES FORM – Vf



ORTHIC A

E HORIZON

NEOCUTANIC
B

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon	Non-calcareous in B horizon				Calcareous in B horizon			
		Clay content of B less than 15%		Clay content of B above 15%		Clay content of B less than 15%		Clay content of B above 15%	
0 – 6	fine	MORELAND	10	MATIGULU	20	SEDGEFIELD	30	KRANSDUINEN	40
	medium	HUDLEY	11	FAIRBREEZE	21	BRENTON	31	MAZEPPA	41
	coarse	ZEEKOE	12	KLAARWATER	22	SWINTON	32	VALLANCE	42
6 – 15	fine	TINLEY	13	BLYTHDALE	23	RHEEBOK	33	GEELBEK	43
	medium	MOYENI	14	CHANTILLY	24	KNYSNA	34	DASSENHOEK	44
	coarse	VILAFONTES	15	NHAMACALA	25	MEULVLEI	35	BLOMBOSCH	45

Underlying material not specified.

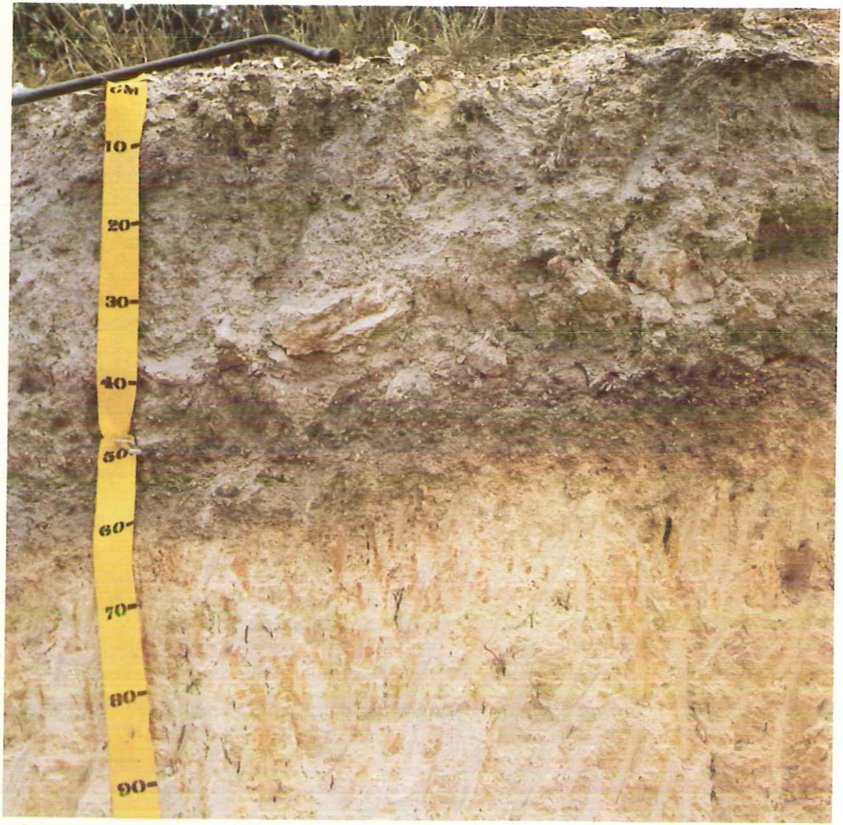
Correlation FAO

ALBIC and GLOSSIC LUVISOLS

Correlation USDA

ALFISOLS – GLOSSOBORALFS;
EUTROBORALFS

HOUWHOEK FORM – Hh



ORTHIC A

E HORIZON

FERRIHUMIC
B

SAPROLITE

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon					
	fine		medium		coarse	
0 – 6	ELGIN	10	ALBERTINIA	20	HOUWHOEK	30
6 – 15	STORMSRIVIER	11	GARCIA	21	GOUNA	31

Saprolite is required to occur under the ferrihumic B in Houwhoek form to distinguish it from Lamotte.

Correlation FAO

HUMO-FERRIC PODZOLS (lithic)

Correlation USDA

SPODOSOLS – Lithic and Leptic HAPLORTHODS and HAPLOHUMODS

LAMOTTE FORM – Lt

ORTHIC A

E HORIZON

FERRIHUMIC B

UNCONSOLIDATED MATERIAL

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon	B horizon not hardened		B horizon irreversibly hardened	
0 – 6	fine	ALSACE	10	LORRAINE	20
	medium	LAPARIS	11	BURGUNDY	21
	coarse	LAMOTTE	12	FRANSCHHOEK	22
6 – 15	fine	VEVEY	13	TILLBERGA	23
	medium	CHAMOND	14	RINGWOOD	24
	coarse	LILLESAND	15	HOOGHALEN	25

Underlying material is diagnostically unconsolidated. At least 500 mm of a material which shows no geogenic character is interposed between the lower limit of the B horizon and underlying saprolite or hard rock.

Correlation FAO

HUMO-FERRIC PODZOLS

Correlation USDA

SPODOSOLS – Typic, Aqualfic and Aquic HAPLORTHODS; HAPLAQUODS

CARTREF FORM – Cf

ORTHIC A

E HORIZON

LITHOCUTANIC B

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon					
	fine		medium		coarse	
0 – 6	AMABELE	10	WATERRIDGE	20	GROVEDALE	30
6 – 15	RUTHERGLEN	11	CARTREF	21	KUSASA	31
15 – 35	ARROCHAR	12	CRANBROOK	22	NOODHULP	32
above 35			BYRNE	13		

Underlying material is saprolite grading into hard rock. When the B horizon has formed in horizontally bedded sediments, litho-cutanic character can be minimal.

Correlation FAO

Not accommodated specifically, but *inter alia* GLEYIC LUVISOLS

Correlation USDA

INCEPTISOLS – HAPLAQUEPTS (Typic, Aeric); HUMAQUEPTS (Typic)

WASBANK FORM – Wa

ORTHIC A

E HORIZON

HARD PLINTHIC B

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon					
	fine		medium		coarse	
0 – 6	HOOPSTAD	10	RONDEVLEI	20	HAMMAN	30
6 – 15	KROMVLEI	11	WASBANK	21	SANDVLEI	31
15 – 35	BURFORD	12	WARRICK	22	WINTERVELD	32
above 35			ENDICOTT	13		

Underlying material is not specified but, as in this particular example which illustrates a gleyed clay subsoil, is typically gleyed.

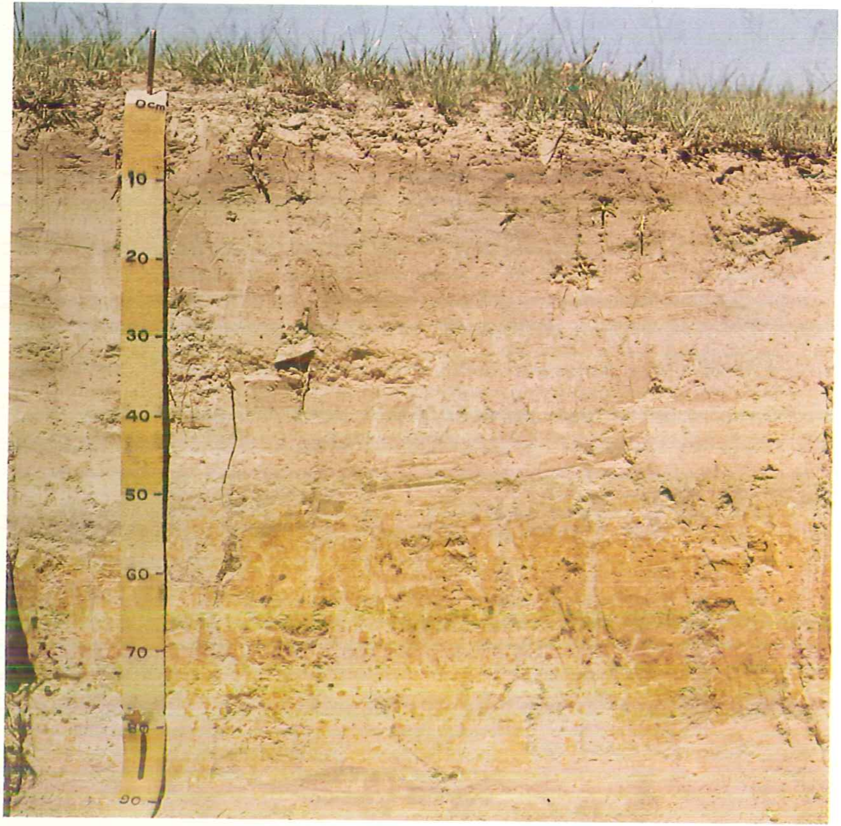
Correlation FAO

Not accommodated specifically

Correlation USDA

ENTISOLS – HAPLAQUENTS (Leptic-Lithic; Leptic-Lithic-Aeric) and PSAMMAQUENTS (Leptic-Lithic, Leptic-Lithic-Mollic) with hardened plinthite below the lithic contact

LONGLANDS FORM – Lo



ORTHIC A

E HORIZON

SOFT PLINTHIC B

SOIL SERIES

Clay content of E horizon (%)	Grade of sand in E horizon					
	fine		medium		coarse	
0 – 6	ORKNEY	10	VASI	20	TAYSIDE	30
6 – 15	WAAISAND	11	LONGLANDS	21	VAALSAND	31
15 – 35	WALDENE	12	ALBANY	22	CHITSA	32
above 35			WINTERTON	13		

Underlying material is not specified, but is invariably gleyed.

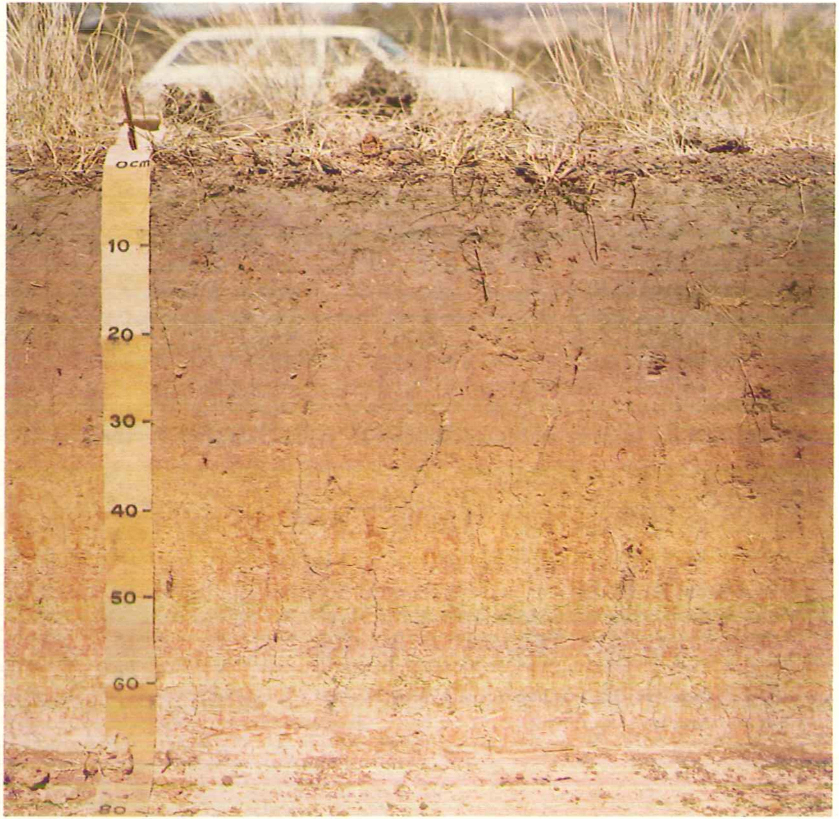
Correlation FAO

PLINTHIC GLEYSOLS (with albic horizon)

Correlation USDA

INCEPTISOLS – PLINTHAQUEPTS (Albic)
ALFISOLS – OCHRAQUALFS (Typic, Arenic, Aeric, Aeric-Umbric); UMBRAQUALFS (Typic); GLOSSAQUALFS (Typic, Aeric, Arenic)

WESTLEIGH FORM – We



ORTHIC A

SOFT PLINTHIC B

SOIL SERIES

Clay content of soft plinthic B (%)	Grade of sand in soft plinthic B					
	fine		medium		coarse	
0 – 6	CHINDE	10	KOSI	20	LANGKUIL	30
6 – 15	WESTLEIGH	11	WITSAND	21	PADDOCK	31
15 – 35	RIETVLEI	12	DEVON	22	DAVEL	32
above 35			SIBASA	13		

Note: The soft plinthic B horizon should have maximally developed soft plinthic character at its upper boundary with an A horizon, or with an A3 or B1 horizon (often dark brown in colour) that qualifies neither as a yellow-brown apedal nor as an E horizon. I't is common in other forms (Avalon, Longlands) to find some plinthic character in an overlying yellow-brown apedal B or E horizon, but then maximum plinthic character does not occur immediately below the topsoil diagnostic horizon. Permeability is usually low when soft plinthic character is not strongly expressed in a fine textured material.

Underlying material is not specified, but is invariably gleyed.

Correlation FAO

PLINTHIC ACRISOLS and
LUVISOLS (plinthic and
argilluvic horizons coincide)

Correlation USDA

ALFISOLS – PLINTHUSTALFS (Aquic);
PLINTHOXERALFS (Aquic)
INCEPTISOLS – PLINTHAQUEPTS

AVALON FORM – Av

ORTHIC A

YELLOW-BROWN
APEDAL
B

SOFT PLINTHIC
B

SOIL SERIES

Clay content of B21 horizon (%)	Grade of sand in B21 horizon	Dystrophic in B21 horizon		Mesotrophic in B21 horizon		Eutrophic in B21 horizon	
0 – 6	fine	MASTABA	10	HOBENI	20	VILJOENSKROON	30
	medium	WELVERDIEND	11	UITHOEK	21	MOOIVELD	31
	coarse	BANCHORY	12	ROSSDALE	22	MIDDELPOS	32
6 – 15	fine	ASHTON	13	VILLIERS	23	BLEEKSAND	33
	medium	KANHYM	14	LEKSAND	24	HEIDELBERG	34
	coarse	WOLWEBERG	15	NEWCASTLE	25	WINDMEUL	35
15 – 35	undifferentiated	RUSTON	16	AVALON	26	SOETMELK	36
above 35	undifferentiated	NORMANDIEN	17	BERGVILLE	27	BEZUIDENHOUT	37

Underlying material is invariably gleyed.

Correlation FAO

PLINTHIC LUVISOLS, FERRALSOLS
and ACRISOLS

Correlation USDA

ALFISOLS – PLINTHUSTALFS;
PLINTHOXERALFS
ULTISOLS – PLINTHUSTULTS; PLINTHUDULTS

GLENCOE FORM – Gc

ORTHIC A

YELLOW-BROWN
APEDAL
B

HARD PLINTHIC
B

SOIL SERIES

Clay content of B21 horizon (%)	Grade of sand in B21 horizon	Dystrophic in B21 horizon		Mesotrophic in B21 horizon		Eutrophic in B21 horizon	
0 – 6	fine	DRIEPAN	10	BOSKUIL	20	VLAKPAN	30
	medium	HARTOG	11	PENHOEK	21	RIBBLESDALE	31
	coarse	TRANENDAL	12	TALANA	22	KWEZANA	32
6 – 15	fine	KLIPSTAPEL	13	STRATHRAE	23	BEATRIX	33
	medium	WELTEVREDE	14	DUNBAR	24	LEEUDOORN	34
	coarse	DELMAS	15	WESSELSNEK	25	UITSKOT	35
15 – 35	undifferentiated	APPAM	16	GLENCOE	26	LESLIE	36
above 35	undifferentiated	SHOTTON	17	ONTEVREDE	27	GRASPAN	37

Underlying material is not specified, but is invariably gleyed.

Correlation FAO

Concretionary (hardened plinthite) phase of OCHRIC and EUTRIC CAMBISOLS

Correlation USDA

As for CLOVELLY form but having a lithic contact with hardened plinthite

PINEDENE FORM – Pn

ORTHIC A

YELLOW-BROWN APEDAL B

GLEYCUTANIC B

SOIL SERIES

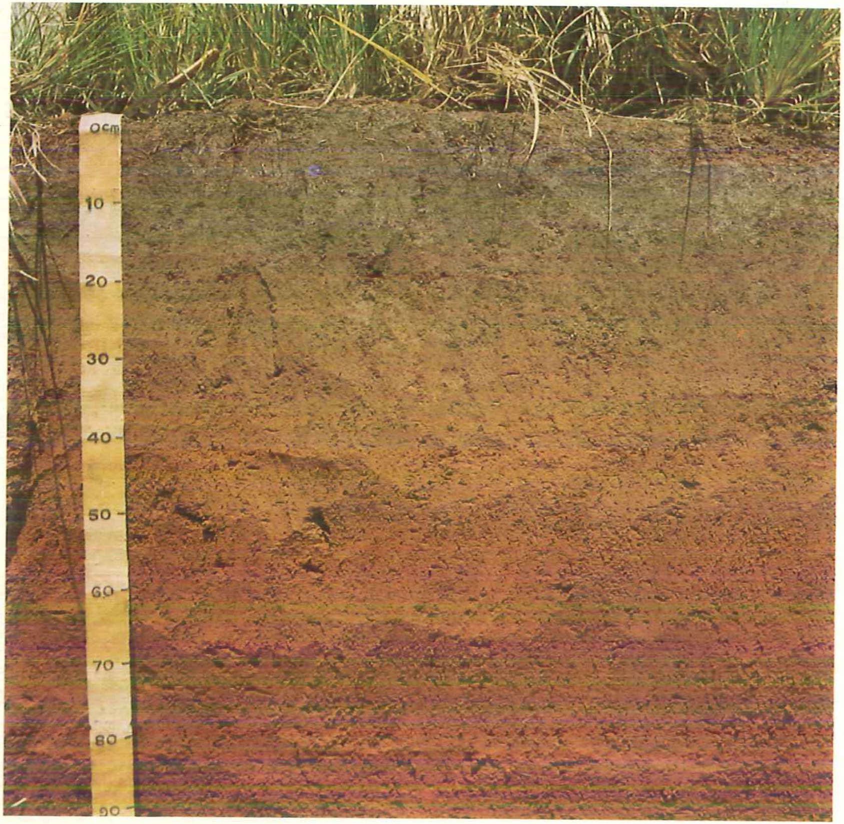
Clay content of B21 horizon (%)	Grade of sand in B21 horizon	Dystrophic in B21 horizon		Mesotrophic in B21 horizon		Eutrophic in B21 horizon	
0 – 6	fine	FORTUIN	10	ROTTERDAM	20	PAPIESVLEI	30
	medium	RADYN	11	WEMMERSHOEK	21	STORMSVLEI	31
	coarse	BETHLEHEM	12	HERMANUS	22	KLEINRIVIER	32
6 – 15	fine	GRAYMEAD	13	VYEBOOM	23	OEWER	33
	medium	PINEDENE	14	TULBAGH	24	NAGTWAGT	34
	coarse	EYKENDAL	15	CHATSWORTH	25	YZERSPRUIT	35
15 – 35	undifferentiated	OUWERF	16	SUURBRAAK	26	KLERKSDORP	36
above 35	undifferentiated	KILBURN	17	AIRLIE	27	WITPOORT	37

Underlying material is not specified, but is invariably gleyed. In this particular example soil excavated from the pit was dumped in such a way as to occupy the upper portion of the photograph.

Correlation FAO
GLEYIC LUVISOLS; GLEYIC ACRISOLS

Correlation USDA
ULTISOLS – AQUULTS
ALFISOLS – AQUALFS

GRIFFIN FORM – Gf



ORTHIC A

YELLOW-BROWN
APEDAL
B

RED APEDAL
B

SOIL SERIES

Clay content of B21 horizon (%)	Dystrophic in B21 horizon		Mesotrophic in B21 horizon		Eutrophic in B21 horizon	
6 – 15	BURNSIDE	10	ERFDEEL	20	RUNNYMEADE	30
15 – 35	CLEVELAND	11	UMZIMKULU	21	WELGEMOED	31
35 – 55	GRIFFIN	12	IXOPO	22	CRADOCK	32
above 55	FARMHILL	13	ZWAGERSHOEK	23	SLAGKRAAL	33

Underlying material is not specified, but is usually saprolite.

Correlation FAO

HELVIC ACRISOLS; HELVIC FERRALSOLS; EUTRIC and CHROMIC CAMBISOLS

Correlation USDA

ULTISOLS – PALEHUMULTS (Typic, Humoxic, Xeric)
OXISOLS – UMBRIORTHOX; HAPLUSTOX (Typic, Arenic)

CLOVELLY FORM – Cv

ORTHIC A

YELLOW-BROWN
APEDAL
B

SOIL SERIES

Clay content of B21 horizon (%)	Grade of sand in B21 horizon	Non-calcareous in B horizon						Calcareous in B horizon	
		Dystrophic in B21 horizon		Mesotrophic in B21 horizon		Eutrophic in B21 horizon			
0 – 6	fine	LISMORE	10	TWEEFONTEIN	20	SUNBURY	30	BLESKOP	40
	medium	GEELHOUT	11	SONNENBLOM	21	SANDSPRUIT	31	ORANJE	41
	coarse	LUNDINI	12	SEBAKWE	22	PALEISHEUWEL	32	THORNHILL	42
6 – 15	fine	VIDAL	13	OFAZI	23	ANNANDALE	33	VAALBANK	43
	medium	MOSSDALE	14	SPRINGFIELD	24	MAKUYA	34	TORQUAY	44
	coarse	SOWETO	15	GUTU	25	DENHERE	35	SKIPSKOP	45
15 – 35	undifferentiated	OATSDALE	16	SOUTHWOLD	26	BLINKKLIP	36	DUDFIELD	46
35 – 55	undifferentiated	CLOVELLY	17	NEWPORT	27	SUMMERHILL	37	KLIPPAN	47
above 55	undifferentiated	BALGOWAN	18	CLYDEBANK	28	KLIPPUTS	38	NELSPAN	48

Underlying material not specified. The yellow-brown apedal B horizon is permitted to have red mottles, but no other signs of gleying such as grey colours. Colour variegation due to faunal activity (earthworm casts, faecal pellets) is also permitted. In this particular example the underlying material is weathering fine grained micaceous sandstone.

Correlation FAO
Mainly OCHRIC, EUTRIC and CALCIC CAMBISOLS; HELVIC and OCHRIC FERRALSOLS but also some ARENOSOLS, RHEGOSOLS, XEROSOLS and ERMOSOLS

Correlation USDA
INCEPTISOLS – Typic XERUMBREPTS, HAPLUMBREPTS, DYSTROCHREPTS, USTOCHREPTS and XEROCHREPTS
OXISOLS – HAPLORTHOX; UMBRIORTHOX; HAPLUSTOX
ARIDISOLS – Typic CAMBORTHIDS; PALEORTHIDS; CALCIORTHIDS

BAINSVLEI FORM – Bv

ORTHIC A

RED APEDAL
B

SOFT PLINTHIC
B

SOIL SERIES

Clay content of B21 horizon (%)	Grade of sand in B21 horizon	Dystrophic in B21 horizon		Mesotrophic in B21 horizon		Eutrophic in B21 horizon	
0 – 6	fine	HLATINI	10	CHELSEA	20	DELWERY	30
	medium	MAKONG	11	VUNGAMA	21	KINGSTON	31
	coarse	CAMELOT	12	OOSTERBEEK	22	TREKBOER	32
6 – 15	fine	DUNKELD	13	ASHKELON	23	VERMAAS	33
	medium	WYKEHAM	14	REDHILL	24	KAREEKUIL	34
	coarse	TYGERKLOOF	15	MAANHAAR	25	WEDGEWOOD	35
15 – 35	undifferentiated	ELYSIUM	16	LONETREE	26	BAINSVLEI	36
above 35	undifferentiated	WILGENHOF	17	METZ	27	OTTOSDAL	37

Underlying material is invariably gleyed.

Correlation FAO

PLINTHIC FERRALSOLS, ACRISOLS
and LUVISOLS

Correlation USDA

OXISOLS – PLINTHAQUOX
ULTISOLS – PLINTHUSTULTS
ALFISOLS – PLINTHUSTALFS; PLINTHOXERALFS

HUTTON FORM – Hu

ORTHIC A

RED APEDAL
B

SOIL SERIES

Clay content of B21 horizon (%)	Grade of sand in B21 horizon	Non-calcareous in B horizon: Dystrophic in B21 horizon		Mesotrophic in B21 horizon		Eutrophic in B21 horizon		Calcareous in B horizon	
0 – 6	fine	ALLOWAY	10	WHITHORN	20	ROODEPOORT	30	LOWLANDS	40
	medium	ARNOT	11	JOUBERTINA	21	GAUDAM	31	NYALA	41
	coarse	STONELAW	12	CHESTER	22	MORIAH	32	QUAGGAFONTEIN	42
6 – 15	fine	WAKEFIELD	13	LICHTENBURG	23	MANGANO	33	MAITENGWE	43
	medium	MIDDELBURG	14	CLANSTHAL	24	ZWARTFONTEIN	34	MALONGA	44
	coarse	KYALAMI	15	BONTBERG	25	PORTSMOUTH	35	VERGENOEG	45
15 – 35	undifferentiated	HUTTON	16	MSINGA	26	SHORROCKS	36	SHIGALO	46
35 – 55	undifferentiated	FARNINGHAM	17	DOVETON	27	MAKATINI	37	HARDAP	47
above 55	undifferentiated	BALMORAL	18	VIMY	28	MARIKANA	38	MINHOOP	48

Underlying material not specified. Colour variegation due to faunal activity (earthworm casts, faecal pellets) is permitted in the red apedal B. Shallow red apedal materials overlying hard rock, hard plinthite, calcrete, silcrete or dorbank are classified in Hutton and not in Mispah form.

Correlation FAO

Mainly RHODIC and HELVIC FERRALSOLS and ARENOSOLS, but also some CAMBISOLS, XEROSOLS and ERMOSOLS

Correlation USDA

OXISOLS – Typic, Plinthic and Arenic EUTRUSTOX, HAPLUSTOX, EUTRORTHOX, HAPLORTHOX and UMBRIORTHOX
INCEPTISOLS – Typic XERUMBREPTS, HAPLUMBREPTS, DYSTROCHREPTS, USTOCHREPTS, XEROCHREPTS
ARIDISOLS – CAMBORTHIDS (Typic, Duric); PALEORTHIDS (Typic); CALCIORTHIDS (Typic)
ENTISOLS – PSAMMENTS; ORTHENTS (Lithic)
ULTISOLS – HAPLOXERULTS

SHORTLANDS FORM – Sd

ORTHIC A
RED STRUCTURED B

SOIL SERIES

Clay content of B21 horizon (%)	Non-calcareous in B horizon				Calcareous in B horizon	
	Mesotrophic in B21 horizon		Eutrophic in B21 horizon			
15 – 35	BOKUIL	10	KINROSS	20	FERRY	30
35 – 55	ARGENT	11	GLENDALE	21	SUNVALLEY	31
above 55	RICHMOND	12	SHORTLANDS	22	TUGELA	32

Underlying material is not specified, but is commonly basic igneous rock (saprolitic). Shallow red structured materials are classified in Shortlands and not in Mispah form.

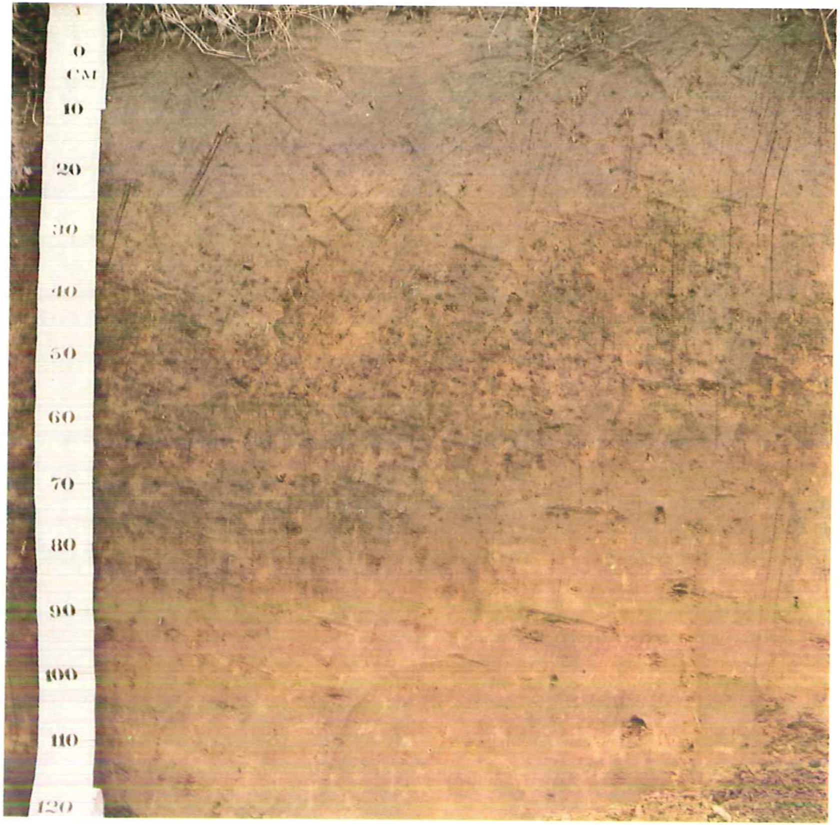
Correlation FAO

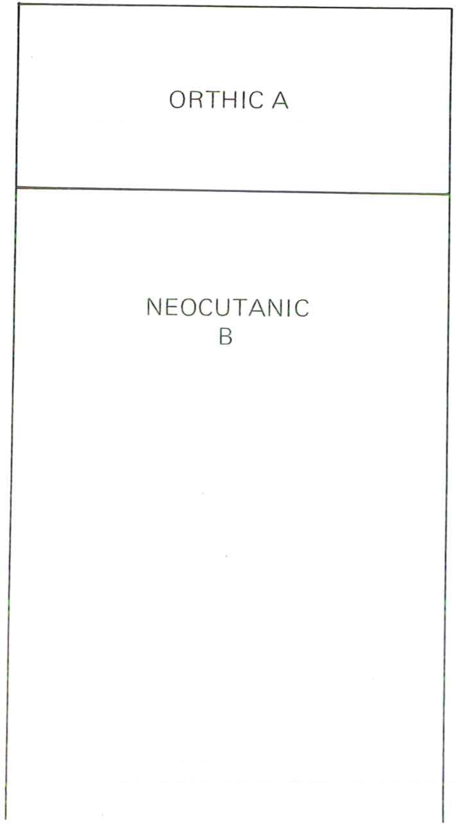
CHROMIC, FERRIC and RHODIC LUVISOLS

Correlation USDA

ALFISOLS – RHODOXERALFS (Typic, Oxic); PALEXERALFS (Ultic); HAPLOXERALFS (Typic, Mollic, Ultic); RHODUSTALFS (Typic, Udic); PALEUSTALFS (Typic, Udic, Ultic); HAPLUSTALFS (Typic, Udic)

OAKLEAF FORM – Oa





SOIL SERIES

Clay content of B horizon (%)	Grade of sand in B horizon	B horizon colours predominantly red				B horizon colours predominantly non-red			
		Non-calcareous in and immediately below B horizon		Calcareous in or immediately below B horizon		Non-calcareous in and immediately below B horizon		Calcareous in or immediately below B horizon	
0 – 6	fine	SMALDEEL	10	WARRENTON	20	OAKLEAF	30	VOORSPOED	40
	medium	MADWALENI	11	DOORNLAAGTE	21	OSHIKANGO	31	LOVEDALE	41
	coarse	MBANYANA	12	HOLPAN	22	SEZELA	32	NAULILA	42
6 – 15	fine	KLIPPLAAT	13	KIRKTON	23	VAALRIVER	33	ALLANRIDGE	43
	medium	ROCKFORD	14	MAGERSFONTEIN	24	LEVUBU	34	OKAVANGO	44
	coarse	POLLOCK	15	HAZELWOOD	25	VENDA	35	CALUEQUE	45
15 – 35	undifferentiated	LEEUFONTEIN	16	LETABA	26	JOZINI	36	LIMPOPO	46
above 35	undifferentiated	HIGHFLATS	17	MAKULEK	27	KOEDOESVLEI	37	MUTALE	47

Note: Red colours are those defined for the red apedal B horizon. Non-red colours are usually brown. Very dark colours are sometimes encountered, both red and, more typically, non-red. Series with such dark coloured neocutanic B horizons can be differentiated by means of the phase.

Underlying material is unconsolidated (see definition of neocutanic B horizon). The thickness (which must always exceed 500 mm) of unconsolidated, non-saprolitic material between the B and saprolite or rock can be used to distinguish phases.

Correlation FAO
OCHRIC, EUTRIC and CALCIC CAMBISOLS; HAPLIC and CALCIC XEROSOLS and ERMOSOLS; OCHRIC SOLONCHAKS

Correlation USDA
INCEPTISOLS – Various OCHREPTS and UMBREPTS
ARIDISOLS – CALCIORTHIDS; CAMBORTHIDS; SALORTHIDS; PALEORTHIDS

FERNWOOD FORM – Fw

ORTHIC A

REGIC SAND

SOIL SERIES

Grade of upper regic sand	Sand of normal topography lacking marked wetness				Wet sands of flat or depression topography			
	Acid		Neutral to alkaline		Acid		Neutral to alkaline	
fine	MAPUTA	10	MOTOPI	20	SHASHA	30	BRINLEY	40
medium	FERNWOOD	11	LANGEBAAN	21	WARRINGTON	31	SOETVLEI	41
coarse	SANDVELD	12	SALDANHA	22	TRAFALGAR	32	MAMBONE	42

Note 1: Wet sands usually have a watertable and abnormal accumulation of organic material at the surface.

Note 2: Acid means a pH value (measured in 1 mol/ℓ KCl) of less than 6,6 in the A horizon in the natural state.

Underlying material is not specified. Lamellae, not always present in regic sands, are present in this particular example.

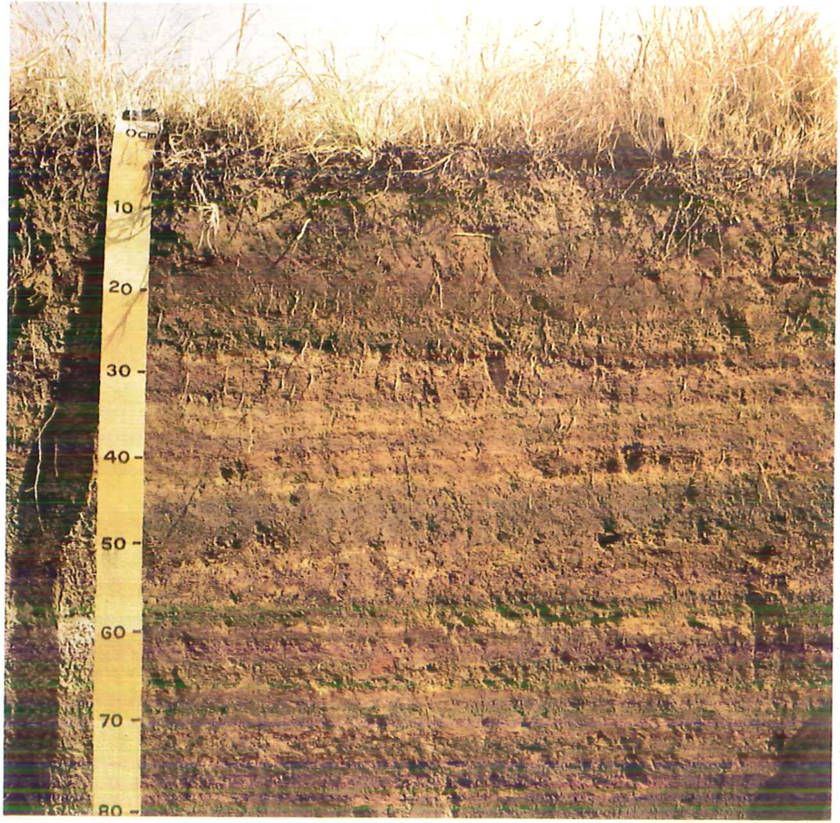
Correlation FAO

DYSTRIC and EUTRIC RHEGOSOLS;
OCHRIC and HUMIC GLEYSOLS
(coarse textured in all cases);
ARENOSOLS

Correlation USDA

ENTISOLS – PSAMMAQUENTS (Typic, Mollic);
QUARTZIPSAMMENTS (Typic); TORRIPSAMMENTS
(Typic); USTIPSAMMENTS (Typic, Alfic);
XEROPSAMMENTS (Typic, Alfic)

DUNDEE FORM – Du



ORTHIC A

STRATIFIED ALLUVIUM

SOIL SERIES

The form contains only one series, namely DUNDEE 10. Phases should be recognized on the basis of texture.

Underlying material not specified.

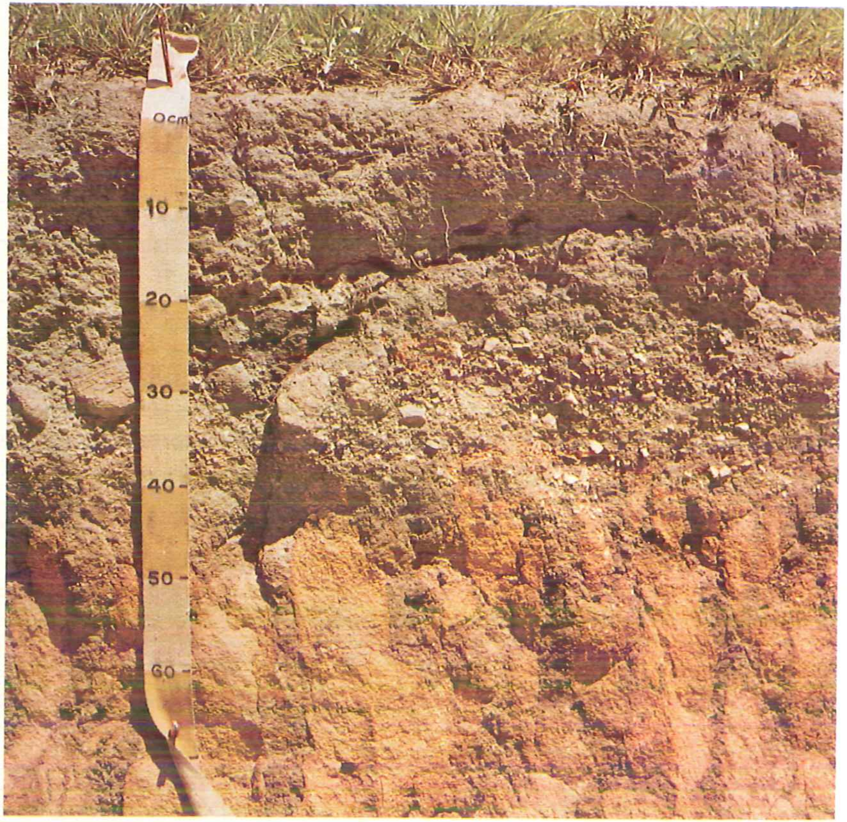
Correlation FAO

EUTRIC, CARBONATIC and possibly DYSTRIC and GLEYIC FLUVISOLS

Correlation USDA

ENTISOLS – TORRIFLUVENTS; UDIFLUVENTS; USTIFLUVENTS; XEROFLUVENTS
ARIDISOLS – CALCIORTHIDS; SALORTHIDS

GLENROSA FORM – Gs



ORTHIC A

LITHOCUTANIC
B

SOIL SERIES

Clay content of A horizon (%)	Grade of sand in A horizon	Non-calcareous in and immediately below B horizon		Calcareous in or immediately below B horizon	
0 – 6	fine	MARTINDALE	10	MALGAS	20
	medium	ORIBI	11	MAJENG	21
	coarse	PAARDEBERG	12	KNAPDAAR	22
6 – 15	fine	KANONKOP	13	SOUTHFIELD	23
	medium	PLATT	14	DUNVEGAN	24
	coarse	GLENROSA	15	LOMONDO	25
15 – 35	fine	WILLIAMSON	16	LEKFONTEIN	26
	medium	TREVANIAN	17	DOTHOLE	27
	coarse	ROBMORE	18	ACHTERDAM	28
above 35	undifferentiated	SAINTFAITHS	19	PONDA	29

Underlying material is saprolite grading into rock which, in this example, is granite.

Correlation FAO

OCHRIC, EUTRIC and CALCIC CAMBISOLS; HAPLIC XEROSOLS (lithic phases common)

Correlation USDA

INCEPTISOLS – EUTROCHREPTS; XEROCHREPTS (Ruptic, Lithic-Ruptic); USTOCHREPTS (Ruptic, Lithic-Ruptic); DYSTROCHREPTS (Ruptic, Lithic-Ruptic, Umbric); XERUMBREPTS (Ruptic, Lithic-Ruptic)
ARIDISOLS – CAMBORTHIDS (Ruptic, Lithic-Ruptic); HAPLARGIDS

MISPAH FORM – Ms

ORTHIC A

HARD ROCK
(in this illustration)
HARDPAN FERRICRETE
HARDPAN CALCRETE
HARDPAN SILCRETE
or
DORBANK

SOIL SERIES

Material underlying A horizon	Non-calcareous in A horizon		Calcareous in A horizon	
Hard rock	MISPAH	10	MUDEN	20
Hardpan ferricrete	KLIPFONTEIN	11	HILLSIDE	21
Hardpan calcrete	LOSKOP	12	KALKBANK	22
Hardpan silcrete	PLETTENBERG	13	MISGUND	23
Dorbank	WINCHESTER	14	VREDENDAL	24

Note 1 : Phases should be recognised on the basis of texture of A horizon material.

Note 2 : Hardpan ferricrete is non-diagnostic hard plinthite.

Note 3 : Hardpan calcrete is a superficial limestone formed by the cementation of soil, sand or gravel by calcium carbonate. The lower part of calcrete is often soft and porous while the upper layers are hard.

Note 4 : Hardpan silcrete is a superficial rock formed by the cementation of soil, sand or gravel by silica.

Note 5 : See glossary for description of dorbank.

Correlation FAO

LITHOSOLS; lithic, concretionary (ironstone), petrocalcic and duripan phases of CALCIC ERMOSOLS, CALCIC XEROSOLS, RHEGOSOLS and SOLONCHAKS

Correlation USDA

ENTISOLS – Lithic and Leptic – Lithic TORRIORTHENTS, XERORTHENTS, USTORTHENTS, UDORTHENTS, TORRIPSAMMENTS, XEROPSAMMENTS, USTIPSAMMENTS and QUARTZIPSAMMENTS; Plinthic ORTHENTS and PSAMMENTS

INCEPTISOLS – XEROCHREPTS (Entic – Lithic); DUROCHREPTS (Entic – Lithic)

ARIDISOLS –DURORTHIDS and PALEORTHIDS

Outline of Diagnostic Horizons and of Classes in the Highest Categories of the USDA[1] and FAO[2] Soil Classification Systems

THE INTENTION is that this section will assist local soil users to orientate themselves with respect to two important systems of classification. The USDA and FAO correlations given in Chapter 4 are in terms of categories lower (ie they describe soils in more detail) than those presented here.

DIAGNOSTIC HORIZONS

Mollic epipedon (USDA), **melanic A horizon** (FAO)

A relatively thick, dark coloured surface horizon with at least 0,58% organic carbon, is not massive and hard when dry, has a base saturation of more than 50% with divalent cations dominant, and has less than 250 ppm of P_2O_5 soluble in 1% citric acid.

Umbric epipedon (USDA), **sombric A horizon** (FAO)

A surface horizon with base saturation less than 50%, otherwise the same as mollic.

Histic epipedon (USDA), **histic A horizon** (FAO)

An organic horizon that is saturated with water at some period of the year, unless artificially drained.

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1 Soil Survey Staff, 1960. Soil Classification – a comprehensive system (7th approximation). US Dept. Agriculture. Washington: US Govt. Printing Office, together with supplements to the system dated March, 1967 and September, 1968.

2 Dudal, R. 1968. Definitions of soil units for the soil map of the world. World Soil Resources Reports No. 33. Rome: World Soil Resources Office, FAO.

Ochric epipedon (USDA), **pallid A horizon** (FAO)

A surface horizon that is too light in colour, too low in organic carbon, or too thin to qualify as mollic, umbric or histic.

Argillic horizon (USDA), **argilluvic B horizon** (FAO)

A mineral subsurface horizon that is characterized by the illuvial accumulation of clay.

Natric horizon (USDA), **natric B horizon** (FAO)

A special kind of argillic horizon which has prismatic or, more commonly, columnar structure and more than 15% saturation with exchangeable sodium.

Spodic horizon (USDA), **spodic B horizon** (FAO)

A mineral subsurface horizon that is characterized by the illuvial accumulation of amorphous materials composed of aluminium and organic matter, with or without iron.

Cambic horizon (USDA), **cambic B horizon** (FAO)

A mineral subsurface horizon in the position of a B with too little evidence of illuviation to meet the requirements of the argillic/argilluvic or spodic horizons, but exhibits alteration and/or removal of mineral material as indicated by mottling or grey colours, removal of carbonates, or development of structure.

Oxic horizon (USDA), **oxic B horizon** (FAO)

A mineral subsurface horizon at least 300 mm thick with more than 15% clay, little or no weatherable primary minerals or 2:1 clays, and no water-dispersible clay; typical properties are the presence of 1:1 clays, hydrated oxides of iron and aluminium, a low CEC and small amounts of exchangeable bases.

Albic horizon (USDA), **albic E horizon** (FAO)

An horizon from which clay and free iron oxides have been removed to the extent that the colour of the horizon is determined primarily by the colour of the uncoated sand and silt particles.

Gleyic horizon (FAO)

An horizon within 500 mm of the surface with pronounced evidence of wetness as indicated by bluish colours and/or prominent mottling, and moist colours with a low chroma.

USDA SOIL ORDERS

Entisols are mineral soils which, apart from an ochric epipedon, have only the beginnings of diagnostic horizons.

Vertisols are mineral soils with more than 30% clay that have deep, wide cracks when dry and one or more of: gilgai, intersecting slickensides, wedge-shaped peds.

Inceptisols are mineral soils of humid areas with various diagnostic surface horizons, but no diagnostic subsurface horizon other than cambic.

Aridisols are mineral soils of arid areas with an ochric epipedon and without an oxic or spodic horizon; they may or may not have other diagnostic subsurface horizons.

Mollisols are mineral soils with a mollic epipedon overlying mineral material with a base saturation of more than 50%.

Spodosols are mineral soils with both an albic and a spodic horizon.

Alfisols are mineral soils, usually moist, with an ochric epipedon and an argillic horizon with medium to high base status.

Ultisols are mineral soils that have argillic horizons with a low base status.

Oxisols are mineral soils with an oxic horizon, but without a spodic or argillic horizon above the oxic.

Histosols are soils with a histic epipedon.

FAO SOIL UNITS

Lithosols have solid rock within 250 mm of the surface.

Histosols have a histic A horizon.

Vertisols have a fine texture and deep cracks when dry and one or more of: gilgai, intersecting slickensides, wedge-shaped peds.

Gleysols are excessively wet with a gleyic horizon; the only other diagnostic horizons permitted are an A horizon and a cambic B.

Podzols have a spodic B horizon.

Halosols have a natric B horizon and/or a high concentration of soluble salts.

Andosols are developed from vitric material and usually have a low bulk density; they are dominated by amorphous material and the only diagnostic horizons permitted are an A and a cambic B.

Ferralsols have an oxic B horizon.

Planosols have an E horizon abruptly overlying an argilluvic B and evidence of wetness in the subsoil.

Rendzinas have a relatively thin melanic A overlying calcareous material.

Chernozems have a black melanic A horizon and free lime in the subsoil; cambic and argilluvic B horizons are permitted.

Castanozems have a dark brown or dark grey melanic A horizon and free lime in the subsoil; cambic and argilluvic B horizons are permitted.

Phaeozems have a melanic A horizon but no free lime in the subsoil.

Xerosols are semi-desert soils with a pallid A horizon and a moderately saline and/or alkaline subsoil; they may have a cambic or argilluvic B.

Ermosols are desert soils with a weakly developed A horizon and a moderately saline and/or alkaline subsoil; they may have a cambic or argilluvic B.

Acrisols have an argilluvic B horizon with base saturation less than 35%.

Luvisols have an argilluvic B horizon with base saturation more than 35%; the subsoil is not saline.

Albisols have an albic E horizon and an argilluvic B horizon with spodic tendencies.

Cambisols have a pallid or sombric A horizon, and a cambic B.

Rankers have a sombric A horizon immediately overlying non-calcareous material; there is no diagnostic B horizon.

Arenosols are highly weathered with less than 15% clay and, apart from a pallid A, no diagnostic horizon.

Fluvisols are recent alluvial deposits with no diagnostic horizons other than a pallid A.

Rhegosols are non-alluvial unconsolidated materials with no diagnostic horizons other than a pallid A.

APPENDIX 2

Glossary of Terms

THIS PUBLICATION is meant to be of use to all who classify and map South African soils and to all who use soil maps and reports. Because certain soil properties are covariant, the classes in this classification are defined in terms of comparatively few properties. However, with time the character of each class will become more comprehensively defined in terms of many soil properties that chanced not to be chosen as diagnostic criteria, and which are important to a wide range of soil users. For these reasons the glossary is not confined to terms which appear in the body of this book. Extensive use has been made of definitions and explanations appearing in the Soil Survey Manual (US Dept. of Agriculture, Handbook No. 18, 1951), Glossary of Soil Science Terms (Soil Science Society of America, 1971), Soil and Water (D. Hillel. Academic Press, London, 1971), Soils of the Tugela Basin (J.J. van der Eyk, C.N. MacVicar and J.M. de Villiers. Natal Town and Regional Planning Commission, Pietermaritzburg, 1969), the 7th Approximation (USDA Soil Survey Staff. Soil classification – a comprehensive system. US Govt. Printing Office, Washington, 1960) and the report of the Second Terminology Committee of Commission I of the International Society of Soil Science (ISSS Bull. No. 48, 1975).

Acid soil – soil with pH$<$7. See reaction, pH.

Air-water permeability ratio – this is a measure of the stability of soil to water. A completely stable, porous material has a ratio of 1, while 20 roughly indicates the threshold of instability in soils.

Alkaline soil – soil with pH$>$7. See reaction, pH.

Allophane – a co-precipitate of silicon and aluminium which contains water, exchangeable ions and frequently iron and organic matter as impurities. Amorphous to X-rays, it is the major constituent of the colloidal fraction in certain soils derived from volcanic efflata and basic igneous rocks, and occurs to some extent in all soils. The composition and properties of allophane are variable, and naturally occurring allophanes of soils are difficult to isolate and study.

Alluvium – unconsolidated materials deposited in close proximity to streams and rivers through the agency of running water.

Aluminium toxicity – below pH 5 in many soils, aluminium compounds, mainly in exchangeable form, occur in quantities sufficient to harmfully affect sensitive plants.

Amendment, soil – a substance used to alter the properties of soil for the purpose of making it more suitable for a particular purpose. Examples are lime and gypsum. The term, fertiliser, is preferable for those amendments which provide elements essential for plant growth.

Ammonification – a biochemical process whereby ammoniacal nitrogen is released from nitrogen-containing organic compounds. Other things being equal: the process is slow at or below wilting point and rapid in moist and wet soils; it is more rapid in neutral to alkaline than in acid soils; as temperature rises from near-zero, the rate increases to a maximum somewhere in the range 40–60°C.

Amorphous compounds – this term is commonly used in soil science for compounds of aluminium, silicon and iron, amorphous to X-rays, highly reactive and believed to be largely responsible for the fixation of compounds of, for example, phosphorus, molybdenum and boron, and for the high buffer capacity of soils in which they occur. See allophane.

Angle of repose – this is the angle between the horizontal and the maximum slope that a soil assumes through natural processes.

Anion exchange capacity (AEC) – by virtue of their clay-size components (both inorganic and organic), most soils possess a positive electrical charge which is balanced by anions so that the system as a whole is electrically neutral (see cation exchange capacity). The anions so held represent a definite quantity known as the anion exchange capacity which may be expressed on a whole soil basis (me % soil) or on a clay basis (me % clay), the latter being calculated from me % soil and the clay content. Because many soils have a pH-dependent positive charge (the lower the pH the higher the charge) it is important to choose the pH at which the AEC is measured so as to serve the specific objective and then to quote this pH when presenting the results. See cation exchange capacity, soluble salts.

Anions – negatively charged ions, for example chloride (Cl^-), sulphate ($SO_4^{=}$), nitrate (NO_3^-), carbonate ($CO_3^{=}$), bicarbonate (HCO_3^-) and the hydroxyl ion (OH^-). See anion exchange capacity, soluble salts.

Anisotropic soil – a soil having different properties in different directions at any given point; the term is normally used in the context of hydraulic properties.

Apedal – see structure.

Association, soil – a number of defined and named taxonomic soil units, regularly geographically associated in a defined pattern. It is the principal soil mapping unit of small-scale maps. See maps (soil), map unit, catena, complex.

Available water capacity (AWC) – that part of the water which can be held by soil and that is readily absorbed by plant roots. In soils with a low soluble salt content it is conventionally taken to be the difference between field capacity and wilting point. However, all such water is not equally available: as the soil water content decreases, its matric potential also decreases and the greater is the energy needed to transport water into the root; hydraulic conductivity decreases with decreasing water content and consequently the slower is the rate of water movement towards the root. As the soluble salt concentration increases the osmotic potential of the soil water decreases and an increasing proportion of otherwise available water is rendered unavailable. Available water capacity is commonly expressed as a percentage of the dry mass of soil or as mm water per m depth of soil. See total available moisture capacity.

Base saturation percentage – the ratio S-value to cation exchange capacity expressed as a percentage.

Base status – see dystrophic, mesotrophic, eutrophic, base saturation percentage.

Beidellite – see smectites.

Biotite – see micas.

Buffer capacity – the capacity of soil to resist an induced change in pH. See amorphous compounds.

Bulk density, soil – the mass of dry soil per unit bulk volume. The bulk volume is determined before drying to constant mass at 105°C. Values range roughly from 1 000–1 800 kg/m^3.

Calcareous soil – soil with sufficient calcium carbonate or calcium-magnesium carbonate to effervesce visibly when treated with cold dilute hydrochloric acid.

Calcrete – see hardpan.

Capillary zone or fringe – the zone above a watertable in which water is held by capillary action.

Category, soil – one of the ranks or levels in a system of classification. Each such rank (eg form, series) contains one or more classes. The classes in one category are defined at roughly the same level of abstraction.

Catena – a sequence of soils of about the same age, derived from similar parent material, and occurring under similar macroclimatic conditions, but having different characteristics due to variation in relief and drainage. See association.

Cation exchange capacity (CEC) – by virtue mainly (silt can contribute to CEC) of their colloidal components (both inorganic and organic), most soils possess a negative electrical charge which is balanced by cations so that the system as a whole is electrically neutral (see anion exchange capacity). The cations so held by a soil represent a definite quantity and can be exchanged by other cations. This quantity is employed as a measure of cation exchange capacity which is given in terms of milli-equivalents (equivalents X 1 000) per 100 g of material (me %). CEC may be given for the whole soil (me % soil) or for the clay separate (me % clay), the latter being calculated from the me % soil and the clay content. Functional groups on surfaces of organic matter, clay and amorphous compounds tend to release protons at specific pH values and this is essentially the mechanism for pH-dependent cation exchange capacity in soils (the higher the pH, the higher the CEC). It is therefore important to choose the pH value at which CEC is measured so as to serve the specific objective, and then to quote this pH value when presenting the results. See cations, soluble salts.

Cations – positively charged ions, for example Ca^{++}, Mg^{++}, K^{+}, Na^{+}, H^{+}, Al^{+++}, NH_4^{+} and H_3O^{+}. The term exchangeable metal cations ordinarily refers to calcium, magnesium, potassium and sodium. See cation exchange capacity, soluble salts.

Cementation – see nodules, fragipan, hardpan, induration.

Chlorite – a clay mineral with structure similar to the smectites, but having an aluminium or magnesium hydroxide sheet situated between the 2:1 unit layers; structure is therefore often indicated as 2:1:1. It has negligible swelling properties.

Classification, soil – see discussion on map unit (of a soil map).

Class, soil – a definition in terms of each of the properties used to define soil (eg 15–35% clay, apedal, calcareous, etc). Hutton form is a class in the form category and Shorrocks series is a class in the series category. See map unit (of a soil map).

Clay – (i) Soil separate consisting of particles <0,002 mm in diameter; clay minerals, quartz and primary minerals, may be found in this separate. (ii) A soil texture class. See texture, separates.

Clay minerals – naturally occurring crystalline compounds of aluminium and silicon <0,002 mm in diameter. The term is often used in a more general sense in relation to soil and sediments, for a wide variety of crystalline and cryptocrystalline, clay-size inorganic materials, *inter alia* kaolinite, mica, the smectites, vermiculite, interstratified clay minerals, chlorite, amorphous compounds (of Fe, Al, Si) and the following crystalline oxides: gibbsite $Al(OH)_3$; diaspore α – AlOOH; boehmite γ – AlOOH; goethite α – FeOOH; lepidocrocite γ – FeOOH; hematite α – Fe_2O_3; maghemite γ – Fe_2O_3; quartz SiO_2.

Claypan – an horizon or layer that is considerably less permeable and more clayey than the material overlying it. Examples are the B horizons of duplex soils.

Clayskins – see cutans.

Coarse sand – (i) A soil separate consisting of particles 2,0–0,5 mm in diameter. (ii) A soil texture class (see texture) with coarse sand more than 20% of the sand fraction and fine sand less than 60% of the sand fraction.

Cobbles – see stones.

Codes – see symbols.

Colluvium – a deposit of soil and/or rock fragments accumulated at the base of slopes as a result of gravitational action.

Colour, soil – description of soil colour has been standardized through the use of Munsell notations (colour charts adapted for use with soils are available from Munsell Color Company, Inc., Baltimore 18, Md., USA). Accordingly colour is given in terms of a verbal description (eg yellowish brown) and the notation (eg 10YR 5/4), the latter being compounded from notations for hue (10YR), value (5) and chroma (4). Hue refers to the dominant spectral colour which is related to the dominant wavelength of the light. Value refers to the relative lightness of colour and is a function of the total amount of light. Chroma is the relative purity or strength of the spectral colour and increases with decreasing greyness. Colour usually varies with the moisture content of the soil. The moisture status (dry or moist) must always accompany colour description and the moist colour at least must always be given.

A mottled or variegated pattern of colours is common in many soil horizons. It may be the result of many processes *inter alia* hydromorphy, illuviation, biological activity, and rock weathering in freely drained conditions (ie saprolite). It is described by noting (i) the colour of the matrix and colour or colours of the principal mottles, and (ii) the pattern of the mottling. The latter is given in terms of abundance (few, common 2 to 20% of the exposed surface, or many), size (fine, medium 5 to 15 mm in diameter along the greatest dimension, or coarse), contrast (faint, distinct or prominent), form (circular, elongated-vesicular, or streaky) and the nature of the boundaries of the mottles (sharp, clear or diffuse); of these, abundance, size and contrast are the most important.

Complex, soil – a mapping unit used in soil surveys where two or more defined taxonomic units are so intimately mixed geographically that it is undesirable or impractical, in view of the scale being used, to separate them. See association.

Concretions – a nodule made up of concentric accretions. See nodule.

Consistence – the degree of cohesion or adhesion within the soil mass, or its resistance to deformation or rupture. When soil is dry its consistence is described as loose, soft, slightly hard, hard or very hard; when moist as loose, friable, slightly firm, firm or very firm; when wet, both in terms of stickiness (non-sticky, slightly sticky, sticky or very sticky) and plasticity (non-plastic, slightly plastic, plastic or very plastic).

Conversion factors

Concentration

$$\text{me/100 g} = \frac{\text{mg/kg} (\equiv \text{ppm})}{\text{equivalent mass x 10}}$$

1 me Ca^{++}/100 g	=	200,4 ppm = 5 mmol/kg = 401 kg/ha/150 mm (BD = 1 333 kg/m^3 or 1,333 g/cm^3)
1 me Mg^{++}/100 g	=	121,5 ppm = 5 mmol/kg = 243 kg/ha per 150 mm depth
1 me Na^{+}/100 g	=	230 ppm = 10 mmol/kg = 460 kg/ha per 150 mm depth
1 me K^{+}/100 g	=	391 ppm = 10 mmol/kg = 782 kg/ha per 150 mm depth
1 ppm P	=	2,0 kg/ha per 150 mm depth
1 me Ca^{++}/l	=	20,0 ppm = 0,5 mmol/dm^3 (1 dm^3 = 1 l)
1 me Mg^{++}/l	=	12,2 ppm = 0,5 mmol/dm^3
1 me Na^{+}/l	=	23,0 ppm = 1,0 mmol/dm^3
1 me K^{+}/l	=	39,1 ppm = 1,0 mmol/dm^3
1 me HCO_3^-/l	=	61,0 ppm = 1,0 mmol/dm^3
1 me $CO_3^=$/l	=	30,0 ppm = 0,5 mmol/dm^3
1 me $SO_4^=$/l	=	48,0 ppm = 0,5 mmol/dm^3
1 me Cl^-/l	=	35,4 ppm = 1,0 mmol/dm^3

Electrical conductivity

1 mS/m = 10 μmho/cm = 0,01 mmho/cm

Pressure

1 kPa = 0,01 bar = 0,00987 atm = 0,145 lb/in^2 = 0,102 m head of water

Miscellaneous

1% organic carbon = 1,72% organic matter (approx)

Area (ha) per cm^2 on a map $= \frac{(\text{map scale})^2}{10^8}$

1 ha soil 150 mm deep has mass 2×10^6 kg at bulk density 1 333 kg/m^3 or 1,333 g/cm^3

Covariant properties – certain properties vary consistently with one another and hence it is unnecessary to specify all such covariant properties in the definition of a class (eg a series) – one is sufficient and the others apply automatically; eg an horizon with free lime automatically has a pH value above 7 and an exchange complex fully saturated with metal cations.

Crotovina – a former animal burrow in a soil horizon that has been filled with organic matter or material from another horizon, or with material from the same horizon but with an altered structure. Also known as a pedotubule.

Crust – a surface layer on soils ranging in thickness up to about 25 mm which is much more compact, hard and brittle when dry, than the material immediately beneath it. See modulus of rupture.

Cutans – occur on the surfaces of peds or individual particles (sand grains, stones). They consist of material which is usually finer than and that has an organisation different to the material that makes up the surface on which they occur. They originate through depostion, diffusion or stress.

Deflocculation – (i) Separation of the individual components of compound particles (eg soil aggregates) by chemical and/or physical means. (ii) Causing the particles of the disperse phase of a colloidal system to become suspended in the dispersion medium. (iii) A high soluble salt content (a high electrolyte concentration) promotes flocculation in soils, whereas a low soluble salt content combined with a high sodium adsorption ratio favours deflocculation. See sodic soils.

Desert pavement – gravel accumulated at the soil surface after removal of the finer material by wind action.

Desert varnish – a glossy sheen or coating (mainly of Fe and Mn oxides) on stones and gravel in arid regions.

Dispersion ratio – this is measured by shaking a soil sample in water for a given time and measuring the proportion (expressed as %) of the total mass of particles less than 0,02 mm in diameter that remains in suspension. It is a measure of soil erodibility. Pre-treatment of the sample and the measurement procedure must be taken into account when evaluating results.

Dorbank – a hard to extremely hard layer of soil (subsoil) in certain soils of arid regions. It may simply be massive or it may be laminated (coarse or fine), the latter parallel to the soil surface. Samples studied to date do not soften on immersion in water. It may or may not be calcareous, or salty. Its colour is related to the soil in which it occurs. It is related to the duripan of other classification systems.

Drift – unconsolidated material deposited by geological processes in one place after having been removed from another.

Duplex soils – refers to soils with a relatively permeable topsoil abruptly overlying a very slowly permeable diagnostic horizon which is not a hardpan.

Duripan – an indurated horizon cemented at least in part by an agent, such as silica or an aluminium silicate, soluble in strong alkali. Duripans which also contain $CaCO_3$ often have high exchangeable sodium values. See dorbank.

Dystrophic – refers to soil that has suffered marked leaching, such that the sum of the exchangeable (as opposed to soluble) Ca, Mg, K and Na, expressed in me/100 g clay, is less than 5. The figure is calculated from the S-value and the clay content. Such soil is said to have a low base status.

Edaphic – (i) Of or pertaining to the soil. (ii) Resulting from or influenced by factors inherent in the soil or other substrate, rather than by climatic factors.

Electrical conductivity – this is measured in millisiemens/m (1 mmho/cm = 100 mS/m). It is a measure of the concentration of salts in solution. Low salinity irrigation waters have values less than 25 mS/m and high salinity irrigation waters have values greater than 75 mS/m. Water with an electrical conductivity of 1 mS/m contains about 0,1 me/litre cations and 0,1 me/litre anions or about 6,4 mg/litre dissolved salts.

Eluviation – removal of soil material in suspension or solution from a part of or from the whole of the soil profile. The term leaching is preferred for removal in solution. See illuviation.

Eutrophic – refers to soil that has suffered little or no leaching, such that the sum of the exchangeable (as opposed to soluble) Ca, Mg, K and Na, expressed in me/100 g clay, is more than 15. The figure is calculated from the S-value and the clay content. Such soil is said to have a high base status. The term is normally confined to non-calcareous soils.

Exchangeable sodium percentage (ESP) – the percentage of the cation exchange capacity of the soil (expressed in me/100 g soil) that is occupied by sodium (expressed in me/100 g soil). See sodium adsorption ratio, deflocculation.

Exchange capacity – see anion exchange capacity, cation exchange capacity, anions, cations.

Expansive soils – see swelling clays.

Ferrallitic – a term originating in Africa describing highly weathered soils characterised by a clay fraction SiO_2/Al_2O_3 molecular ratio of less than 1,3, a friable consistence and a low cation exchange capacity of the clay separate which predominantly consists of kaolinite and/or sesquioxides. Amorphous compounds are often present, as is gibbsite. Primary weatherable minerals are generally absent. Para-ferrallitic soils have a clay fraction SiO_2/Al_2O_3 ratio between 1,3 and 1,7; values of up to 2,0 are accepted in some quarters. Soils with diagnostic dystrophic (and some with mesotrophic) red and yellow-brown apedal B horizons are normally ferrallitic. See ferralsols, ferrisols.

Ferralsols – a term originating in Africa for ferrallitic soils with more than 20% clay and with a low silt/clay ratio; they have apedal structure and less than 50% base saturation.

Ferricrete – see hardpan.

Ferrisols – a term originating in Africa which refers to latosols slightly less weathered than ferralsols. Although, like ferralsols, they have SiO_2/Al_2O_3 ratios less than 2, and less than 50% base saturation, ferrisols have a structured B horizon, a higher silt/clay ratio and some primary weatherable minerals. The concept probably fits many mesotrophic members of Shortlands form and certain members of the Hutton and Clovelly forms that exhibit some pedality.

Ferruginous tropical soils – a class name originating in tropical pedology for soils generally similar to fersiallitic soils.

Fersiallitic – a term used in tropical pedology to describe soils less weathered than ferrallitic. The clay fraction SiO_2/Al_2O_3 ratio ranges from 1,7 (see ferrallitic) to about 2,3. The consistence is firmer (in fine textured soils) and the cation exchange capacity of the clay separate (which includes 2:1 layer clays) is higher than in ferrallitic soils. Some primary weatherable minerals are present. Many diagnostic eutrophic and mesotrophic red and yellow-brown apedal, and red structured B horizons are fersiallitic.

Field capacity – this is the water content of a freely draining soil that has been saturated with water in the field and allowed to drain for 2–3 days. At this point saturated flow has recently ceased and the redistribution of water within the soil owing to hydraulic gradients is very slow. It should preferably be measured on isotropic material. FC is used in the design and management of irrigation schemes and is not capable of very accurate definition. It is estimated in the laboratory as the amount of water contained in an undisturbed soil sample that has been saturated then drained to equilibrium at a pressure differential of 10 kPa (in sands) or 33 kPa (in loams and clays). It is commonly expressed as a percentage of the dry mass of soil or as mm water per m depth of soil. See available water capacity.

Fill – man-made deposits of geological, soil and diverse waste materials, or one or two of these.

Fine sand – (i) A soil separate consisting of particles 0,2–0,02 mm in diameter. (ii) A soil texture class (see texture) with fine sand more than 60% of the sand fraction.

Flocculation – see discussion of deflocculation.

Flow, unsaturated – the movement of water in soil that is not filled to capacity with water.

Flux – see hydraulic conductivity.

Form, soil – see discussion of soil forms in Chapter 2.

Fragipan – a natural subsurface horizon with high bulk density relative to the soil above, seemingly cemented when dry, but when moist showing a moderate to weak brittleness. The layer is low in organic matter, mottled, slowly or very slowly permeable to water, and usually shows occasional or frequent bleached cracks forming polygons. It is not found in calcareous material.

Gibbsite – crystalline aluminium hydroxide, $Al(OH)_3$.

Gilgai — the microrelief sometimes produced by swelling clays during prolonged expansion and contraction due to changes in moisture content; usually a succession of microbasins and microknolls in nearly level areas, or of microvalleys and microridges parallel to the direction of the slope.

Gley — a material that has been or is subject to intense reduction as a result of prolonged saturation with water. Grey, blue and green colours predominate, but stains of ferric and manganese oxides and hydrates (yellow, brown, red and black) may be present and indicate localized areas of better aeration. Grey colours are due to an absence of iron compounds; blue and green are due to the presence of ferrous compounds. Gleyed sands are friable and clays firm. See hydromorphy.

Gravel — consists of many pebbles each more than 2 mm and less than about 75 mm in diameter. See soil separates.

Gypsum — calcium sulphate ($CaSO_4.2H_2O$) occurs in some soils of arid regions. It is used to replace exchangeable sodium in saline-sodic and sodic soils.

Halloysite — a 1:1 aluminosilicate mineral similar in structure to kaolinite. Due to variations in hydration, halloysite has a variable inter-layer spacing: 7,4 A up to 10 A (10 A = 1 nm) compared with 7,2 A for kaolinite. Electron micrographs of well crystallized kaolinite show six-sided flakes, whereas halloysite typically shows tubular crystal shapes.

Halomorphic soils — are soils the properties of which are determined wholly or in part by the presence of neutral or alkali salts, or both.

Hardpan — a massive material enriched with and strongly cemented by sesquioxides, chiefly iron oxides (also known as ironpan, hard plinthite, ferricrete, *ouklip*, laterite, laterite hardpan and *ngubane*), silica (silcrete) or lime (calcrete). Ortstein hardpans are cemented with iron oxides and/or organic matter. Excluded from diagnostic hardpans are horizons that consist either of lumps of cemented material in a softer matrix, or of harder portions which cannot be cut with a spade and softer portions that can be cut with a spade. Calcrete or silcrete, which displays marked cutanic character immediately beneath a diagnostic orthic, melanic, humic or E horizon, becomes a diagnostic lithocutanic B. See nodules, induration and text definitions of soft plinthic B horizon and hard plinthic B horizon. See dorbank.

Heave — see swelling clays.

Hectorite — see smectites.

Horizon — unlike the layers in recent alluvium which are the result of simple deposition (see Dundee form), horizons have developed through processes (eg a fluctuating watertable) taking place within the soil. An horizon is bounded by air, hard rock or by soil material that has different characteristics.

Hydraulic conductivity (K) — this is the proportionality factor in Darcy's law as applied to the viscous flow of water in soil. It is the ratio of the flux (q = the volume of water flowing through a given cross-sectional area in given time) to the gradient, viz $K = q/\frac{\Delta H}{L}$.

In saturated soil K is mainly a function of the geometry of soil pore space; the hydraulic gradient is more or less constant throughout saturated, isotropic soil. Free water above soil brings about an increase in the flux owing to an increase in hydraulic gradient, but K in the saturated soil remains constant. As the soil dries to below saturation, K decreases because, at a given hydraulic gradient, the flux, on account of increasing resistance to flow, decreases. See potential.

Hydraulic gradient — is the driving force responsible for the movement of water in soils. It can be expressed as the head drop per unit distance in the direction of flow $\frac{(\Delta H).}{L}$

Hydromorphy — a process of gleying and mottling resulting from the intermittent or permanent presence of excess water. Hydromorphic soils display evidence of this process.

Hysteresis — the relation between matric potential and soil wetness can be obtained in *desorption* by subjecting a saturated sample to increasing suction and measuring the water content versus suction, or in *sorption* by wetting a dry sample while reducing suction. The equilibrium soil wetness at a given suction is greater in desorption than in sorption. This dependence of the equilibrium content and state of soil water upon the direction of the process leading up to it is called hysteresis.

Illuviation — deposition of soil material removed by percolating water from one part of the soil profile to another. See eluviation, cutans.

Infiltration — the downward entry of water into the soil. Infiltration rate is the maximum rate at which water can enter the soil under specified conditions, expressed in mm/unit time. Infiltration velocity is the actual rate at which water is entering the soil expressed in mm/unit time.

Induration — a brittle, hard consistence caused by cementing substances other than quartz and crystalline alumino-silicates. Common cementing agents are sesquioxides, lime and silica. Typically cementation is not altered by wetting. It may be continuous or discontinuous in an horizon. See hardpan.

Interstratified clay minerals — mica from which some of the K^+ cations have been removed by weathering and replaced by other, larger, hydrated cations such as H_3O^+, Ca^{++} and Mg^{++}. They are a mixture of mica and its weathering product, vermiculite, and have negligible swelling properties.

Ironpan — see hardpan.

Isotropic soil — soil having similar properties in different directions at any given point; the term is normally used in the context of hydraulic properties.

Kaolinite — a non-swelling clay mineral with a 1:1 crystal structure; ie each unit layer consists of one silicon-oxygen tetrahedral sheet and one aluminium oxide — hydroxide octahedral sheet. It has a CEC range of 5—10 me %. See halloysite.

Laterite/laterite hardpan — see hardpan, lateritic weathering.

Lateritic weathering — a term used to describe the process of soil formation which, in freely drained conditions, results in a loss of Ca, Mg, K, Na and silica and a relative accumulation of sesquioxides. It leads to the formation of fersiallitic and ferrallitic soils. Laterite hardpan is not the result of lateritic weathering, but of the absolute accumulation of sesquioxides (chiefly iron) in the zone of a fluctuating watertable.

Latosols – a general term in tropical pedology for soils that have reached a fairly advanced stage of lateritic weathering.

Leaching – removal of materials in solution from a part of or from the whole of the soil profile. See eluviation.

Leaching requirement – the fraction of irrigation water that must be leached through the root zone to maintain the soluble salt content at a specified level which is determined by the salt tolerance of the proposed crop. Since electrical conductivity is the usual measure of soluble salt concentration, the LR is defined as the ratio of the EC of the irrigation water to the EC of the saturation extract at the specified soluble salt level.

Lime – calcium carbonate, often termed "agricultural" or "calcitic" lime to distinguish it from dolomitic lime. Recognised liming materials contain at least 70% $CaCO_3 + MgCO_3$, while dolomitic lime contains at least 15% $MgCO_3$ and at least 70% $CaCO_3$ equivalent.

Lime requirement – the mass of lime, or the equivalent of other specified liming material, required to raise the pH of a given mass of soil to a desired value under field conditions.

Line of seepage – the free water surface of the zone of seepage.

Liquid limit – the minimum percentage (by mass) of moisture at which a small sample of soil will barely flow under a standard treatment. Synonymous with upper plastic limit.

Lithosols – shallow soils, often with weakly expressed morphology. The soil may contain rock fragments, and in many instances bedrock is exposed at the surface. A majority of soils in Mispah form, for example, are lithosols.

Litter layer – a layer of dead plant material upon the soil's surface.

Lower plastic limit – see plastic limit.

Macronutrients – chemical elements necessary in large amounts for the growth of plants. N, P, K, Ca, Mg and S are normally regarded as the macronutrients.

Made land – areas filled with earth, or with earth and trash mixed, usually by or under the control of man. Synonymous with fill.

Maps, soil – detailed maps are required to accommodate information that can only be shown at scales larger than 1:50 000. Generalized maps are prepared at 1:50 000 and smaller scales either as a result of properly executed surveys, or from reliable information contained on larger scale maps. Reconnaissance maps are prepared as a result of systematic field survey, such that the accuracy of boundaries on the resultant map is less than normally accepted on detailed and generalized maps of the same scale; reconnaissance surveys are usually undertaken either as a preliminary to further surveys or simply to provide a rough and fairly elementary account of the soils of a region. Schematic maps are prepared from scant knowledge of the soils of a region using *inter alia* available information about the nature of the soil forming factors in the region; map scales are usually small.

Map unit (of a soil map) — a description that defines the soil composition of land, identified by a symbol and a boundary on a map. When a soil class (eg a series) is used for such description, the procedure is soil mapping, not soil classification. Soil classification or identification is the placing of soil profiles in soil classes. A soil class contains only profiles of that class, whereas a soil map unit seldom, if ever, refers to land that contains profiles belonging only in one soil class. See association.

Margalitic — refers to A horizons that are dark coloured with a high base status, Ca and Mg being the predominant exchangeable cations.

Medium sand — (i) A soil separate consisting of particles 0,5—0,2 mm in diameter. (ii) A soil texture class (see texture) with coarse sand less than 20% of the sand fraction and fine sand less than 60% of the sand fraction.

me/100 g (me %) — see cation exchange capacity.

Mesotrophic — refers to soil that has suffered moderate leaching, such that the sum of the exchangeable (as opposed to soluble) Ca, Mg, K and Na, expressed in me/100 g clay, is 5—15. The figure is calculated from the S-value and the clay content. Such soil is said to have a medium base status.

Micas — are a group of minerals similar in structure to the smectites except that instead of large hydrated cations, the smaller K^+ cations are situated between the 2:1 unit layers. Examples of common micas are muscovite (di-octahedral; Al-rich) and biotite (tri-octahedral; Mg, Fe, Al-rich). See vermiculite, interstratified clay minerals.

Micronutrients — chemical elements necessary in small amounts for the growth of plants. B, Cl, Cu, Fe, Mn, Mo and Zn are normally regarded as micronutrients.

Mineralization — the transformation of organic forms of elements (particularly N, P, S) to inorganic forms.

Modulus of rupture — this is the stress (kPa) needed to rupture a briquette made by saturating a soil sample and drying it out. It is a measure of the tendency for soil to form crusts which may impede seedling emergence. Crusts with values greater than 80 kPa are likely to impede emergence in sensitive crops.

Moisture percentage — see water percentage, water content.

Montmorillonite — see smectites.

Mottling — see colour.

Muscovite — see micas.

Neutral soil — see reaction, pH.

Ngubane — see hardpan.

Nitrification — the biochemical oxidation of ammoniacal to nitrate nitrogen under conditions of good aeration. Other things being equal: the rate is highest between pH 7—8, falls off markedly below pH 6, and is usually negligible below pH 5. Lack of oxygen (eg in wet conditions) and lack of moisture suppress the process; the optimum temperature is in the range 30—35°C, and the process is very slow outside the range 5—40°C.

Nitrogen losses – (i) Losses, particularly of nitrate, by leaching can occur from sandy soil with a low exchange capacity. (ii) Non-biological volatilization of NH_3 is insignificant below pH 7, but may be appreciable above pH 8. Warm conditions favour the process. Losses are less marked in soils with high cation exchange capacities. (iii) Biological volatilization of N_2 in alkaline soils and N_2O in acid soils, known as denitrification, is the more important form of nitrogen loss. Losses are greatest from well drained and actively nitrifying soils which become poorly aerated temporarily during wet periods. A source of organic matter is essential. The transformation is slow at 2°C and is most rapid at 25°C or higher.

Nodules – bodies of various shapes, sizes and colour that have been hardened to a greater or lesser extent by chemical compounds such as lime, sesquioxides, animal excreta and silica. These may be described in terms of kind (durinodes, gypsum, insect casts, ortstein, iron-manganese, lime, lime-silica, plinthite, salts), abundance (few, less than 20% by volume percentage; common, 20–50%; many, more than 50%), hardness (soft, hard meaning barely crushable between thumb and forefinger, indurated) and size (threadlike, fine, medium 2–5 mm, coarse).

Nontronite – see smectites.

Ortstein – see hardpan, nodules.

Ouklip – see hardpan.

Parent material – the material from which soil is developed. One may speak of the parent material of an horizon, or of a number of horizons which constitute a profile, or even of stratified alluvium which although nearly identical to its parent material, has often undergone changes in organic matter content and base status.

Pebble – a somewhat rounded, smallish stone. See gravel.

Pedology – see soil science.

Pedon – see discussion on profile, soil.

Permeability, soil – generally, this refers to the ease with which gases, plant roots or, more usually, liquids penetrate or pass through a soil horizon. For penetration of water into the topsoil see infiltration. Intrinsic permeability is a property (measured quantitatively) of the porous medium itself that relates to the ease with which gases and liquids can pass through it. Unlike hydraulic conductivity, IP is independent of the density and viscosity of the permeating liquid.

pH – a measure of the activity of the hydrogen ions and is expressed as the negative logarithm to the base 10 of the hydrogen ion activity. Soil pH values can be up to 1,5 units lower when measured in 0,01 mol/ℓ (10 mmol/dm^3) $CaCl_2$ or 1mol/ℓ (1 000 mmol/dm^3) KCl suspensions than when measured in a water suspension. In the interests of standardization it is recommended that, for purposes of classification, 1 mol/ℓ KCl (1 part soil: 2,5 parts solution) be used.

Phreatic line – see line of seepage.

Phase, soil – a subdivision of a unit of classification (eg a series) made in order to distinguish properties (eg depth) important to the use and management of land.

Phosphate fixation – the process whereby readily soluble phosphorus compounds, when added to the soil, become changed to less soluble forms not readily available to the plant. It is a common phenomenon in ferrallitic soils. See amorphous compounds.

Piping or tunnelling, soil – accelerated erosion which results in subterranean voids and channels.

Plasticity index – see plasticity number.

Plasticity number – the numerical difference between the lower and upper plastic limits. Sometimes termed plasticity index.

Plastic limit – the minimum moisture percentage by mass at which a small sample of soil material can be deformed without rupture. Synonymous with lower plastic limit. Upper plastic limit is synonymous with liquid limit.

Podzolization – the mobilization in and removal from an A horizon of sesquioxides and/or organic matter, so giving rise to a highly leached, whitish E horizon. The process takes place typically in quartzose parent materials under a coniferous, coniferous-deciduous, macchia or heath vegetal cover. Lamotte form, a good example of a podzol, has an illuvial B horizon enriched with sesquioxides and organic matter.

Porosity – the volume percentage of the total bulk not occupied by solid particles.

Potential, soil-water – the potential energy owing to position or internal condition is of primary importance in determining the state and movement of water in soil. Differences in potential energy between one point and another give rise to the tendency for water to flow in the direction of decreasing potential energy. Soil water is subject to a number of force fields which cause its potential to differ from that of pure, free water. These fields result from *inter alia* the attraction of the solid matrix for water, as well as from the presence of solutes and the action of gravity; other contributors to these force fields would need to be mentioned in an exhaustive account of total soil-water potential. *Soil-water potential* (total potential) is the sum of the separate contributions of these factors: matric potential, osmotic potential and gravitational potential. Two points in soil at the same elevation and having the same salt concentration (ie gravitational and osmotic potential differences are excluded), but with different soil moisture contents, have different total potentials due to differences in matric potential. Matric potential is zero in saturated soil and increasingly negative with decreasing soil water content. In low soluble salt content soils it is about – 1 500 kPa (energy/unit volume) or – 1 500 joules/kg (energy/unit mass) at wilting point. See hydraulic conductivity.

Profile, soil – a concept which is defined by giving a single value to each property used to describe soil. The definition is made by sampling a vertical section of the soil mantle. Evaluation of some properties can be effected in a very small sample, while the evaluation of others (eg tonguing) requires a larger portion. Although the profile closely approaches real expression in a vertical section of the soil mantle, the latter, unlike the profile, displays a range of values for each property (eg clay percentage). Profiles are used as indices to the nature of the naturally occurring, fairly homogeneous bodies of soil which make up the soil mantle. A pedon (Soil Survey Staff, 1960. Soil classification

— a comprehensive system. 7th Approximation, USDA Washington) is the smallest volume that can be called "a soil". Therefore pedon would seem to be synonymous with the volume of soil that is needed to define a profile.

Quartz — crystalline silica, SiO_2.

Quick — a condition (eg in some sands) in which the bearing capacity of the material is markedly reduced by upward flowing water.

Reaction, soil — the degree of acidity or alkalinity of a soil, usually expressed in terms of pH value. Descriptive terms commonly used are: *strongly acid* pH $<$5,5; *moderately acid* pH 5,5–6,5; *neutral* pH 6,6–7,4; *moderately alkaline* pH 7,5–8,4; *strongly alkaline* pH $>$8,4. See pH.

Regolith — the unconsolidated mantle of weathered rock and soil material on the earth's surface; loose earth materials above solid rock.

Regosol — a general term for deep, unconsolidated, soft mineral deposits without definite genetic horizons.

Relative density — the relative density of the mineral particles of soil ranges roughly from 2,4–2,8. Previously known as specific gravity.

Rendzina — a dark coloured, commonly black, friable soil underlain by soft, highly calcareous material.

Resistance, electrical — this is measured (and expressed in ohms) on a saturated paste in a US Bureau of Soils cup. It is a rough but simply measured guide to the quantity of soluble salts in the soil.

Saline — sodic soils — these have a high soluble salt content of which sodium forms a high proportion, so that were the soil leached with a low salt content water, a sodic soil would be formed. See soluble salts, sodic soil, sodium adsorption ratio.

Saline soils — these have a high soluble salt content, of which sodium forms a small or moderate proportion, so that were the soil leached with a low salt content water, a sodic soil would not be formed. The term is sometimes used incorrectly in a general sense for soils with a high soluble salt content, irrespective of the nature of the salts; the term "salty soils" is preferred for the latter. See electrical conductivity, solonchak, salt-affected soil, soluble salts.

Salt — affected soil — soil that has been adversely modified for the growth of most crop plants by the presence of soluble salts, exchangeable sodium or both.

Salty soil — see discussion on saline soils.

Sand — (i) A soil separate consisting of particles 2,0–0,02 mm in diameter. (ii) A texture class. See texture, separates.

Saponite — see smectites.

Saprolite — weathering rock in various stages of decomposition. It has a general organization with respect to colour, structure or consistence which still has distinct affinities with the parent rock.

Saturated paste – a mixture of soil and water such that all the voids between the soil particles are filled with water while at the same time there is no accumulation of free water on the surface. The soil sample should preferably be crushed to pass a 2 mm sieve.

Saturation extract – the solution which is extracted under suction from a saturated paste.

Saturation percentage – the water held by a soil at saturation (ie in a saturated paste) expressed as a percentage of the dry mass of soil.

Self-mulching – a process of swelling and shrinking due either to alternate wetting and drying or to freezing and thawing, which gives rise to a surface layer of well aggregated granules or fine blocks that does not crust.

Separates, soil – mineral particles < 2,0 mm in diameter, ranging between specified limits.

The names and size limits used in this classification are: *coarse sand* 2,0–0,5 mm; *medium sand* 0,5–0,2 mm; *fine sand* 0,2–0,02 mm; *silt* 0,02–0,002 mm; *clay* <0,002 mm.

USDA equivalents are: *very coarse sand* 2,0–1,0 mm; *coarse sand* 1,0–0,5 mm; *medium sand* 0,5–0,25 mm; *fine sand* 0,25–0,10 mm; *very fine sand* 0,10–0,05 mm; *silt* 0,05–0,002 mm; *clay* <0,002 mm.

International Society of Soil Science equivalents are: (i) *coarse sand* 2,0–0,2 mm; (ii) *fine sand* 0,2–0,02 mm; (iii) *silt* 0,02–0,002 mm; (iv) *clay* <0,002 mm.

British Standards (BS 1377:1967 for civil engineering) equivalents are: *coarse sand* 2,0–0,6 mm; *medium sand* 0,6–0,2 mm; *fine sand* 0,2–0,06 mm; *coarse silt* 0,06–0,02 mm; *medium silt* 0,02–0,006 mm; *fine silt* 0,006–0,002 mm; *clay* <0,002 mm.

S. African Dept. of Transport (Standard methods of testing materials) equivalents are: as for British Standards, except that the clay limit is 0,005 mm, thus virtually eliminating the fine silt fraction.

Series, soil – see discussion of soil series in Chapter 2.

Sesquioxide – a binary compound of a metal and oxygen in the proportion of 2 to 3, as in Al_2O_3, Fe_2O_3. "Sesquioxides" is also used generally to describe free iron and aluminium (and, to a lesser extent, manganese) oxides in soils.

Silcrete – see hardpan.

Silt – (i) A soil separate consisting of particles 0,02–0,002 mm in diameter. (ii) A soil texture class. See texture, separates.

Slickensides – refer here to polished or grooved surfaces within the soil resulting from part of the soil mass sliding or moving against adjacent material along a plane which defines the extent of the slickenside. They occur only in clayey materials with a relatively high smectite content.

Smectites – are a group of minerals that are made up of unit layers, each layer consisting of two silicon-oxygen tetrahedral sheets enclosing one aluminium-oxygen (or hydroxyl) octahedral sheet (ie a 2:1 unit layer). The layers are continuous in the a and b directions and are stacked one above the other in the c direction. Cations that are large on account of hydration (eg Ca^{++}) are situated between the 2:1 unit layers. Water and other polar molecules can enter between the unit layers causing the lattice to expand in the c direction. Members of the group include di-octahedral montmorillonite (Mg-rich), beidellite (Al-rich) and nontronite (Fe-rich), and tri-octahedral hectorite (Mg, Li-rich) and saponite (Mg-rich). CEC ranges from 80–100 me % and surface area ranges from 600–800 m^2/g. See sodium adsorption ratio.

Sodic soils — these have a low soluble salt content but sufficient adsorbed sodium to have caused significant deflocculation. See soluble salts, sodium adsorption ratio, deflocculation, saline-sodic soils.

Sodium adsorption ratio (SAR) — this is a measure of the quality of salts in solution (eg in a saturation extract, an irrigation water).

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

where Na, Ca and Mg are expressed in me/l.

The SAR of a soil saturation extract is approximately equal to the ESP of the soil. In smectitic soils deflocculation can commence at fairly low SAR values (6–8), while in other soils deflocculation commences at higher values. Although a soil solution tends to take on the SAR of its irrigation water, the SAR of the former can become higher than that of the latter due to salt precipitation (eg of $CaCO_3$, $MgCO_3$) and to concentration as a result of evapotranspiration. SAR values less than 3 indicate a very good quality irrigation water.

Soil — (i) Broadly, soil (or the pedological sphere of interest) denotes that part of the geological sphere of interest which concerns weathered rock or unconsolidated sediments with properties attributable to the interaction of parent material, time, climate, topography, *fauna* and *flora* at the sites where these materials occur at present. (ii) More specifically, soil denotes that part of the pedological sphere of interest which is circumscribed by a classification (MacVicar, C.N., 1969. A basis for the classification of soil. J. Soil Sci. 20, 141-152).

Soil science — the science which deals with soil as a natural phenomenon on the surface of the earth, including soil formation, classification and mapping, and the physical, chemical and biological properties of soils *per se*, and these properties in relation to land management (hitherto mainly agricultural land management). Soil science would seem therefore to span the fields of pedology and applied pedology.

Solifluction — the slow, viscous, downslope flow of waterlogged soil.

Solonchak — a friable salty soil commonly with a thin, salty crust at the surface.

Solonetz — a soil with a thin, porous topsoil underlain by a columnar, usually sodic horizon.

Soluble salts — these are salts present in soil which have solubility in water greater than calcium carbonate and which are not neutralizing positive and negative charges on the exchange complex (see cation exchange capacity and anion exchange capacity). Soluble salt content has not been used as a differentiating criterion in this classification because it is very easily changed by management. Sodium salts, particularly NaCl, are the most common soluble salts in South African soils. The salt tolerance of crops varies, some being adversely affected when the electrical conductivity of the saturation extract is in the region of 200 mS/m (≡ 2 mmhos/cm); a large number of crops is adversely affected when the figure is 400 mS/m or higher. See saline soils, saline-sodic soils, deflocculation, resistance, electrical conductivity.

Specific gravity, soil — see relative density.

Sticky point (or limit) — the lowest soil water content at which a soil sticks to a metal blade when drawn across the surface of the soil mass.

Stoneline — a concentration of stones, boulders, gravels or concretions (or mixtures of these) which occurs in the soil and appears in profile as a horizontally disposed line or layer.

Stones — fragments larger than about 75 mm in diameter. The term "cobbles" has been used for fragments 75—250 mm in diameter.

Stoniness — this should be described in soils in terms of abundance (few, less than 20% by volume percentage; common, 20—50%; many, more than 50%), size (small, medium 20—100 mm, large) and shape (rounded, angular).

Structure, soil — refers to a natural aggregation of primary soil particles into compound units or peds which are separated from one another by planes or surfaces of weakness. Cohesion within peds is greater than adhesion between them. Concretions are distinct from peds in that they are units cemented by localized concentrations of substances such as iron oxides and lime. Field description of structure involves qualifying terms for *type* (shape and arrangement), *size* and *distinctness* of the visible peds. There are four primary types of structure, viz blocky (vertical and horizontal dimensions roughly equal and each unit bounded by flat or rounded surfaces which are casts of the moulds formed by faces of adjoining peds), spheroidal or polyhedral (as for blocky, but surfaces curved and very irregular so that adjoining peds are not neatly accommodated), prismlike (vertical exceeds horizontal dimensions), and platy (horizontal dimensions exceed vertical). Blocky structures are subdivided into angular and subangular types, prisms into prismatic (flat tops) and columnar (rounded tops), and spheroidal into granular (relatively non-porous) and crumb (porous). Five size classes are recognised of which *three* are more commonly used, viz very fine, *fine, medium, coarse* and very coarse. Medium platy has a thickness of 2—5 mm, medium prismatic and medium columnar a cross-section of 20—50 mm, medium blocky a cross-section of 10—20 mm, and medium granular and medium crumb a cross-section of 2—5 mm. Four terms describe distinctness or degree of aggregation. These are: structureless, with no observable aggregation and no orderly arrangement of natural lines of weakness as in a sand (massive if coherent, single grain if non-coherent); weak where peds are indistinct and poorly formed, being barely observable in place; moderate where peds are well formed and durable, but not distinctly separate from one another in undisturbed soil; strong where peds are well formed and durable and distinctly separate from one another in undisturbed soil. The term apedal is used in general to denote materials that are well aggregated although well formed peds cannot be detected macroscopically. Highly weathered materials, by virtue of their mineralogical composition (predominantly kaolinite with free crystalline and amorphous oxides and hydrates of iron and aluminium), develop a characteristic micro-aggregate or micro-crumb structure that is not clearly visible to the unaided eye. However, the term apedal is also used in this classification in connection with two diagnostic horizons, namely *red apedal B horizon* and *yellow-brown apedal B horizon*, to refer to a range of structure covering structureless (as in sands), apedal as defined above and structure that is weaker than moderate blocky or prismatic in the moist state. It may have been more satisfactory to have used clay mineral data, with or without soil structure, as differentiae. However, there is presently neither the information to set up the limits nor the means to identify, on a routine basis, the mineral composition of soils. In red and yellow-brown soils it would seem, tentatively, that dystrophic (and often mesotrophic) diagnostic apedal B horizons have CEC values of less than 30 me/100 g clay and usually less than 20 me/100 g clay, whereas most diagnostic structured B horizons have CEC values greater than 30 me/100 g clay and usually greater than 40 me/100 g clay. Coarse textured apedal materials can have relatively high CEC values per 100 g clay. The air-water permeability ratios of red and yellow-brown apedal horizons are usually below 10, whereas diagnostic red structured B horizons have values above 10 (usually above 20) but below 100.

S-value – sum of exchangeable (as opposed to soluble) Ca, Mg, Na and K, expressed in me/100 g soil.

Swelling clays – refer either to clay minerals such as the smectites that exhibit interlayer (≡interlamellar) swelling when wetted, or to clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried. The latter are also known as soils which heave.

Symbols – Soil series are a means of facilitating communication about soil. However, there often occur instances where a certain feature of the soil (eg stoniness at the surface, the nature of the underlying material, etc) is not defined and hence not communicated by a series. It is sometimes necessary, for example when mapping, to codify soil series (eg the code for Clovelly series is Cv 17) and thus far conflicting symbols have been used by different workers to communicate features additional to the soil series. The following list of symbols is designed to eliminate much of this conflict and promote better communication about soil. The basic unit of the code is the series, for example Cv 17. Symbols which describe features either on top of the soil (eg stones) or in the diagnostic topsoil horizon are placed before the series code in the vertical sequence of their occurrence, beginning with the uppermost feature. Symbols which describe features that occur below the topsoil diagnostic horizon are placed after the series code, again beginning with the uppermost feature. The symbol of a feature which forms the boundary between the topsoil diagnostic horizon and the soil beneath is placed immediately before the series code. Such codification is not a general requirement for soil classification. In the event of it being necessary to codify, the extent to which these additional features are added to the series code is dictated by the objectives of the particular survey. Unnecessary codification should be avoided. The following unusually detailed code illustrates the method of codification: srahCv17gvUkoHsc refers to Clovelly series with a stony (rounded) surface, an orthic diagnostic topsoil horizon unusually rich in organic matter, with a gravelly profile, overlying unconsolidated colluvium which, in turn, overlies a hypabyssal silicic rock. Note that Clovelly series has an orthic diagnostic topsoil horizon and so the symbol ah in the above code cannot mean a *diagnostic* humic topsoil horizon; it indicates humic character insufficient to qualify as diagnostic humic. Secondly, these symbols may be used in a different way in the margin of a profile description to indicate to the reader the nature of the horizons described. Thus B2rh indicates a B2 horizon with ferrihumic character which may or may not qualify as a diagnostic ferrihumic B.

General symbols

ag — illuvial horizon developed as a result of cultivation.
ah — topsoil with an unusually high content of humified organic matter; it does not overlie gleyed material.
al — alluvial material.
ba — bauxite.
bu — buried horizon.
ca — an accumulation of carbonates of alkaline earths, commonly of calcium.
Cl — clay.
cn — an abundance of sesquioxide-rich hard concretions or nodules.
co — coarse.
cs — an accumulation of calcium sulphate.
db — dorbank.
df — dystrophic.
ef — eutrophic.
eo — aeolian material.
fi — fine.
gc — gleyed clay, usually with a firm consistence.
gs — gleyed coarse textured materials, usually friable or slightly firm, non-sticky and non-plastic.
gv — gravelly (particles 2-75 mm in diameter).
hp — an indurated material cemented by iron and manganese oxides which cannot be cut with a spade, even when wet (hardpan ferricrete).
ih — illuvial humus.
ir — illuvial iron.
ka — an indurated material cemented by calcium carbonate (calcrete).
ko — colluvium.
lc — material in various stages of alteration between hard rock and completely homogenized soil that has cutanic character expressed usually as tongues or prominent colour variegations resulting from residual soil formation and illuviation.
Lm— loam.
ma— topsoil that is dark coloured with a high base status, Ca and Mg being the predominant exchangeable cations (margalitic).
mc— a subsilicic or basic rock with mafic minerals predominant.
md— unconsolidated marine or salt lake deposit.
me— medium.
mf — mesotrophic.
ml — a dark coloured topsoil with a high base saturation value and without slickensides, marked cracking or marked self-mulching.
ms — indurated material (other than hp, ka, si, db) that is irreversibly cemented.
na — a high exchangeable sodium percentage.
ne — unconsolidated material in which pedogenesis is weakly expressed, but in which there are indications of, for example, aggregate formation, illuviation, disappearance of stratifications in an initially stratified material.
ob — a recent geological deposit upon a soil (overburden).
oo — topsoil with an unusually high content of organic matter; it overlies gleyed material.
ot — topsoil which conforms with the requirements of a diagnostic orthic topsoil horizon.

p — denotes that the material has been ploughed or otherwise disturbed.

pa — desert pavement.

pr — a material, which is not a gleyed clay, that has a strong prismatic or columnar structure (usually coarse).

re — a red soil material with structure that is weaker than moderate blocky or prismatic in the moist state.

rh — illuvial iron and humus.

rs — material that largely conforms to the requirements of diagnostic regic sand.

Sa — sand.

sa — an accumulation of salts more soluble than calcium sulphate.

sc — a silicic or persilicic (acid) rock in which minerals rich in silica are dominant.

sf — stony (flat or flaggy; see sr).

Si — silt.

si — an indurated material cemented by silica.

sl — unconformable material, for example a stoneline.

so — weathering rock which, although unconsolidated, still has easily visible geogenic character (saprolite).

sp — a material, which can be cut with a spade when wet, in which sesquioxides have accumulated as mottles and/or concretions through operation of a fluctuating watertable.

sr — stony (rounded; see sf).

t — illuvial clay.

um— ultramafic or ultrabasic rock containing less than 45% silica, virtually no quartz or felspar and with ferromagnesian minerals predominant.

ve — material with vertic properties as evidenced by one or more of slickensides, cracking, self-mulching.

vp — soil material which is not gleyed and whose colour is not predominantly red, with structure that is at least moderate blocky in the moist state.

vr — soil material which is predominantly red in colour, with structure that is at least moderate blocky in the moist state.

xp — a material, usually mottled, low in organic matter with a high bulk density, seemingly cemented when dry, commonly with bleached fracture planes that form polygons, and slowly permeable to water; when moist it has moderate or weak brittleness (fragipan).

ye — a brown or yellowish brown soil material with structure that is weaker than moderate blocky or prismatic in the moist state.

Underlying materials

F — fine grained metamorphic rocks such as slate, phyllite.

H — hypabyssal rocks, medium grained or porphyritic, with a fine grained groundmass, such as porphyry, dolerite.

I — coarse grained plutonic rocks such as granite, diorite, norite, gabbro.

K — very coarse, clastic sedimentary rocks such as conglomerates, breccia, tillite.

L — fine grained extrusive rocks (lavas) such as basalt, rhyolite, andesite.

M — coarse grained metamorphic rocks such as gneiss, schist, marble.

P — fine grained, clayey, clastic sedimentary rocks such as shales, mudstones (pelites).

R — hard rock requiring a hammer to break it; it need not be fresh rock.

S — coarse grained clastic sedimentary rocks such as sandstones, arkoses, greywacke (psammites).

so — weathering rock which, although unconsolidated, still has easily visible geogenic character (saprolite).

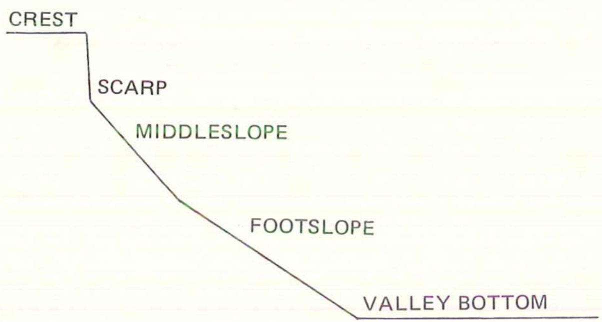
U — unconsolidated material without saprolite character.

V — deposits of volcanic ejecta, including tuffs and volcanic ash.

Talus — natural colluvial deposits of rock fragments at the base of steep slopes.

Taxon (*pl* **taxa**) — a taxonomic entity or group. Synonymous with class.

Terrain morphological units



Texture, soil — the relative proportions of the various size separates in the soil as described by the classes of soil texture shown in the soil texture chart below. The sand, loamy sand, sandy loam and sandy clay loam classes are further subdivided (using the sand grade chart below) according to the relative percentages of the coarse, medium and fine sand subseparates.

Thixotropy — a property of a material that permits it to become solid on standing for a short time, but on agitation its consistence becomes soft or it changes to a highly viscous fluid. It is a reversible process.

Total available moisture capacity (TAM) — this is the capacity (expressed in mm water) of a soil to store water for plant use. TAM (mm) = AWC (mm/m) x Effective rooting depth (m). AWC differences in anisotropic soils need to be taken into account. At best TAM is a very rough approximation for a number of reasons, one of which is the difficulty of estimating effective rooting depth.

T-value — cation exchange capacity expressed as me/100 g. The value can vary according to the method of analysis used. See cation exchange capacity.

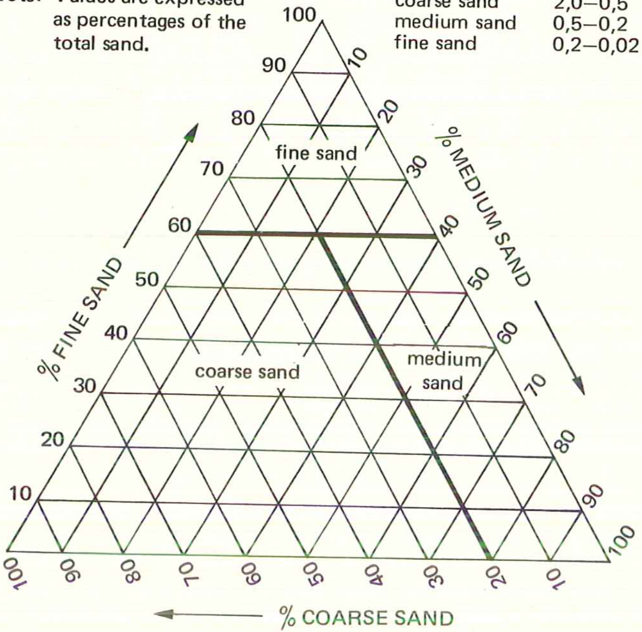
Type, soil — a subdivision of a soil class (eg a series) primarily on the basis of topsoil texture.

Upper plastic limit — see liquid limit, plastic limit.

Variant, soil — a soil whose properties are such as to exclude it from existing classes in a classification (eg from existing series), but which covers such a limited area that creation of a new class is not justified.

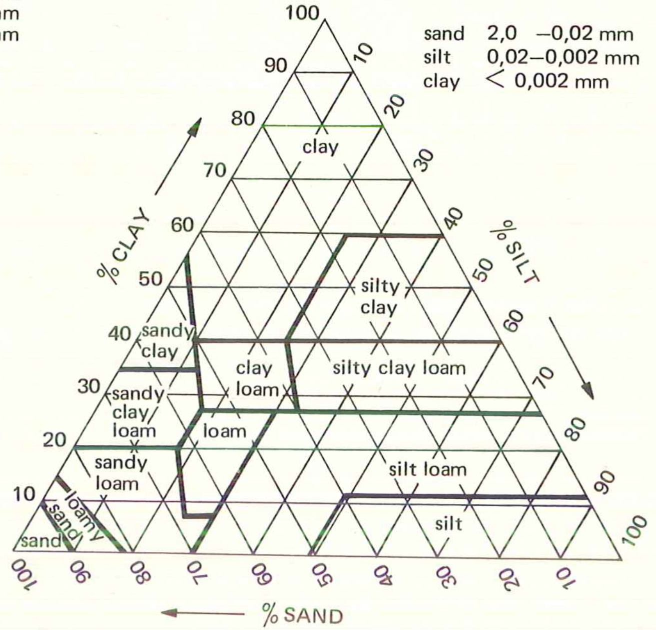
Note: Values are expressed as percentages of the total sand.

coarse sand	2,0–0,5 mm
medium sand	0,5–0,2 mm
fine sand	0,2–0,02 mm



SAND GRADE CHART

sand	2,0 –0,02 mm
silt	0,02–0,002 mm
clay	< 0,002 mm



TEXTURE CHART

Vermiculite – this is a clay mineral similar in structure to the smectites, except that most of its negative charge lies in the tetrahedral silica sheet, and consequently it does not swell to the same extent as the smectites. It has a CEC range of 140–160 me %.

Volume fraction of liquid – is the volume of the liquid phase per unit bulk volume of soil, expressed in m^3 liquid per m^3 bulk volume.

Water content or wetness – is the amount of water lost from the soil upon drying at 105°C, expressed in kg water per kg of solid phase after drying.

Water percentage – the water held by a soil expressed as a percentage of the dry mass of soil. See water content.

Watertable – the upper surface of groundwater, or that level below which the soil is saturated. A watertable of a saturated layer of soil underlain by an unsaturated layer is known as a perched watertable.

Wilting point – is a point in the range of soil water content below which a majority of plants wilt permanently. The latter occurs when the hydraulic conductivity of the soil has decreased to such an extent that water will not move rapidly enough towards the roots of plants to satisfy their requirement, even during periods of low water demand, such as at night. Temporary wilting occurs when the water flow to the roots is insufficient to meet their requirement during short periods of high demand. WP is estimated in the laboratory as the amount of water contained in an undisturbed soil sample that has been saturated, then drained to equilibrium at a pressure differential of 1 500 kPa. It is commonly expressed as a percentage of the dry mass of soil or as mm water per m depth of soil. See available water capacity.

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Printed in the Republic of South Africa by Keartland Press (Pty) Ltd. for the Government Printer, Pretoria and obtainable from the Division of Agricultural Information, Private Bag X144, Pretoria 0001.