AG : BOT/85/011
FIELD DOCUMENT 9

Soil Mapping and Advisory Services

Botswana

# BOTSWANA SOIL DATABASE

## GUIDELINES FOR SOIL PROFILE DESCRIPTION

FOOD & AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

UNITED NATIONS DEVELOPMENT PROGRAMME

REPUBLIC OF BOTSWANA

GABORONE, 1988

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# GUIDELINES FOR SOIL PROFILE DESCRIPTION

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United Nations Development Programme

Republic of Botswana

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**Contents**

# INTRODUCTION

These 'Guidelines for Soil Profile Description' were developed to facilitate the storage of soil profile descriptions in a computerized database, as well as to give specific information on the description of soils in Botswana. The guidelines provide standard terminology and codes for the recording of site and profile characteristics. The methodology and terminology basically follows the FAO 'Guidelines for Soil Profile Description' (1977). The guide presented here should be considered as an addition to the FAO Guidelines rather than a replacement.

However, these guidelines are constructed in such way that the field description can be carried out without further references. For background information, full definitions of properties and further concepts the user is referred to the standard text books, such as the FAO Guidelines for Soil Profile Description (FAO, 1977), the Soil Survey Manual (Soil Survey Staff, 1951) and revised SSM chapters (1981), Soil Taxonomy (Soil Survey Staff, 1975), Keys to Soil Taxonomy (Soil Survey Staff, 1987), the Legend of the Soil Map of the World (FAO/UNESCO, 1974) and the Revised Legend of the Soil Map of the World (1988).

A number of changes as compared to FAO Guidelines and SSM is introduced. Some of these changes relate to Botswana conditions, but others are of a more general nature and are recommended for application in revised guidelines.

The site description has been further standarized, in particular the methods of description of the geomorphology, vegetation and land use. Major modifications introduced are:

**Letter suffixes in horizon designation**: The definitions of the revised SSM (1981) are followed, except for **c**.
**Texture**: The subdivision of sands was changed.
**Topography**: 'Flat and almost flat' subdivided into two separate classes.
**Surface stones - size**: 'Fine gravel' introduced.
**Salts**: Redefined.
**Cutans - quantity, thickness**: The definitions were further specified.
**Cementation**: 'Partly cemented' introduced. Classes redefined.
**Pores, Roots**: Described by size and abundance only.
**Mineral Nodules - size**: Redefined, the size classes now match the classes used to describe the size of mottles.
**Pans and Texture >2mm**: No longer described.

Instructions on the use of the Botswana Soil Database, as well as technical details are given in the Botswana Soil Database User Manual (Van Waveren, 1988).

## NOTES ON THE USE OF THE DESCRIPTION FORM

The information is recorded on a special soil profile description form (see appendix A).

Information should be given on each variable. Please note that 0 (zero) is used in the abundancy and quantity classes as a positive statement (e.g. no roots, no surface stones). Leaving entries blank suggests that no information is available, or that no observations were made.

The profile description allows two entries per item. The first entry is always entered on the upper line.

Six horizons can be fully entered on one description form, if more space is required a second form should be used. Note that the computer accepts at most nine horizons per profile.

Comments should be as brief as possible , since space under remarks is limited to 256 characters.

## PROFILE NUMBER

The profile number consists of a two letter location code, followed by a 4 digit number e.g. MA0001, L 0235. A list of valid location codes is given in Appendix B. Please note that the so-called A and B numbers are no longer used.

## AGRO CLIMATIC ZONE

The Agro Climatic zone in which the site is located (see Map 1).

## SHEET NUMBER

The number of the applicable topographic sheet at scale 1:50.000. If not available the number of the 1:100.000 or 1:250.000 sheet is given.

## GRID REFERENCE

Instructions to determine the grid reference are given on most 1:50.000 topographic sheets. If no grid is given on the sheet, it can be constructed with the aid of adjacent maps and the grid marks normally present in the margins of the map.

## MAPPING UNIT

Reference is made to the General Soil Legend of Botswana, the standard legend of the 1:250.000 soil map series (Remmelzwaal, 1988). A key to the Legend is given in Appendix H.

## STATUS

The status of the soil profile description is determined on the basis of the quality of the soil description and analytical data. The status is allocated by the soil correlator after the completion of all analyses.

1 - Reference pit:
No relevant elements or details are missing from the description, sampling or analysis. The description and number of samples is sufficient to characterize all sub-horizons to a depth of 125cm, or deeper if required for full classification. The soil depth in the pit is 125cm or more, or down to a cemented C or R horizon/layer (lithic or paralithic contact) if shallower.

2 - Routine pit:
No essential elements are missing from the description, sampling or analysis. The number of samples is sufficient to characterize the major soil horizons, but may be not sufficient to precisely define all sub-horizons, especially at depth. The soil depth in the pit is 80cm or more, or down to a cemented or gravelly C or R horizon/layer (lithic or

paralithic contact), with additional augering and sampling if required for higher level classification.

3 - Incomplete pit:
Certain elements are missing from the description, sampling or analysis. In most cases the depth of the pit is insufficient, or none or too few samples were taken, or they were taken at incorrect depth. However, the data present a satisfactory indication of the soil properties and higher level classification.

4 - Augering:
By definition the description from an augering is incomplete, but satisfactory information on soil characteristics and classification can be obtained . In some cases samples are taken from augerings.

5 - Other Observations:
Essential elements are missing from the pit or augering description, and no satisfactory soil characterization and classification can be obtained.

Note: Descriptions of augerings or other observations made for routine checks are normally not included in the database, but available on ordinary soil profile description sheets.

## LOCATION

The location of the pit should be given in km from points recognizable in the field and on the map. Distances along roads or traverses relate to a marked starting point (0.0km).

## COORDINATES

Coordinates are determined from the appropriate topographic sheet.

## DATE

Date of profile description.

## AUTHOR

Initials of the authors should be entered. The first author should be the officer doing the actual profile description.
A valid list of initials is given in appendix C.

## CLASSIFICATION

Tentative classifications according to both FAO (1974 and 1988) and Soil Taxonomy (1975; 1987) onto subgroup level, should be made in the field.

Amendments and modifications of the FAO system for use in Botswana are described in detail in the General Soil Legend of Botswana (Remmelzwaal, 1988).
For easy reference and to avoid confusion the classifications should also be written in full on the sheets.

**FAO** Enter soil unit according to the FAO/UNESCO Legend (1974), the Revised FAO/UNESCO Legend (1988) and phase (if appropriate). Codes are listed in appendixes D1 and D2.

The following phases are recognized, leaving out the phases that do not occur in Botswana and adding a clayey phase, a sandy phase and several subphases on basis of shallow occurrence (within 50cm). For instance a petroferric at 40cm is described as shallow petroferric.

Definitions of the phases are given in FAO/UNESCO (1974) and FAO (1988).

| | | | |
|---|---|---|---|
| **ST** | Stony (rudic '88) | **DU** | Duripan |
| **LI** | Lithic | **FR** | Fragipan |
| **PE** | Petric | **SA** | Saline (salic '88) |
| **SP** | Shallow petric (Skeletic '88) | **SO** | Sodic |
| **PC** | Petrocalcic | **SS** | Saline and sodic |
| **SC** | Shallow petrocalcic | **GI** | Gilgai ('88) |
| **PG** | Petrogypsic | **IN** | Inundic ('88) |
| **SG** | Shallow petrogypsic | **YE** | Yermic ('88) |
| **PF** | Petroferric | **CL** | Clayey |
| **SF** | Shallow petroferric | **AR** | Sandy |
| **PH** | Phreatic ('88) | **TA** | Takyric ('88) |

**Clayey phase** (**CL**): 10 to 30cm thick loam/silt/clay sedimentary surface layer over sand/loamy sand (see also Soil Survey Staff, 1987).
**Sandy phase** (**AR**): 10 to 50cm thick sand/loamy sand sedimentary surface layer over clayloam/siltloam/clay (see also Soil Survey Staff, 1987).

Soils with a lithic contact between 50 - 100cm are considered to have a petric phase (**PE**).

**ST** Classification according to Soil Taxonomy (1987; 1975). A list of codes is given in appendix E.

**SMR** Soil Moisture Regime. In Botswana the following soil moisture regimes are recognized:

| | |
|---|---|
| **A** | Aridic |
| **AU** | Aridic transitional to ustic |
| **UA** | Ustic transitional to aridic |
| **U** | Ustic |
| **UQ** | Ustic transitional to aquic |
| **QU** | Aquic transitional to ustic |
| **Q** | Aquic |
| **D** | Udic |

Definitions of the Soil Moisture Regimes are given in Soil Taxonomy (1975; 1987).

## DIAGNOSTIC HORIZONS

Write in full the diagnostic horizons recognized.

## ELEVATION

The elevation should be entered as accurately as possible. Contour maps should be used if available, otherwise the best possible estimate is given from ordinary topographical maps or other sources. Elevation is given in meters (1 foot=0.3048 meter).

## LANDFORM

The landform characterizes the general geomorphology of the area in which the soil unit is located.

| | | | |
|---|---|---|---|
| **PL** | Plain | **PT** | Plateau |
| **AP** | Alluvial plain | **ES** | Escarpment |
| **LP** | Lacustrine plain | **HI** | Hill |
| **SP** | Sandplain | **VA** | valley |
| **PE** | Pediment | **AF** | Alluvial fan |
| **DF** | Dunefield | **X** | Other, see remarks |

Describe the landform as accurately as possible, e.g. plain (**PL**) should not be used to describe sand plains, alluvial plains, lacustrine plains or floodplains. The use of **X** should be avoided as much as possible.

## LAND ELEMENT

The land element describes the geomorphology of the immediate surroundings of the site.

The dimensions of a land element are in general comparable with the dimensions of mapping units on semi-detailed map scales (1:50.000). On a reconnaissance map scale (1:250.000) the mapping unit often includes more than one land element. In a mapping unit that consists of an association of soil units, the ocurrence of the individual soil units is generally related to the landelements.

| | | | |
|---|---|---|---|
| **NA** | Not applicable | **BD** | Beach-dune complex |
| **IF** | Interfluve | **FP** | Floodplain |
| **DU** | Dune | **TE** | Terrace |
| **TD** | Transverse dune | **BA** | Backswamp |
| **LD** | Longitudinal dune | **DT** | Delta |
| **PD** | Parabolic dune | **CH** | Channel |
| **RD** | Barchan dune | **LE** | Levee |
| **ID** | Interdunal depression | **VA** | Valley |
| **PA** | Pan | **VF** | Valley floor |
| **DE** | Depression | **AF** | Alluvial fan |
| **RI** | Ridge | **IS** | Island |
| **BE** | Beach (ridge) | **X** | Other, see remarks |

Enter **NA** (not applicable) if the landform itself adequately describes the geomorphology of the soil unit, e.g. soil units on flat lacustrine plains.

The use of **X** should be avoided as much as possible. The most appropriate land element must be selected, even if the choice is not completely satisfactory. A further specification may then be added under Remarks.

## POSITION OF SITE

The position of site indicates the relative position of the observation within the soil unit or complex of soil units.

| **Position in undulating/hilly terrain** | | **On (almost) flat terrain** | |
|---|---|---|---|
| **CR** | Crest | **HI** | Higher part |
| **US** | Upper slope | **IN** | Intermediate part |
| **MS** | Middle slope | **LO** | Lower part |
| **LS** | Lower slope | | |
| **SL** | Slope | | |

If the mapping unit consists of a soil complex the relative position within the mapping unit is given.
If the mapping unit consists of an association of soil units, the relative position within the soil unit is given, e.g. in a pan-dune system the relative position within the pan or on the dune is entered.

Intermediate positions (**IN**) are usually the most representative in the soil units.

The position of site gives information on the hydrological conditions of the site, as described in the 'System of Land Evaluation for Arable Farming' (Rhebergen, 1988). Lower parts of plains (**LO**) and lower slopes (**LS**) are mostly water receiving, whereas crests (**CR**), upper slopes (**US**) and to a certain extend higher parts of plains (**HI**) are watershedding.

## TOPOGRAPHY

Topography (relief) indicates the differences in elevation over a large area, often the landform. In Botswana the following classes are recognized (After FAO,1977):

| | | |
|---|---|---|
| **F** | Flat | Slopes not steeper than 0.5% |
| **A** | Almost flat | Steepest slopes between 0.5 and 2% |
| **G** | Gently undulating | Steepest slopes between 2 and 5% |
| **U** | Undulating | Steepest slopes between 5 and 8% |
| **R** | Rolling | Steepest slopes between 8 and 16% |
| **H** | Hilly | Steepest slopes between 16 and 30%, range of elevation moderate |
| **S** | Steeply dissected | Steepest slopes greater than 30%, range of elevation moderate |

## MICRO-TOPOGRAPHY

Micro-topography refers to differences in height measured over short distances. Height differences are given in centimeters over distances in meters.

If more than one type of micro topography is observed the dominant or more relevant type should be entered, others should be described under remarks.

| | | | |
|---|---|---|---|
| **0** | Even | - Surface is (nearly) level | |
| **GL** | Low gilgai | - Height difference (within 10m) | < 20cm |
| **GM** | Medium gilgai | - Height difference (within 10m) | 20 - 40cm |
| **GH** | High gilgai | - Height difference (within 10m) | > 40cm |
| **GI** | Gilgai, unspecified | - Height difference unspecified | |
| **TM** | Termite mounds | | |
| **AT** | Animal tracks | | |
| **AB** | Animal burrows (holes/heaps) | | |
| **HL** | Low hummocks | - Height difference | < 20cm |
| **HM** | Medium hummocks | - Height difference | 20 - 40cm |
| **HH** | High hummocks | - Height difference | > 40cm |
| **HU** | Hummocks, unspecified | - Height difference unspecified | |
| **UN** | Uneven (unspecified) | | |

**Remarks**

If the distance between the mounds and depressions is more than 10m low gilgai (**GL**) is generally applicable.

If the mounds and depressions are not occurring in about equal proportions, or if specific types of gilgai, such as linear gilgai, are observed, details should be given under remarks.

The use of uneven (**UN**), unspecified gilgai (**GI**) and unspecified hummocks (**HU**) should be avoided.

## SLOPE GRADIENT

Slope gradient refers to the avarage slope in % of the area immediately surrounding the site, within the soil unit. If the slope of this area varies, both the highest and the lowest value should be entered.

Slope gradients should be entered as accurately as possible. The slope gradients are measured in the field using a clinometer. If clinometer readings are not available field estimates should be matched with gradients calculated from contour maps.

Field estimates in almost flat terrains are often too high. In open plains slope gradient of more 0.2% (this means 20cm height difference over 100m) are clearly visible.

For relatively flat areas, such as the Pandamatenga plains, the following slope classes are recommended (if more accurate estimates are not possible):

0.1 - 0.3%
0.3 - 0.7%
0.7 - 1.5%

## SLOPE FORM

The slope form indicates the general shape of the slope taking into account both the vertical and the horizontal component. The following forms are distinguished:

**V** Convex
**C** Concave
**S** Straight

## SEALING

Sealing is used to describe crusts that form on the surface after the top soil dries out. These crusts influence germination of plants, infiltration and surface run off.

| | | |
|---|---|---|
| **0** | Nil | - No crust observed. |
| **SL** | Slight sealing | - Soft or slightly hard crust, less than 0.5cm thick. |
| **MO** | Moderate sealing | - Soft or slightly hard crust, more than 0.5cm thick or, hard crust less than 0.5cm thick. |
| **ST** | Strong sealing | - Hard crust more than 0.5cm thick. |

## CRACKS

Average width (in cm) of surface cracks is indicated. The width of holes should not be taken into account.

## SALT

Describe the occurrence of salts on the surface. The following classes are used:

| | | |
|---|---|---|
| **0** | Nil | - No salts observed. |
| **SL** | Slight | - Salt is observed, but does not form a crust. |
| **ST** | Strong | - Salt forms a crust. |

## BLEACHED SAND

Indicate the presence of bleached sand on the surface. The occurrence of bleached sand influences the reflection characteristics of the surface.

**0** No bleached sand present.
**Y** Bleached sand present.

## LAND USE

The present type of land use in the soil unit:

**0** No apparent management system observed
**FR** Forest reserve
**GR** Game reserve
**WM** Wildlife management area
**DV** Disturbed vegetation

**Dryland farming:**
**DT** Traditional
**DI** Improved traditional
**DM** Mechanized
**DC** Commercial
**DU** Unspecified

**Irrigated farming**
**IS** Small scale
**IM** Medium or medium-large scale
**IU** Unspecified

**Molapo farming**
**MT** Traditional
**MI** Improved

**Grazing**
**GT** Traditional (communal)
**GC** Commercial
**GU** Unspecified

The land use type should be described as precisely as possible. The use of unspecified dryland farming (**DU**), unspecified irrigated farming (**IU**) and unspecified grazing (**GU**) should be avoided.

Disturbed vegetation (**DV**) is used for sites with a strongly disturbed vegetation and a presently no clearly defined land use e.g.:
- disturbed strips along roads, fences, lands
- heavily overgrazed areas
- former fields with encroaching shrub vegetation

Although **DV** is not really a land use type, it is indicated here to allow a further description of the vegetation structure.

## CROPS

Enter dominant crops of the land use type (if applicable). At most two crops can be described.

**SO** Sorghum
**MA** Maize
**MI** Millet
**WH** Wheat
**PE** Peas
**BE** Beans
**GR** Groundnuts
**SU** Sunflower
**CO** Cotton
**CP** Cowpeas
**DO** Dolichos lablab
**FO** Fodder crops
**VE** Vegetables
**FR** Fruits

## VEGETATION STRUCTURE

The vegetation structure of the soil unit is described. The following vegetation structures are recognized in Botswana:

| | | |
|---|---|---|
| 0 | No (semi-) natural vegetation | |
| **GR** | Grassland | - Grasses, subordinate forbs, no woody species. |
| **FL** | Forbland | - Herbaceous plants predominant. |
| **F** | Forest | - Climax vegetation with a large number of tree and shrub species, the structure is characterized by distinct tree and shrub layers, the crowns are overlapping. |
| **W** | Woodland | - Continuous tree layer, crowns usually not touching. Understorey may be present. |
| **SH** | Shrubland | - A continous layer of shrubs, crowns are touching |

**Savanna:** Discontinuous layer of trees and/or shrubs:

| | | |
|---|---|---|
| **SA** | Savanna | - Scattered trees and shrubs, moderately dense. |
| **SAD** | Dense savanna | - Species approximately a few crown diameters apart. |
| **SAO** | Open savanna | - A few isolated trees and shrubs. |
| **ST** | Tree savanna | - Predominantly trees, scattered moderately dense |
| **STD** | Dense tree savanna | - Trees approximately a few crown diameters apart |
| **STO** | Open tree savanna | - A few isolated trees |
| **SS** | Shrub savanna | - Predominantly shrubs, scattered moderately dense |
| **SSD** | Dense shrub savanna | - Shrubs approximately a few crown diameters apart |
| **SSO** | Open shrub savanna | - A few isolated shrubs |
| **SL** | Low shrub savanna | - Predominantly low shrubs, scattered moderately dense. |
| **SLD** | Dense low shrub savanna | - Low shrubs approximately a few crown diameters apart. |
| **SLO** | Open low shrub savanna | - A few isolated low shrubs |

Trees: Mostly single stemmed species with a height of more than 3m.
Shrubs: Mostly multi stemmed species with a height between 1-3m.
Low shrubs: Shrubs lower than 1m.

## GRASS COVER

The following classes are distinguished in estimating the grass cover:

0 Bare, grass cover less than 10%
1 Grass cover between 10 and 30%
2 Grass cover between 30 and 70%
3 Grass cover over 70 %

## TREES

Enter the dominant tree species and at most five other common species. If no dominant tree can be distinguished, the first entry should be left open. A list of species is given in appendix F.1.

## SHRUBS

Enter the dominant shrub species and at most five other common species. If no dominant shrub can be distinguished, the first entry should be left open. A list of species is given in appendix F.1.

## GRASSES/FORBS

Enter the dominant grass/forb species and at most five other common species. If no dominant grass/forb can be distinguished, the first entry should be left open. A list of species is given in appendix F.2.

## PARENT MATERIAL

Indicate the parent material in which the soil has formed. If the soil has formed in two layers of different origin, e.g. aeolian over lacustrine, both parent materials should be entered.

| | | | |
|---|---|---|---|
| **AS** | Aeolian sand | **AV** | Alluvium |
| **AR** | Aeolian red sand | **DE** | Deltaic |
| **AP** | Aeolian pale sand | **LI** | Littoral |
| **AL** | Aeolian reworked lacustrine | **CO** | Colluvium |
| **LA** | Lacustrine reworked aeolian | **CA** | Calcrete |
| **LC** | Lacustrine | **SI** | Silcrete |
| **FL** | Fluvial reworked lacustrine | **WE** | In situ weathered |

If the soil has formed in weathering material of the underlying rock, it is described as in situ weathered parent material (**WE**). **WE** may also be used in the case of colluviated but unmixed materials.

In the case of one parent material overlying a second different one, the latter is indicated in the second section. If the second material is in situ weathered parent material, **WE** is entered in the second section and the rock type is indicated in the following one.

Aeolian reworked lacustrine (**AL**) occurs in lacustrine plains, such as the Makgadikgadi. Lacustrine sands are found reworked by wind as dunes and other aeolian features.

Lacustrine reworked aeolian (**LA**): Dunefields on the margins of previous lakes are found influenced or reworked in a lacustrine environment (e.g. Pandamatenga, Okavango). These sands still show the original aeolian morphology, but have undergone alteration in the surface layers, such as clay enrichment.

Fluvial reworked lacustrine (**FL**) refers to parent materials of lacustrine

plains that have been reworked by rivers (after the lakes dried up). In most cases the original lacustrine material itself has not been changed very much, only the topography (e.g. in the Chobe enclave, Makgadikgadi).

Deltaic sediments (**DE**) are found in lacustrine plains (Mababe, Makgadikgadi) where deltas were formed by deposition in the lake of fluvial transported material which has been deposited in the lake. After drying up of the lake these deposits may have been eroded or reworked again.

The deposits of the Okavango are not considered as deltaic. Although the area is called a delta, it is not a delta in the sense of a depositional environment. The Okavango deposits are normally considered as alluvial (river floodplains and adjacent marshlands).

## ROCK TYPE

The following rocktypes are distinguished:

**Acid igneous and metamorphic rocks:**
**GR** Granite
**IG** Intermediate granite
**GN** Gneiss
**GG** Granite-gneiss
**QZ** Quartzite
**SC** Schist
**FE** Felsite
**FV** Felsic volcanics
**AC** Unspecified, or other acid igneous and metamorphic rocks

**Basic igneous and metamorphic rocks:**
**BT** Basalt
**DO** Dolerite
**DI** Diorite
**UB** Ultrabasic
**BA** Unspecified , or other basic igneous and metamorphic rocks

**Sedimentary rocks:**
**CO** Conglomerate
**SA** Sandstone
**QS** Quartzitic sandstone
**FS** Feldspatic sandstone
**SI** Siltstone
**SH** Shale
**MA** Marl
**LI** Limestone
**DM** Dolomite
**SE** Unspecified, or other sedimentary rocks

Actual information derived from geological maps should be checked in the field if possible, since the lithology at the site might not represent the geological map unit.

## GEOLOGICAL UNIT

The geological unit refers to the units on the Geological map of Botswana on scale 1:1.000.000 (1984). The units are listed in appendix G.

## DRAINAGE

The drainage is described according to FAO (1977). It should be noted that the definitions of the drainage classes seem to fit humid climates better than (semi-) arid climates. The lengths of wet periods as in the definitions do not apply to the Botswana conditions, but the effects of also relatively short wet periods are considered essential to soil genesis, soil classification and land evaluation. Therefore the length of the wet period as in the definition is interpreted in the context of the semi-arid climate with a relatively short wet period.

| | | |
|---|---|---|
| **V** | Very poorly drained | - Water is removed from the soil so slowly that the water table remains at or on the surface the greater part of the time. |
| **P** | Poorly drained | - Water is removed so slowly that the soil remains wet for a large part of the time. The water table is commonly at ar near the surface during a considerable part of the year. |
| **I** | Imperfectly drained | - Water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. |
| **M** | Moderately well drained | - Water is removed from the soil somewhat slowly, so that the profile is wet for a small but significant period of the time. |
| **W** | Well drained | - Water is removed from the soil readily but not rapidly. Well drained soils commonly retain optimum amounts of moisture for planth growth after rains or additions of irrigation water. |
| **S** | Somewhat excessively drained | - Water is removed from the soil rapidly. |
| **E** | Excessively drained | - Water is removed from the soil very rapidly. |

Transitional classes are indicated by a combination of the codes of both classes, e.g. poorly to imperfectly drained is entered as **PI**.

**Interpretation and examples:**

Very poorly drained (**V**): only applicable in areas with standing water (ponding) during the greater part of the year, as in the Okavango.

Poorly drained (**P**): in most years ponding occurs for some period or periods leading to complete reduction conditions (aquic moisture regime).
Examples: Vertisols and Gleysols in relatively low positions.

Imperfectly drained (**I**): ponding with complete reduction conditions (aquic moisture regime) occurs infrequently or has recently occurred. Imperfect drainage may also be applicable to soils with a soil moisture regime transitional to other moisture regimes.
Examples: Vertisols and Gleyic Luvisols in relatively high positions, Orthic Luvisols in relatively low positions.

Moderately well drained (**M**): in most years the soil is wet for one or more short periods, which is generally due to a slowly permeable layer (argillic, calcic horizon).
Examples: Calcic Luvisols; Orthic Luvisols in relatively high positions; Ferric Luvisols in relatively low positions.

Well drained (**W**): wet conditions may occur, but only for very short periods. Well drained soils do not have a slowly permeable layer and generally also not a high permeability. Unless very sandy they do not occur in relatively low positions.
Examples: Nitosols, Chromic Luvisols, Arenic Ferric Luvisols; Arenosols in relatively low positions.

Somewhat excessively drained (**S**): somewhat excessively drained soils have a high permeability and do not occur in relatively low positions.
Examples: Arenosols; medium textured Regosols with lithic or petric phase.

Excessively drained (**E**): excessively drained soils are very shallow or shallow and sandy.
Examples: Lithosols; Arenosols with a lithic phase.

## MOISTURE CONDITIONS

Describe moisture conditions prevailing in the profile during time of examination. Enter depth (in cm) at which the changes of conditions occur.

| | |
|---|---|
| **D** | Dry |
| **S** | Slightly moist |
| **M** | Moist |
| **W** | Wet |

## SURFACE STONES

Both the abundance and the average size of the surface stones are described:

**ABUNDANCE**

| | | |
|---|---|---|
| **0** | Nil | - No surface stones observed |
| **1** | Very few | - Less than 2% of the surface covered |
| **2** | Few | - 2 to 10% of the surface covered |
| **3** | Common | - 10 to 50% of the surface covered |
| **4** | Many | - 50 to 90% of the surface covered |
| **5** | Abundant | - over 90% of the surface covered |

**SIZE**

| | | |
|---|---|---|
| **F** | Fine gravel | - Average diameter less than 2cm |
| **G** | Gravel | - Average diameter between 2 and 7.5cm |
| **S** | Stones | - Average diameter between 7.5 and 25cm |
| **B** | Boulders | - Average diameter more than 25cm |

## ROCK OUTCROPS

Rock outcrops are described according to the following definitions (FAO,1977):

| | | |
|---|---|---|
| **0** | No rocks | - No bedrock exposed |
| **VF** | Very few rocks | - Less than 2% bedrock exposed |
| **FA** | Fairly rocky | - 2 to 10 % bedrock exposed, exposures roughly 35 to 100m apart |
| **RO** | Rocky | - 10 to 25% bedrock exposed, exposures roughly 10 to 35m apart |
| **VE** | Very rocky | - 25 to 50% bedrock exposed, exposures roughly 3 to 10m apart |
| **EX** | Extremely rocky | - More than 50% bedrock exposed |

## EROSION/DEPOSITION

Describe intensity and type of accelerated erosion or deposition at the site and its immediate surroundings. At most two types can be entered. If the intensity and/or type of process at the site is not representative for the soil unit, a remark should be made.

| **INTENSITY** | |
|---|---|
| **0** | Nil |
| **SL** | Slight |
| **MO** | Moderate |
| **ST** | Strong |

| **TYPE OF PROCESS** | |
|---|---|
| **S** | Sheet erosion |
| **R** | Rill erosion |
| **G** | Gully erosion |
| **W** | Wind erosion/deposition |
| **E** | Wind erosion |
| **D** | Wind deposition |
| **A** | Accumulation (deposition) by water |

## HUMAN INFLUENCE

Human influence refers to evidence of human activity which is likely to have affected the physical or chemical characteristics of the profile described. The following activities are used to indicate the human influence on the profile:

| | |
|---|---|
| **0** | Nil |
| **P** | Ploughing |
| **I** | Irrigation |
| **C** | Clearing |
| **B** | Borrow pit (digging) |
| **S** | Surface compaction |

If necessary, additional information should be given under remarks.

## HORIZON DESIGNATION

### MASTER HORIZONS

Various definitions of master horizons are given in the FAO guidelines (1977), FAO Soil Map of the World (1974), SSM (1951), the revised provisional chapters of SSM (1981), and Keys to Soil Taxonomy (1987). The definitions as given in the revised SSM and Keys to Soil Taxonomy are considered as the most appropriate. In abbreviated form they read as follows:

**O** horizons or layers: layers dominated by organic material, except limnic layers that are organic. Some are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated.

**A** horizons: Mineral horizons that are formed at the surface or below an O horizon and:
(1) are characterized by an accumulation of humified organic matter intimately mixed with the mineral fraction and not dominated by properties characteristic of E or B horizons (defined below),
or (2) have properties resulting from cultivation, pasturing or similar kinds of disturbance.

**E** horizons: Mineral horizons in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration of sand and silt particles of quartz or other resistant minerals.

**B** horizons: horizons that are formed below an A, E or O horizon and are dominated by obliteration of all or much of the original rock structure and by:
(1) illuvial concentration of silicate clay, iron, aluminum, humus carbonates, gypsum, or silica, alone or in combination;
(2) evidence of removal of carbonates;
(3) residual concentration of sesquioxides;
(4) coatings of sesquioxides that make the horizon conspicuously lower in value, higher in chroma, or redder in hue than overlying and underlying horizons without apparent illuviation of iron;
(5) Alteration that forms silicate clay or liberates oxides or both and that forms granular, blocky, or prismatic structure if volume changes accompany changes in moisture content;
or (6) any combination of these.

**C** horizons/layers: Horizons or layers, excluding hard bedrock, that are little affected by pedogenic processes and lack properties of O, A, E, or B horizons. Most are mineral layers, but limnic layers whether organic or inorganic, are included. The material of C horizons may be either like or unlike that from which the solum presumably formed. A C horizon may have been modified even if there is no evidence of pedogenesis.

**R** layers: Hard bedrock, which is sufficiently coherent to make hand digging with a spade impractical. The bedrock may contain cracks, but only few and small, with only few roots penetrating. The cracks may be infilled.

Transitional horizons such as AB or EB may be distinguished but their use is not recommended, only in cases where subordinate properties occur in significant proportions and the simple use of a gradual or diffuse boundary is not satisfactory.
In cases where horizons contain distinct parts with recognizable properties of another master horizon, a slash is used, as in E/B, B/E, B/C.

## SUBORDINATE DISTINCTIONS (letter suffixes)

The definitions of the revised SSM (1981) are followed, except for **c**. The following suffixes are used:

- **b** buried genetic horizon
- **c** concretions or hard non concretionary nodules
- **g** strong gleying. Most of the affected layers have low chromas (of 2 or less), or green/blue hues and many are mottled , and there should be a history of wetness.
- **k** accumulation of carbonates
- **m** cementation or induration. No restriction as to cementing material. The horizon is for more than 90 % cemented, though it may be fractured and having some roots in cracks.
- **n** accumulation of sodium. The accumulation of sodium should be expressed by visible soil profile characteristics.
- **o** residual accumulation of sesquioxides
- **p** ploughing or other disturbances
- **q** accumulation by silica
- **r** weathered or soft bedrock. Used with C horizon. Can be dug with spade.
- **t** accumulation of silicate clays. Either formed in the horizon or moved into by illuviation, in the form of coatings, lamellae or bridges.
- **v** plinthite
- **x** fragipan
- **y** accumulation of gypsum
- **z** accumulation of salts more soluble than gypsum

### Remarks

Letter suffixes are applied during the field description and are based on field observable soil profile characteristics.

The properties should occur in appreciable quantities or significant degree of development.

Suffix **c** also applies to hard calcareous nodules.

The use of **k** is not recommended for minor accumulations, described as slightly (to moderately) calcareous or very few (to few) nodules.

The recommended use of **sm** (iron cemented) is not consequent in the case of cemented residual sesquioxides and therefore **mo** (and corresponding suffixes) is used.

Suffix **w** for colour and structure development is not used as it seems largely superfluous, being almost always applicable if not one of the

other suffixes applies. The only exception would be a B horizon having 'evidence of removal of carbonates' without accompanying colour change or structure development.

**SSM versus FAO approach**

The FAO guidelines show differences in the use and definitions of letter suffixes, as compared with SSM (1981). This is the case with c, q, h, r, s and u. SSM and KST also present a larger number of subordinate distinctions of the master horizons.

Differences between FAO and SSM are as follows:

**c** accumulation of concretions without restriction to material (FAO) versus concretions or nodules with material restrictions (SSM).

**g** The FAO concept of the occurrence of mottling reflecting variations in oxidation and reduction is considered too general as it may be too weakly developed to justify a separate suffix. The occurrence of strong gleying , with or without mottles, suggesting the occurrence of an aquic moisture regime, indicated by one suffix (SSM) is prefered above the use of **g** and **r** of FAO.

**h** The use of **h** also for A horizons by FAO seems superfluous as the definition already applies to almost all A horizons, following the master horizon concept.

**r** FAO strong reduction **r** is part of SSM strong gleying **g**. SSM suffix **r** should be available to another subordinate distinction (weathered rock).

**s** FAO definition of **s** combines SSM **o** and **s**, respectively residual and illuvial accumulation of sesquioxides.

**u** FAO only, meaning unspecified. The use as to avoid confusion with former horizon notation is not considered relevant. The suffix does not give any information.

## DEPTH

Average depth of upper and lower boundaries of the horizon is given in cm. Accurate figures are given when boundaries are abrupt or clear. Rounded off figures (to the nearest 5 or 10cm) are entered when the boundaries are gradual or diffuse, in order to avoid the suggestion of a level of precision which is not there.

Most horizons do not have a constant depth, and the variation is indicated by the description by the topography of the boundary (smooth, wavy, irrigular, broken). Ranges in depth should therefore not be given, but rather the average depth.

Extremes or special cases can be recorded under remarks.

## COLOUR

Enter moist and dry matrix colour (notation US Munsell Color, 1975). Colours are recorded in the shade from broken peds (clods).
If due to abundant mottling no single matrix colour can be distinguished, the two predominant colours (moist or dry) should be given (see also under mottles).

The moisture condition and/or mottling is indicated by a code following the colour:

| | | | |
|---|---|---|---|
| **M** | Moist | **MM** | Mottled, moist |
| **D** | Dry | **MD** | Mottled, dry |

**Remarks**

It appears that colour recordings by different individuals give quite a variety of results. Since colours play an important role in classification a routine of reproducable observations should be developed.

Comparison with the chip on the colour card should be made in the shade by looking unfocused with one eye to the boundary of chip and piece of soil. Where this boundary fades and the chip and soil colour merge, the colour fits best.

Recording of intermediate colours is encouraged, especially so if this makes sense for the distinction of the soil horizons and the classification and interpretation of the soil profile.

Intermediate hues (important for Chromic, Rhodic, colour B, etc) used are: 3.5YR, 4YR, 6YR, 6.5YR, 8.5YR and 9YR.

If values and chromas are near diagnostic values, rounded off figures should never be used, but precise recordings should be made by using intermediate values, or by adding a + and - .

Some important diagnostic values are:

Value 4 and 5: Albic horizons and hydromorphic properties
3.5 and 5.5: Mollic Horizons

Chroma 1 and 2: Hydromorphic properties
2: Chernozems
1.5: Vertisols
3.5: Mollic and Umbric horizons
4: Chromic

## MOTTLES

Mottles are described according to FAO (1977). Two types of mottles can be recorded. Note that rusty colours along rootchannels are not considered as mottles.

### ABUNDANCE

| | | |
|---|---|---|
| 0 | Nil | - No mottles observed. |
| F | Few | - Mottles occupy less than about 2% of the exposed surface. |
| C | Common | - Mottles occupy about 2 to 20% of the exposed surface. |
| M | Many | - Mottles occupy more than 20% of the exposed surface. |

When mottles are so abundant that it is not possible to distinguish a single predominant matrix colour, the two predominant colours should be entered under colour (see colour).

### MOTTLES SIZE

There are three classes to indicate approximate diameters of individual mottles. These classes now correspond with the new size classes of mineral nodules.

| | | |
|---|---|---|
| F | Fine | - Mottles less than 5mm along greatest dimension. |
| M | Medium | - Mottles range between 5 and 15mm along greatest dimension. |
| C | Coarse | - Mottles are greater than 15mm along greatest dimension. |

### MOTTLES CONTRAST

Colour contrast between mottles and matrix.

| | | |
|---|---|---|
| F | Faint | - Indistinct mottles are evident and recognizable only with close examination. Soil colours in both the matrix and mottles have closely related hues and chromas. |
| D | Distinct | - Although not striking, the mottles are readily seen. The hue value and chroma of the matrix are easily distinguished from those of the mottles. They may vary as much as one or two hues or several units in chroma or value. |
| P | Prominent | - The conspicious mottles are obvious and mottling is one of the outstanding features of the horizon. Hue, chroma and value may be several units apart. |

### SHARPNESS OF BOUNDARIES

| | | |
|---|---|---|
| S | Sharp | Knive-edge boundaries between colours. |
| C | Clear | Colour transition less than 2mm wide. |
| D | Diffuse | Colour transition extends over more than 2mm. |

### COLOUR OF MOTTLES

The colour of the mottles is described by the following main standard colours as defined in the Munsell Soil Color Charts (Munsell, 1975).

| | | | |
|---|---|---|---|
| **W** | White | **RY** | Reddish yellow |
| **R** | Red | **Y** | Yellow |
| **RS** | Reddish | **GR** | Greenish |
| **YR** | Yellowish red | **G** | Gray |
| **RB** | Reddish brown | **GS** | Grayish |
| **YB** | Yellowish Brown | **B** | Bluish-black |
| **BR** | Brown | **N** | Black |
| **BS** | Brownish | | |

## TEXTURE

For describing the texture of the fine earth fraction the basic terminology of SSM (1951) and FAO (1977) is used (see below). The code of the textural class is entered on the first line. The second line is only used when transgrades are described, e.g. sand to loamy sand.

The original field estimate is kept in the final description, also if not confirmed by the analytical results.

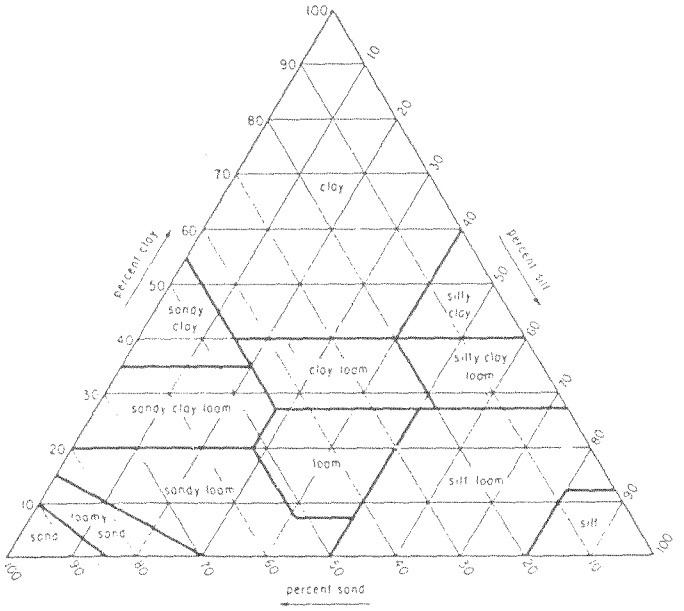
In addition an estimate of the percentage of clay is given. This estimate is useful to indicate clay increases or decreases within textural classes, and to compare field estimates with analytical results.

The texture of the fraction over 2mm (gravel, stones, boulders) is no longer entered under texture, since it is already described under rock fragments.

### TEXTURAL CLASSES

Note that the definitions of the sand subclasses are modified for specific Botswana conditions. A full explanation is given below. Other definitions are according to FAO (1977).

| | | | |
|---|---|---|---|
| **C** | Clay | **LS** | Loamy sand |
| **L** | Loam | **LVS** | loamy very fine sand |
| **CL** | Clay loam | **LFS** | Loamy fine sand |
| **SI** | Silt | **LFMS** | Loamy fine-medium sand |
| **SIC** | Silty clay | **LCS** | Loamy coarse sand |
| **SICL** | Silty clay loam | | |
| **SIL** | Silt loam | **S** | Sand |
| **SC** | Sandy clay | **VS** | Very fine sand |
| **SCL** | Sandy clay loam | **FS** | Fine sand |
| **SL** | Sandy loam | **FMS** | Fine-medium sand |
| **VSL** | Very fine sandy loam | **CS** | Coarse sand |
| **FSL** | Fine sandy loam | | |
| **FMSL** | Fine-medium sandy loam | | |
| **CSL** | Coarse sandy loam | | |




**Subdivision of sand fraction**

Sands, loamy sands and sandy loams are subdivided according to the proportions of very coarse/coarse, medium, fine and very fine sand in the sand fraction. The proportions are calculated from the particle size distribution, taking the total of the sand fraction as 100%.

Reading as a key, new definitions are as follows:

| | |
|---|---|
| **Very fine sand** | - 50% or more very fine sand |
| **Fine sand** | - 50% or more very fine and fine sand, and less than 25% coarse sand. |
| **Fine-medium sand** | - 35 % or more very fine and fine sand, and less than 15% of coarse/very coarse sand. |
| **Coarse sand** | - 25% or more very coarse and coarse sand, and less than 50% medium sand. |
| **Sand** | - other |

The subclasses are shown in triangular diagram 2.

Different subdivisions of sand, loamy sands and sandy loams as in SSM (1951) and FAO (1977) are not considered practical.

The new subclass of fine-medium sand has been defined to separate fine-medium windblown Kalahari sands from other sands.

**Remarks**

Reasons for changing the sand subclass definitions are the following:
(1) The SSM (and FAO) definitions are not mutually exclusive (e.g. sand and coarse sand).
(2) The proportion of the total fine sand and very fine sand is not satisfactory reflected. This, however, governs important soil physisal properties such as available water holding capacity and influences land evaluation procedures.

The following examples show that the SSM definitions are not satisfactory.

(a) Examples of sands with a considerable coarse fraction:

| | C/VC | M | F | VF | SSM/FAO |
|---|---|---|---|---|---|
| (a1) | 40 | 55 | 5 | | sand |
| (a2) | 30 | 40 | 30 | | coarse sand |
| (a3) | 30 | 20 | 50 | | fine sand |
| (a4) | 30 | 20 | 25 | 25 | coarse sand |

Classification of (a2) as a coarse sand is not satisfactory as it is definitely finer compared to (a1) classified as sand. Example (a3) represents an unlikely natural sorting , which would be difficult to classify.In comparing however, is does not seem logical to classify the finer (a4) as a coarse sand.

b) Examples of sands with a considerable fine fraction:

| | C/VC | M | F | VF | SSM/FAO |
|---|---|---|---|---|---|
| (b1) | 30 | 10 | 60 | | fine sand |
| (b2) | 30 | 10 | 30 | 30 | coarse sand |
| (b3) | 10 | 30 | 60 | | fine sand |
| (b4) | 10 | 30 | 40 | 20 | sand |

Similar conclusions can be reached, (b2) is finer than (b1) and (b4) is finer than (b3).

**Diagram 2. New sand subclasses**

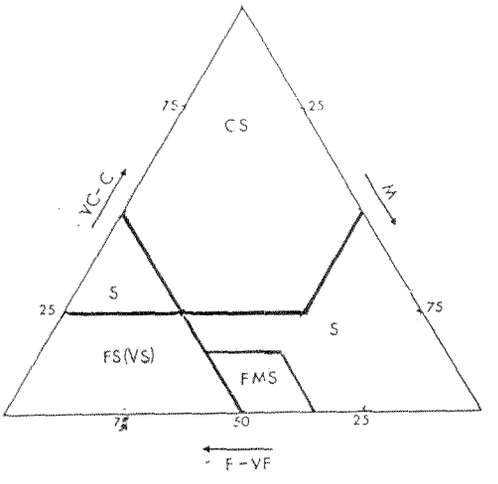
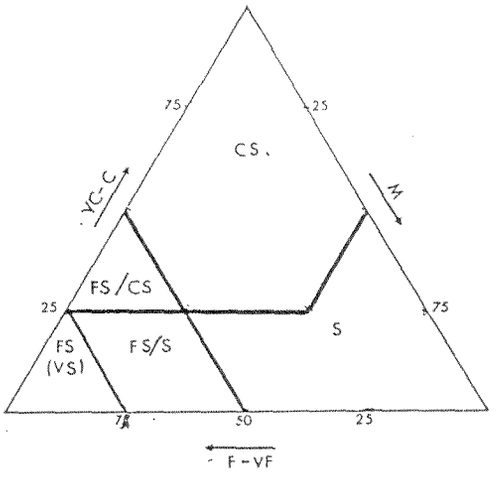



**Diagram 3. SSM/FAO sand subclasses**




| | | | |
|---|---|---|---|
| **VS** | Very fine sand | **FS/CS** | fine or coarse sand depending on proportion fine and very fine sand. |
| **FS** | Fine sand | | |
| **FMS** | Fine-medium sand | **FS/S** | fine sand or sand depending on proportion fine and very fine sand. |
| **S** | Sand | | |
| **CS** | coarse sand | | |

## STRUCTURE

The soil structure is decribed according to SSM (1951) and FAO (1977). The structure is often difficult to determine when the soil profile is moist to wet. If possible, an estimate should be made of the structure (especially the grade) as it would be in a dry or slightly moist state, e.g. by comparison with similar profiles. Additional observations can be made by revisiting the profile.

Two structure types can be entered for each horizon. In general this is sufficient to describe compound structures (with a primary and secondary structure), otherwise additional information can be added under remarks.

### STRUCTURE GRADE

The following classes are used to describe the grade of structure:

| | | |
|---|---|---|
| **SG** | Single grain | - Structureless with a loose consistency. |
| **WC** | Weakly coherent | - Structureless with a soft to slightly hard consistency. |
| **MC** | Moderately coherent | - Massive with a hard consistency, including transitions to slightly and very hard. |
| **SC** | Strongly coherent | - Massive with a very hard to extremely hard consistency. |
| **VW** | Very weak | |
| **WE** | Weak | |
| **WM** | Weak to moderate | |
| **MO** | Moderate | |
| **MS** | Moderate to strong | |
| **ST** | Strong | |
| **VS** | Very strong | |

Definitions of the terms for grade of structure are according to SSM (1951) and FAO (1977):

**Structureless/massive**: That condition in which there is no observable aggregation or no definite orderly arrangement of natural lines of weakness.
**Weak**: That degree of aggradation characterized by poorly formed indistinct peds that are barely observable in place. When disturbed, soil material that has this grade of structure breaks into a mixture of few entire peds, many broken peds, and much unaggregated material.
**Moderate**: That degree of structure characterized by well-formed distinct peds that are moderately durable and evident but not distinct in undisturbed soil. Soil material of this grade, when disturbed, breaks down into a mixture of many distinct entire peds, some broken peds, and little unaggregated material.
**Strong**: That grade of structure characterized by durable peds that are quite evident in undisturbed soil, that adhere weakly to one another, and that withstand displacement and become separated when the soil is disturbed. When removed from the profile, soil material of this grade of structure consists very largely of entire peds and includes few broken peds and little or no aggregated material.

## SIZE OF STRUCTURE

The size classes follow the definitions in SSM (1951) and FAO (1977). Note that the size classes vary with the structure type and that for prismatic, columnar and platy structures the size classes refer to the measurements of the smallest dimension.

| | | | |
|---|---|---|---|
| **VF** | Very fine | **C** | Coarse |
| **FF** | Fine and very fine | **CV** | Coarse and very coarse |
| **F** | Fine | **VC** | Very coarse |
| **FM** | Fine and medium | **FC** | Fine to coarse |
| **M** | Medium | **MV** | Medium to very coarse |
| **MC** | Medium and coarse | | |

**Size classes (mm)**

| | Platy | Prismatic Columnar | Ang blocky Sub blocky | Granular | Crumb |
|---|---|---|---|---|---|
| very fine | < 1 | < 10 | < 5 | < 1 | < 1 |
| fine | 1 - 2 | 10 - 20 | 5 - 10 | 1 - 2 | 1 - 2 |
| medium | 2 - 5 | 20 - 50 | 10 - 20 | 2 - 5 | 2 - 5 |
| coarse | 5 -10 | 50 -100 | 20 - 50 | 5 - 10 | |
| very coarse | > 10 | > 100 | > 50 | > 10 | |

## TYPE OF STRUCTURE

The following structure types are distinguished:

| | | | |
|---|---|---|---|
| **GR** | Granular | **SB** | Subangular blocky |
| **CR** | Crumb | **AS** | Angular and subangular blocky |
| **PR** | Prismatic | **SA** | Subangular and angular blocky |
| **CO** | Columnar | **PL** | Platy |
| **AB** | Angular blocky | **RS** | Rock structure |
| **AW** | Angular blocky, including wedge shaped | | |

Definitions are according to SSM (1951) and FAO (1977):

**Granular**: Spheroids or polyhedrons, with the three dimensions in the same order of magnitude, having plane or curved surfaces which have slight or no accomodation to the faces of surrounding peds. Relatively non-porous peds.
**Crumb**: as granular, but with porous peds.
**Angular blocky**: blocks or polyhedrons, with the three dimensions of the same order of magnitude, having plane or curved surfaces that are casts of the molds formed by the faces of the surrounding peds. Faces flattened; most vertices sharply angular.
**Subangular blocky**: As angular blocky, but with mixed rounded and flattened faces with many rounded vertices.
**Prismatic**: Two horizontal dimensions limited and considerably less than the vertical; arranged around a vertical line; vertical faces well defined; vertices angular. Without rounded caps.
**Columnar**: As prismatic, but with rounded caps.
**Platy**: Vertical dimension limited and greatly less than the other two; arranged around an horizontal plane; faces mostly horizontal.

### RELATION 1st AND 2nd STRUCTURE

If a second structure is described its relation to the first structure is indicated:

| | |
|---|---|
| + | The first and second structure alternate, e.g. columnar and prismatic structure. |
| > | Primary structure falls apart into the secundary structure. |
| / | The first structure merges to the second structure, e.g platy merges to prismatic. |

## CONSISTENCE

The consistence is described acccording to SSM (1951) and FAO (1977). For routine descriptions normally only the natural moisture condition of the profile is described. For reference profiles (Status 1) a full description is required.

### CONSISTENCE DRY

Determined by breaking an air dry mass between thumb and forefinger or in the hand:

| | | | |
|---|---|---|---|
| **LO** | Loose | **HA** | Hard |
| **SO** | Soft | **HV** | Hard to very hard |
| **SS** | Soft to slightly hard | **VH** | Very hard |
| **SH** | Slightly hard | **EH** | Extremely hard |
| **HH** | Slightly hard to hard | | |

**Loose**: Noncoherent
**Soft**: Soil mass is very weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.
**Slightly hard**: Weakly resistant to pressure; easily broken between thumb and forefinger.
**Hard**: Moderately resistant to pressure; can be broken in the hands without difficulty but is barely breakable between thumb and forefinger.
**Very hard**: very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger.
**Extremely hard**: extremely resistant to pressure; can not be broken in the hands.

### CONSISTENCE MOIST

Determined by attempting to crush a mass of moist or slightly moist soil material.

| | | | |
|---|---|---|---|
| **LO** | Loose | **FM** | Firm |
| **VF** | Very friable | **FV** | Firm to very firm |
| **VV** | Very friable to friable | **VM** | Very firm |
| **FR** | Friable | **EM** | Extremely firm |
| **FF** | Friable to firm | | |

**Loose**: Noncoherent
**Very friable**: Soil material crushes under very gentle pressure, but

coheres when pressed together.
**Friable**: Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together.
**Firm**: Soil material crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.
**Very firm**: Soil material crushes under strong pressure; barely crushable between thumb and forefinger.
**Extremely firm**: Soil material crushes only under very strong pressure; can not be crushed between thumb and forefinger, and must be broken apart bit by bit.

## CONSISTENCE WET - STICKINESS

Determined when the soil is wet (at or slighly above field capacity). Stickiness is the quality of adhesion of the soil material to other objects. Determined by noting the adherence of soil material when it is pressed between thumb and finger.

| | | | |
|---|---|---|---|
| **NS** | Non sticky | **ST** | Sticky |
| **SS** | Slightly sticky | **SV** | Sticky to very sticky |
| **SL** | Slightly sticky to sticky | **VS** | Very sticky |

**Non sticky**: After release of pressure, practically no soil material adheres to thumb and finger.
**Slightly sticky**: after pressure soil material adheres to both thumb and finger but comes off one or the other rather cleanly. It is not appreciable stretched when the digits are separated.
**Sticky**: After pressure soil material adheres to both thumb and finger and tends to stretch somewhat and pull apart rather than pulling free from either digit.
**Very sticky**: after pressure, soil material adheres strongly to both thumb and finger and is decidedly stretched when they are separated.

## CONSISTENCE WET - PLASTICITY

Determined when the soil is wet (at or slightly above field capacity). Plasticity is the ability of soil material to change shape continuously under the influence of an applied stress and to retain the impressed shape on removal of stress. Determined by rolling the soil between thumb and forefinger.

| | | | |
|---|---|---|---|
| **NP** | Non plastic | **PL** | Plastic |
| **SP** | Slightly plastic | **PV** | Plastic to very plastic |
| **PP** | Slightly plastic to plastic | **VP** | Very plastic |

**Non plastic**: No wire is formable.
**Slightly plastic**: Wire formable but soil mass easily deformable.
**Plastic**: Wire formable and moderate pressure required for deformation of the soil masss.
**Very plastic**: Wire formable and much pressure required for deformation of the soil mass.

## CUTANS

Under this item cutans, slickensides, pressure faces and lamellae of clay are described. Two types can be entered, use remarks if more space is required for details on e.g. colour or lamellae (depth of occurrence, frequency, intervals).

### QUANTITY OF CUTANS

| | | |
|---|---|---|
| 0 | Nil | - No cutans observed. |
| P | Patchy | Cutans occur in scattered patches on pedfaces (less than approximately 25%). |
| B | Broken | - Cutans cover considerable parts of pedfaces (approximately 25 - 50%). |
| C | Continuous | - Cutans cover the predominant part of pedfaces (more than approximately 50%). |

### THICKNESS OF CUTANS

Thickness of pressure faces and slickensides is not described.

| | | |
|---|---|---|
| **TH** | Thin | - Surface of cutans shows only little contrast, especially in smoothness, with the adjacent pedface. Fine sand grains are readily apparent in the cutan<br>- Lamellae less than 3mm thick. |
| **MO** | Moderately- | Surface of cutans is distinctly smoother than adjacent thick pedface.Fine sand grains are enveloped in the cutan and their outlines are indistinct.<br>- Lamellae between 3 and 7mm thick. |
| **TK** | Thick | - Surface of cutan is smooth showing no outlines of fine sand grains.<br>- Lamellae more than 7mm thick. |

### NATURE OF CUTANS

| | |
|---|---|
| **C** | Clay |
| **CS** | Clay and sesquioxides |
| **CH** | Clay and humus (organic matter) |
| **PF** | Pressure faces |
| **S** | Slickensides, non intersecting |
| **SP** | Slickensides, partly intersecting |
| **SI** | Slickensides, predominantly intersecting |

### LOCATION OF CUTANS

Enter location of the cutans or clay accumulation. For pressure faces and slickensides no location is indicated since they are by definition located on pedfaces.

| | | | |
|---|---|---|---|
| **P** | Pedfaces | **LA** | Lamellae (clay bands) |
| **PV** | Vertical pedfaces | **PO** | Pores |
| **PH** | Horizontal pedfaces | **RA** | Random |

## CEMENTATION

The following terms are used to describe the degree of cementation:

| | | |
|---|---|---|
| 0 | Non cemented | |
| W | Weakly cemented | - Cemented mass is brittle and hard but can be broken in the hands. |
| P | Partly cemented | - In parts (less than 90%) cemented, can not be broken in the hands. |
| C | Cemented | - Cemented mass can not be broken in the hands (comparable with suffix **m**). |

## PORES

The description of pores is simplified as compared to FAO (1977). It is our experience that continuity, orientation, distribution and morphology can not adequately be described in the field, and are therefore better left out from the routine description. Two abundance/size combinations can be entered.

### ABUNDANCE OF PORES

| | | |
|---|---|---|
| **0** | Nil | - No pores observed |
| **F** | Few | - 1 - 50 pores per square decimeter |
| **C** | Common | - 50 - 200 pores per square decimeter |
| **M** | Many | - More than 200 pores per square decimeter |

The quantitative figures should only be used as a guide. The relative amounts within the profile should be given rather than exact measurements.

### SIZE OF PORES

| | | | |
|---|---|---|---|
| **VF** | Very fine | - < 1mm | |
| **FF** | Fine and very fine | | |
| **F** | Fine | - 1-2mm | |
| **FM** | Fine and medium | | |
| **M** | Medium | - 2-5mm | |
| **MC** | Medium and coarse | | |
| **C** | Coarse | - >5mm | |

## ROCK FRAGMENTS

Abundance, grade of weathering and shape of large particles (>2mm) are described according to FAO (1977). The size classes used are more detailed than those given in FAO (1977). The class limits correspond with those of the size classes of surface stones.

### ABUNDANCE OF ROCK FRAGMENTS

| | | | | | |
|---|---|---|---|---|---|
| **0** | None | | **FQ** | Frequent | - 15-40% |
| **VF** | Very few | - < 5% (by volume) | **VQ** | Very frequent | - 40-80% |
| **F** | Few | - 5-15% | **DO** | Dominant | - >80% |

### SIZE OF ROCK FRAGMENTS

| | | | | | |
|---|---|---|---|---|---|
| **F** | Fine | < 2cm | **C** | Coarse | 7.5-12cm |
| **FM** | Fine and medium | | **CV** | Coarse and very coarse | |
| **M** | Medium | 2-7.5cm | **VC** | Very coarse | 12-25cm |
| **MC** | Medium and coarse | | **EC** | Extremely coarse | > 25cm |

### SHAPE OF ROCK FRAGMENTS

Describe shape of the rock fragments by one of the following terms:

| | |
|---|---|
| **R** | Rounded |
| **F** | Flat |
| **A** | Angular |

### WEATHERING

Describe state of weathering of the rock fragments:

| | | |
|---|---|---|
| **F** | Fresh/slightly weathered | - Fragments show little or no signs of weathering. |
| **W** | Weathered | - Partial weathering is indicated by discoloration and loss of crystal form in the outer parts of the fragments but the centers remain relatively fresh and the fragments have lost little of their original strength. |
| **S** | Strongly weathered | - All but the most resistant minerals are strongly discoloured and altered throughout the fragments which tend to desintegrate under only moderate pressure. |

### NATURE OF ROCK FRAGMENTS

The nature of the rock fragments is described according to the rocktype classification (see Rocktype). In addition quartz and chert are distinguished:

| | |
|---|---|
| **QU** | Quartz |
| **CH** | Chert |

## MINERAL NODULES

The description of the mineral nodules follows the concept of FAO (1977). However the size classes are redefined to match the size classes of mottles.

### ABUNDANCE OF NODULES

| | | | | | |
|---|---|---|---|---|---|
| **0** | None | | **FQ** | Frequent | 15-40% |
| **VF** | Very few | < 5% (by volume) | **VQ** | Very frequent | 40-80% |
| **F** | Few | 5-15% | **DO** | Dominant | >80% |

KIND OF NODULES

| | | | |
|---|---|---|---|
| **C** | Concretions | **S** | Soft segregations |
| **T** | Crystals | **N** | Nodules |

**Concretion**: A discrete body with a concentric internal structure, generally cemented (Soil Survey Staff, 1981).
**Soft segregation** (or soft accumulation): differs from the surrounding soil in colour and composition but is not easily separated as a discrete body (Soil Survey Staff, 1981).
**Nodule**: Discrete body without an internal organisation (Soil Survey Staff, 1981).

SIZE OF NODULES

| | | |
|---|---|---|
| **F** | Fine | - Largest diameter < 5mm |
| **M** | Medium | - Largest diameter 5-15mm |
| **C** | Coarse | - Largest diameter > 15mm |

SHAPE OF NODULES

| | |
|---|---|
| **S** | Spherical (rounded) |
| **I** | Irregular |
| **A** | Angular |

HARDNESS OF NODULES

| | |
|---|---|
| **H** | Hard |
| **S** | Soft |
| **B** | Both hard and soft |

NATURE OF NODULES

Describe the composition of mineral nodules. Leave open if the composition is unknown.

| | | | |
|---|---|---|---|
| **K** | Carbonates | **Q** | Silica |
| **C** | Clay | **S** | Iron-manganese (sesquioxides) |
| **G** | Gypsum | **F** | Iron |
| | | **M** | Manganese |

COLOUR OF NODULES

The following colour names as defined in Munsell Color Charts (1975) are used to describe the colour of the nodules:

| | | | |
|---|---|---|---|
| **W** | White | **RY** | Reddish yellow |
| **R** | Red | **Y** | Yellow |
| **RS** | Reddish | **GR** | Greenish |
| **YR** | Yellowish red | **G** | Gray |
| **RB** | Reddish brown | **GS** | Grayish |
| **YB** | Yellowish brown | **B** | Bluish-black |
| **BR** | Brown | **N** | Black |
| **BS** | Brownish | | |

## CARBONATES

Calcium carbonate content tested with 10% HCL:

| | | | |
|---|---|---|---|
| **0** | Non calcareous | - | No detectable effervescence (visible or audible). |
| **SL** | Slightly calcareous | - | Effervescence audible, but not visible |
| **MO** | Moderately calcareous | - | Visible effervescence. |
| **ST** | Strongly calcareous | - | Strong visible effervescence. Bubbles form low foam. |
| **EX** | Extremely calcareous | - | Extremely strong reaction. Thick foam forms quickly. |

Note that the reaction to acid depends upon soil texture and can be expected to be more vigorous in sandy material than in fine textured material having the same carbonate content.

## BIOLOGICAL FEATURES

Two types of biological activity can be entered. In general this is sufficient to describe the most important biological features, otherwise additional information can be recorded under remarks.

### ABUNDANCE OF BIOLOGICAL FEATURES

Abundance of biological activity is recorded in the following descriptive terms:

| | | | |
|---|---|---|---|
| **0** | Nil | **C** | Common |
| **F** | Few | **M** | Many |

### KIND OF BIOLOGICAL FEATURES

| | | | |
|---|---|---|---|
| **B** | Burrows (unspecified) | **T** | Termite/ant activity (channels, nests) |
| **BO** | Open burrows | | |
| **BI** | Infilled burrows | **I** | Other insect activity |

## ROOTS

Two types of roots can be described. In general the recording of both the size and the abundance of the roots is sufficient to characterize the distribution of roots in the profile. In specific cases additional information can be entered under remarks.

### ABUNDANCE

Quantity of roots is described in the following descriptive terms:

| | | | |
|---|---|---|---|
| **0** | No roots | **C** | Common roots |
| **VF** | Very few roots | **M** | Many roots |
| **F** | Few roots | **A** | Abundant roots |

### SIZE OF ROOTS

The size of the roots is described according to FAO (1977):

| | | |
|---|---|---|
| **VF** | Very fine | - diameter < 1mm |
| **FF** | Very fine and fine | - |
| **F** | Fine | - diameter 1-2mm |
| **FM** | Fine and medium | - |
| **M** | Medium | - diameter 2-5mm |
| **MC** | Medium and coarse | - |
| **C** | Coarse | - diameter > 5mm |

## BOUNDARY

The boundary with horizon below is described according to SSM (1951) and FAO (1977).

### WIDTH OF BOUNDARY

| | | |
|---|---|---|
| **A** | Abrupt | - Boundary < 2cm wide. |
| **C** | Clear | - Boundary 2-5cm wide. |
| **G** | Gradual | - Boundary 5-12cm wide. |
| **D** | Diffuse | - Boundary > 12cm wide. |

### TOPOGRAPHY OF BOUNDARY

| | | |
|---|---|---|
| **S** | Smooth | - Boundary is nearly a plane surface. |
| **W** | Wavy | - Pockets are wider than their depth. |
| **I** | Irregular | - Pockets are deeper than their width. |
| **B** | Broken | - Horizon boundary is not continuous. |

## FIELD pH

Enter pH measured in the field (if appropriate). The method used should be indicated under remarks.

## SAMPLES

Enter sample code and sample depth.

The number given to the sample is the profile number plus an additional capital letter (A, B, C, D etc) for each of the samples taken from top to bottom, regardless the horizon they are taken from (some may not be sampled and from others more than one sample is taken). Samples are never taken across horizon boundaries. The amount of material taken per sample is 1 to 2 kg.

There are two ways of taking samples:

(1) The first is to take the sample in equal proportions over a depth of 20cm, either from the center, or the maximum expression of the horizon, or if more than one sample is taken from the same horizon, at balanced distances.

(2) The second way of sampling is to take the sample in equal proportions over a whole horizon. In this manner the whole surface of the soil profile is sampled. This method may be followed for reference (status 1) profiles where a dense sampling is required. Normally the depth of the horizon sampling should not exceed 30/40cm. This may lead to artificial splitting up of otherwise homogeneous horizons (as in the USDA practice).

In both methods the boundary and nearby area is not sampled, and in practice there will be not much difference between the two methods of sampling.

The topsoil is sampled over the first 20cm or shallower if the horizon depth is less. This is also to facilitate comparison of topsoil characteristics in land evaluation. If the possibility of a mollic horizon is raised, the sampling depth for a soil with a solum of more than 60cm thick is more than 20cm, but not exceeding 30cm (mostly it is 25cm, see also definition Mollic horizon).

Taxonomic criteria should be realized when determining the depths of sampling. To indicate the occurrence of an argillic horizon, which is defined for having a quantified clay increase over 30cm, the samples are preferably taken at this 30cm interval (e.g. A 0-20cm, B 30-50cm).
Where e.g. classification as Nitosol is a possibility, a sample must be taken at a depth of 140-160cm, in addition to one from the part of the B horizon where the clay content is estimated to be the highest.

## REFERENCES


DAMBE, D, 1987; Agro Climatic Zones in Botswana. Department of Meteorological Services, Botswana. Draft.

FAO, 1977; Guidelines for Soil Profile Description. Food and Agriculture Organization of the United Nations, Rome.

FAO/UNESCO, 1974; Soil Map of the World 1:5000000. Volume 1: Legend. United Nations Educational, Scientific and Cultural Organization, Paris.

FAO/UNESCO/ISRIC, 1988; Revised Legend of the FAO-UNESCO Soil Map of the World (Amended Final Draft). Food and Agriculture Organization of the United Nations, Rome.

MUNSELL, 1975; Munsell Soil Color Charts, Baltimore.

REMMELZWAAL, A, 1988; General Soil Legend of Botswana. FAO/UNDP/Govt. of Botswana Project BOT/85/011. Field Document.

RHEBERGEN, G.J., 1988; A system of land evaluation for arable farming in Botswana. FAO/UNDP/Govt. of Botswana Project BOT/85/011, Field Document.

SOIL SURVEY STAFF, 1951; Soil Survey Manual. United States Department of Agriculture. Washington.

SOIL SURVEY STAFF, 1975; Soil Taxonomy. A basic system of soil classification for making and interpreting soil surveys. United States Department of Agriculture. Washington.

SOIL SURVEY STAFF, 1981; Soil Survey Manual. Revised chapter 4.

SOIL SURVEY STAFF, 1987; Keys to Soil Taxonomy (third printing).SMSS technical monograph no.6. Ithaca, New York.

VAN WAVEREN, E.J., 1988; Botswana Soil Database. User manual. FAO/UNDP/Govt. of Botswana Project BOT/85/011. Field Document.

APPENDIX A: 1. Summary of codes (Field Reference Card)
2. Soil Profile Description Form
3. Printed Soil Profile Descriptions

**STATUS**

1 reference pit
2 routine pit
3 pit;incomplete
4 augering
5 other observations

**LANDFORM**

PL plain
AP alluvial plain
LP lacustrine plain
SP sandplain
PE pediment
DF dunefield
PT plateau
ES escarpment
HI hill
VA valley
AF alluvial fan
X other see remarks

**LAND ELEMENT**

NA not applicable
IF interfluve
DU dune
TD transverse dune
LD longitudinal dune
PD parabolic dune
RD barchan dune
ID interdunal depression
PA pan
DE depression
RI ridge
BE beach (ridge)
BD beach-dune complex
FP floodplain
TE terrace
BA backswamp
DT delta
CH channel
LE levee
VA valley
VF valley floor
AF alluvial fan
IS island
X other see remarks

**POSITION OF SITE**

CR crest
US upper slope
MS middle slope
LS lower slope
SL slope
HI higher part plain
IN intermediate part
LO lower part plain

**TOPOGRAPHY**

F flat
A almost flat
G gently undulating
U undulating
R rolling
H hilly
S steeply dissected

**MICRO TOPOGRAPHY**

0 even
GL gilgai low
GM - medium
GH - high
GI gilgai unspecified
TM termite mounds
AT animal tracks
AB animal burrows
HL hummocks low
HM - medium
HH - high
HU hummocks unspecied
UN uneven (unspecified)

**SLOPE FORM**

V convex
C concave
S straight

**SEALING**

0 nil
SL slight
MO moderate
ST strong

**SALTS**

0 nil
SL slight
ST strong

**BLEACHED SAND**

0 nil
Y present

**LAND USE TYPE**

U none
FR forest reserve
GR game reserve
WM wildlife man. area
DV disturbed vegetation along fields,roads
DU dryland farming
DT - traditional
DI - improved
DM - mechanized
DC - commercial
IU irrigated farming
IS - small scale
IM - medium scale
GU grazing
GT - traditional
GC - commercial
MT Molapo traditional
MI Molapo improved

**CROPS**

SO sorgum
MA maize
MI millet
WH wheat
PE peas
BE beans
GR groundnuts
SU sunflower
CO cotton
CP cowpeas
DO dolichos lablab
FO fodder crops
VE vegetables
FR fruits

**VEGETATION**

0 none
GR grassland
FL forbland
F forest
W woodland
SH shrubland
SA savanna
SAD dense
SAO - open
ST tree savanna
STD - dense
STO - open
SS shrub savanna
SSD - dense
SSO - open
SL low shrub savanna
SLD - dense
SLO - open

**GRASSCOVER**

0 0 - 10%
1 10 - 30%
2 30 - 70%
3 > 70%

**PARENT MATERIAL**

AS aeolian sand
AR aeolian red sand
AP aeolian pale sand
AL aeolian rew.lacustrine
LA lacustrine rew.aeolian
LC lacustrine
FL fluvial rew.lacustrine
AV alluvium
DE deltaic
LI littoral
CO colluvium
CA calcrete
SI silcrete
WE in situ weathered

**ROCK TYPE**

GR granite
IG intermed. granite
GN gneiss
GG granite-gneiss
QZ quartzite
SC schist
FE felsite
FV felsic volcanics
AC acid igneous/ metamorphic rock
BT basalt
DO dolerite
DI diorite
UB ultra basic rock
BA basic igneous/ metamorphic rock
CO conglomerate
SA sandstone
QS - quartzitic
FS - feldspatic
SI siltstone
SH shale
MA marl
LI limestone
DM dolomite
SE sedimentary rock
QU quartz
CH chert

**DRAINAGE**

V very poor
P poor
I imperfect
M moderately well
W well
S somewhat excessive
E excessive

**MOISTURE CONDITION**

D dry
S slightly moist
M moist
W wet

**SURFACE STONES**

**abundance**
0 nil
1 very few <2%
2 few 2-10%
3 common 10-50%
4 many 50 - 90 %
5 abundant > 90%

**size**
F fine gravel <2cm
G gravel 2- 7cm
S stones 7-25cm
B boulders >25cm

**ROCK OUTCROPS**

0 nil
VF very few
FA fairly rocky
RO rocky
VE very rocky
EX extremely rocky

**EROSION**

**intensity**
0 nil
S1 slight
MO moderate
ST strong

**type**
S sheet erosion
R rill erosion
G gully erosion
W wind erosion/ deposition
E wind erosion
D wind deposition
A accumulation by water

**HUMAN INFLUENCE**

0 nil
P ploughing
I irrigation
C clearing
B borrow pit
S surface compaction

**COLOR MODIFIER**

M moist
D dry
MM mottled moist
MD mottled dry

**MOTTLES**

**abundance**
0 none
F few <2%
C common 2-20%
M many >20%

**size**
F fine <5mm
M medium 5-15mm
C coarse >15mm

**contrast**
F faint
D distinct
P prominent

**boundary**
S sharp
C clear <2mm
D diffuse >2mm

**color**
W white
R red
RS reddish
YR yellowish-red
RB reddish-brown
YB yell.-brown
BR brown
BS brownish
RY red.-yellow
Y yellow
GR greenish
G gray
GS grayish
B bluish-black
N black

**TEXTURE**

basic codes:
C clay
SI silt
L loam
S sand
VS very fine sand
FS fine sand
FMS fine-medium sand
CS coarse sand

**STRUCTURE**

**grade**
SG single grain
WC masive weakly coherent
MC - mod. coherent
SC - strongly coherent
VW very weak
WE weak
WM weak + moderate
MO moderate
MS moderate + strong
ST strong
VS very strong

**size**
VF very fine
FF very fine + fine
F fine
FM fine+medium
M medium
MC medium + coarse
C coarse
CV coarse + v.coarse
VC very coarse
FC fine-coarse
MV medium-very coarse

**type**
GR granular
CR crumb
PR prismatic
SB subangular blocky
AB angular blocky
AW ang.blocky incl. wedge shaped
SA sub+ang blocky
AS ang+sub blocky
CO columnar
PL platy
RS rock structure

**relation I->II**
+ and
> falls apart
/ to

**CONSISTENCY**

**dry**
LO loose
SO soft
SS soft-slightly hard
SH slightly hard
HH slightly hard-hard
HA hard
HV hard-very hard
VH very hard
EH extremely hard

**moist**
LO loose
VF very friable
VV very fr-friable
FR friable
FF friable-firm
FM firm
FV firm-very firm
VM very firm
EM extremely firm

**stickiness**
NS non sticky
SS slightly sticky
SL sl.sticky-sticky
ST sticky
SV sticky-very sticky
VS very sticky

**plasticity**
NP non plastic
SP slightly plastic
PP sp-plastic
PL plastic
PV pl-very plastic
VP very plastic

**CUTANS**

**quantity**
0 none
P patchy
B broken
C continuous

**thickness**
TH thin
MO moderately thick
TK thick

**nature**
C clay
CS clay-sesquioxides
CH clay-humus
PF pressure faces
S slickensides
SP partly intersecting slickensides
SI intersecting slickensides

**location**
P pedfaces
PV vertical pedfaces only
PH horizontal pedfaces only
PO pores
LA lamellae
RA random

**CEMENTATION**

0 non cemented
W weakly cemented
P partly cemented
C cemented

**PORES/ROOTS**

**abundance**
0 nil
VF very few (roots only)
F few
C common
M many
A abundant (roots only)

**size**
VF very fine <1mm
FF very fine+fine
F fine 1-2mm
FM fine+medium
M medium 2-5mm
MC medium+coarse
C coarse > 5mm

**ROCK FRAGMENTS**

**abundance**
0 none
VF very few <5%
F few 5-15%
FQ frequent 15-40%
VQ very fq 40-80%
DO dominant >80%

**size**
F fine < 2cm
FM fine+medium
M medium 2-7.5cm
MC medium+coarse
C coarse 7.5-12cm
CV coarse+v.coarse
VC very coarse 12-25cm
EC extremely coarse >25cm

**shape**
R rounded
F flat
A angular

**weathering**
F fresh-slightly weathered
W weathered
S strongly weath.

**nature**
see rocktype

**MINERAL NODULES**

**abundance**
see rock fragments

**kind**
C concretions
T crystals
S soft segregation
N nodules

**size**
F fine < 5mm
M medium 5-15mm
C coarse >15mm

**shape**
S spherical
I irregular
A angular

**hardness**
S soft
H hard
B both

**nature**
K carbonates
C clay
G gypsum
Q silica
S iron-manganese
F iron
M manganese

**color**
see mottles

**CARBONATES**

0 non calcareous
SL slightly calc.
MO moderately calc
ST strongly calc.
EX extremely calc.

**BIOL FEATURES**

**abundance**
see pores

**kind**
B burrows
BO burrows, open
BI burrows, infilled
T termite/ant act.
I other insect act.

**BOUNDARY**

**width**
A abrupt < 2cm
C clear 2-5cm
G gradual 5-12cm
D diffuse >12cm

**topography**
S smooth
W wavy
I irregular
B broken

## TREES AND SHRUBS

ABL Abutilon lycioides
AAL Acacia albida
AAM Acacia arenaria
AAT Acacia ataxacantha
ABU Acacia burkei
ACA Acacia caffra
AER Acacia erioloba
AEB Acacia erubescens
AFL Acacia fleckii
AGA Acacia galpinii
AGE Acacia gerrardii
AGR Acacia grandicornuta
AHA Acacia haematoxylon
AHE Acacia hebeclada
AHR Acacia hereroensis
AKA Acacia karroo
AKI Acacia kirkii
ALU Acacia luederitzii var.luederitzii
ALR Acacia luederitzii var.retinens
AME Acacia mellifera
ANE Acacia nebrownii
ANG Acacia nigrescens
ANL Acacia nilotica
APE Acacia permixta
APO Acacia polyacantha
ARH Acacia rehmanniana
ARO Acacia robusta
ASC Acacia schweinfurthii
ASE Acacia senegal var.feiorachis
ASR Acacia senegal var.rostata
ASI Acacia sieberana
AC Acacia sp.
AST Acacia stuhlmanii
ATE Acacia tenuispina
ATO Acacia tortilis subs. heterocantha
ATS Acacia tortilis subs. spirocarpa
AXA Acacia xanthophloea
ADD Adansonia digitata
AFQ Afzelia quanzensis
ALV Albezia versicolor
ALA Albizia anthelmintica
ALH Albizia harveyi
AL Albizia sp.
AOM Aloe marlothii
BBH Babiana hypogea
BKP Baikiaea plurijuga
BPM Baphia massaiensis
BPO Baphia obovato
BUP Bauhinia petersiana
BUT Bauhinia tonningii
BQM Bequaertiodendron megalismontanum
BED Berchemia discolor
BOS Bolusanthus speciosus
BSA Boscia albitrunca
BSF Boscia foetida subsp. rehmanniana
BSM Boscia mossambicensis
BRB Brachystegia boehmii
BRS Brachystegia spiciformis
BIM Bridelia mollis
BUA Burkea africana
CSB Carissa bispinosa
CAA Cassia abbriviata
CTA Catophractes alexandri
CLM Colophospermum mopane
COB Combretum albopunctatum
COA Combretum apiculatum
COG Combretum elaegnoides
COE Combretum erythrophyllum
COF Combretum fragrans
COH Combretum hereroense
COI Combretum imberbe
COL Combretum molle
COM Combretum mossambicense
COZ Combretum zeyheri
CMA Commiphora africana
CML Commiphora angolensis
CME Commiphora edulis
CMO Commiphora mollis
CMM Commiphora mossambicensis
CMG Commiphora pyracanthoides subsp. glandulosa
CMP Commiphora pyracanthoides subsp. pyracanthoides
CMS Commiphora schimperi
CM Commiphora sp.
CRG Croton gratissimus
CRM Croton megalobotrys
CRY Croton menyharthii
CR Croton sp.
DAE Dialium engleranum
DRC Dichrostachys cinerea
DPL Diospyros lycioides
DPM Diospyros mespiliformis
DSC Diplorhynchus condylocarpon
DMR Dombeya rotundifolia
EHA Ehretia amoena
EHR Ehretia rigida
ELG Elephantorrhiza goetzei
ELB Elephantorrhizia burkei
ENC Entandrophragma caudatum
EYA Erythrophleum africanum
EUD Euclea divinorum
EUN Euclea natalensis
EUU Euclea undulata
EP Euphorbia sp.
FAS Fauria saligna
FIC Ficus capensis
FIO Ficus soldanella
FIS Ficus sycomorus
FIV Ficus verruculosa
FRO Friesodietsia obovato
GAL Garcinia livingstonei
GDR Gardenia resinflua
GDV Gardenia volkensii
GRB Grewia bicolor
GRF Grewia flava
GRV Grewia flavescens
GRM Grewia monticola
GRO Grewia occidentalis
GRR Grewia retinervis
GR Grewia sp.
GRS Grewia subspathulata
GUC Guibourtia coleosperna
HYC Hyphaene natalensis
HY Hyphaene sp.
HYV Hyphaene ventricosa
JUG Julbernardia globiflora
KGA Kigelia africana
KIA Kirkia acuminata
KI Kirkia sp.
LAD Lannea descolor
LAS Lannea stuhlmannii
LOC Lonchocarpus capassa
LON Lonchocarpus nelsii
LYA Lycium arenicolum
LY Lycium sp.
MEA Maerua angolensis
MRA Markhamia acuminata
MAH Maytenus heterophylla subsp.heterophylla
MAS Maytenus senegalensis
MAT Maytenus tenuispina
MIZ Mimusops zegheri
MUS Mundulea sericea
OAP Ochna pulchra
OLA Olea africana
OSM Ostiospermum muricatum
OTS Ostryoderrus stuhmannii
OZP Ozoroa paniculosa
PAC Pappea capensis
PVZ Pavetta zeyheri
PEA Peltophorum africanum
PXR Phoenix redinata
PHR Phyllanthus reticulatus
PIT Piliostigma tonningii
PPO Popowia obovata
POH Pouzalzia hypoleuca
PRG Protea gaguedi
PTA Pterocarpus angolensis
RGB Rhigozum brevispinosum
RGT Rhigozum trichotomum
RHA Rhus lancea
RHL Rhus leptodictya
RHU Rhus lucens
RHP Rhus pyroides
RH Rhus sp.
RHT Rhus tenuinervis
RIR Ricinodendron rautanenii
SCC Sclerocarya caffra
SAB Scotia brachypetala
SEL Securidaca longi-pedunculata
SRV Securinega virosa
SSL Sesamothamnus lugardii
SO Solanum sp.
SPA Spirostachys africana
STA Steganotaenia araliacea
STC Strychnos cocculoides
STP Strychnos pungens
SWM Swartzia madagascariensis
SYG Syzyguim guinecense var barotsense
TAC Tarchonanthus camphoratus
TES Tephrosia sericea
TMP Terminalia prunioides
TMR Terminalia randii
TMS Terminalia sericea
VAL Vangueria infausta
VIZ Vitex zeyheri
XAZ Xanthocercis zambesiaca
XIA Ximenia americana
XIC Ximenia caffra
ZIM Ziziphus mucronata

## FORBS

ALL Aloe littoralis
AL Aloe spp
ASF Asclepias fruticosa
AM Amaranthus spp
AP Asparagus spp
AGM Argemone mexicana
BAE Bauhinia esculenta
BO Boophone spp
BLG Blumea gariepina
CAI Cassea italica
CIP Ciniclia polycephala
CRS Crotolaria spastioides
DPG Dipeadi glaucum
DTS Datura stramonium
DTF Datura ferox
GE Geigeria sp
GNP Gnidia polycephola
HAP Harpagophytum procumbens
IN Indigoferra spp
OTB Otoplera burchelli
PGE Pergularia extensa
SA Sansevieria sp
SRV Sarcostemma vinimale
SOI Solanum incanum
SOK Solanum kwebense
SON Solanum nigrens
TAM Tagetes minuta
TBT Tribulus terrestris
XAS Xanthium spinosum

## GRASSES

ANA Andropogon amplectens
ANE Andropogon eucomus
ATA Antephora argentea
ATP Antephora pubescens
ARB Aristida brevifolia
ARC Aristida ciliata
ARA Aristida congesta
ARM Aristida meridionalis
ARN Aristida namaquensis
AR Aristida sp.
ARS Aristida stipitata
ARU Aristida uniplumis
BTR Bothriochloa radicans
BRD Brachiaria deflexa
BRM Brachiaria marlothii
BRN Brachiaria nigropedata
CEC Cenchrus ciliaris
CHG Chloris gayana
CHM Chloris myrostachya
CH Chloris sp.
CHV Chloris virgata
CSM Chrysopogon montanus
CYE Cymbopogon excavatus
CYM Cymbopogon marginatus
CYP Cymbopogon plurinodes
CND Cynodon dactylon
DAA Dactyloctenium aegyptium
DAG Dactyloctenium gigantium
DNG Danthonia glauca
DCA Dichanthium annulatum
DCP Dichanthium papillosum
DIE Digitaria eriantha
DIM Digitaria milanjiana
DIP Digitaria pentzii
DIV Digitaria pentzii var. stolonifera
DIS Digitaria setivalva
DI Digitaria sp.
ECH Echinochloa holubii
ECP Echinochloa pyramidalis
ELA Eleusine africa
EYA Elyonurus argenteus
ENC Enneapogon cenchroides
ENS Enneapogon scoparium
ER Erachrostis sp.
ERA Eragrostis atherstonii
ERB Eragrostis biflora
ERC Eragrostis ciliaris
ERF Eragrostis colifera
ERD Eragrostis denudata
ERE Eragrostis echinochloidea
ERG Eragrostis gummiflua
ERL Eragrostis lehmannniana
ERP Eragrostis pallens
ERR Eragrostis rigidior
ERO Eragrostis rotifer
ERS Eragrostis superba
EUP Eustachys paspaloides
FIA Fingerhuthia africana
HEC Heteropogon contortus
HPF Hyparrhenia filipendula
HPH Hyparrhenia hirta
HYD Hyperthelia dissoluta
IMC Imperata cylindrica
ISB Ischaemum brachyatherum
MEA Megaloprotachne albescens
ODP Odyssea paucinervis
ORC Oropetium capense
PAC Panicum coloratum
PAK Panicum kalaharense
PAL Panicum lanides
PAM Panicum maximus
PAE Panicum meyerianum
PAN Panicum novemnerve
PAR Panicum repens
PA Panicum sp.
PEP Pennisetum purpureum
PRP Perotis patens
PHC Phragmites communis
POS Pogonarthria squarrosa
RHR Rhynchelytrum repens
RHV Rhynchelytrum villosum
SCB Schmidtia bulbosa
SCK Schmidtia kalahariensis
SCP Schmidtia pappophoroides
SEP Setaria pallide-fusca
SES Setaria sphacelata
SEV Setaria verticillata
SOV Sorghum verticilliflorum
SPV Sporobolus festivus
SPF Sporobolus fimbriatus
SPI Sporobolus ioclados
SPP Sporobolus pyramidalis
SPR Sporobolus rangei
SPS Sporobolus spicatus
STU Stipachrostis uniplumus
STA Stipagrostis amabilis
STS Stipagrostis stipitata
THT Themeda triandra
TGB Tragus berteronianus
TGR Tragus racemosus
TCM Tricholaena monachne
TNG Trichoneuro grandiglumis
TPA Tripogon abyssinicus
TRA Triraphis andropogonoides
TRS Triraphis schlechteri
URS Urelytrum squarrosum
UCD Urochloa bolbodes
UCR Urochloa brachyura
UCM Urochloa mosambiscensis
UCT Urochloa trichopus

SOIL DESCRIPTION SHEET | SOIL SURVEY OF BOTSWANA | FAO BOT/85/011 | No. PA 000 1

ACZ 1B1 | SHEET 1825 A4 | GRID REF LK 360742 | UNIT L25 B1 | STATUS 2

LOC Kgale/Mwane Seloko (N. plain) TRAVERSE 6. 0.9 km W

COORD. S 24 19 06 (DEG MIN SEC) E 25 26 57 (DEG MIN SEC) | DATE 03 04 84 (DAY MONTH YEAR) | AUTHOR(S) AR KR TDM

CLASSIFICATION FAO VP (UNIT PHASE) (1974) VRP (REV) Pellic Vertisol / Pellic Vertisol

ST VUL AA (GREAT GR SUB GR PART MIN STR SR) Typic Pellustert | SMR 9

DIAGN. HOR. Ochric Cambic

ELEV 1070 | LANDFORM LP | LAND ELEMENT AA | POSITION LP

TOPO F | MICROTOPO GH | SLOPE 0 0.1 (MIN MAX) | FORM

SEALING 0 | CRACKS 5 | SALT 0 | BLEACHED SAND 0

LAND USE 0 | CROPS | VEGETATION STRUCT. 5L 0 | GRASS COVER 2

TREES (DOMINANT OTHER) | SHRUBS CLM ANL AGE (DOMINANT OTHER)

GRASSES/FORBS HPH (DOMINANT OTHER)

PARENT MATERIAL LC | OVER | ROCK TYPE | GEOL. UNIT

DRAINAGE P | MOIST. COND. M 0 (CON) 25 (TO) 5 (CON) 22 (TO) 0 (CON) (TO)

STONES 3 G | ROCK OUTCROPS 0 | EROSION/DEP I 0 (INT TYPE) II (INT TYPE) | HUMAN INF. 0

REMARKS After recent rains few cracks in topsoil. Cracks in B horizon 3cm. wide. Less from 80cm. One month earlier wide surface cracks. Augering from 100cm depth.

| DESIGNATION | DEPTH UP/LOW | COLOUR I/II HUE | VALUE | CHROMA | MOD | MOTTLES I/II AB | SI | CO | BO | COLOUR | TEXTURE < 2 MM | % CLAY | > 2 MM | STRUCTURE I/II GRA | SIZE | TYPE | > | CONSISTENCY DRY STICK | MOIST PLAST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 A1 | 0 / 3 | 10YR / 10YR | 3 / 3 | 0.5 / 0.5 | M / D | O | | | | | C | | | ST | MC | GR | | H | FR |
| 2 A2 | 3 / 10 | 10YR / 10YR | 3 / 3 | 0.5 / 0.5 | M / D | O | | | | | C | | | MO | FM | SB | | VF | FV |
| 3 AJ | 10 / 25 | 10YR / 10YR | 3 / 3 | 0.5 / 0.5 | M / D | O | | | | | C | | | MO | MC | SA | | E | HVM |
| 4 B1 | 25 / 65 | 10YR / 10YR | 3 / 3 | 0.5 / 0.5 | M / D | O | | | | | C | | | MO / ST | VC / CV | PR / AB | | E | HVM |
| 5 B2 | 65 / 175 | 10YR / 10YR | 3 / 4 | 0.5 / 0.5 | M / D | O | | | | | C | | | MO / ST | VC / CV | PR / AW | | E | HVM |
| 6 Bck | 175 / 220 | 10YR / 10YR | 4 / 4+ | 0.5 / 0.5 | M / D | O | | | | | C | | | | | | | | |

| CUTANS I/II QU | THICK | NAT | LOC | CEM | PORE I/II AB | DIA | ROCK FRAGMENTS I/II AB | SIZE | SH | WE | NAT | NODULES I/II AB | KI | SI | SH | H | NA | COLOUR | CARB | BIO I/II QU | KI | ROOTS I/II QU | SIZE | BOUN WI | TO | PH | SAMPLES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 O | | | | O | | | VF | MC | R | FK | H | O | | | | | | | SL | O | | | | AW | | | 1 |
| 2 O | | | | O | M | FM | VF | MC | R | FC | H | O | | | | | | | SL | O | M | | | CS | | | A 0-10 |
| 3 O | | | | O | C | FM | VF | MC | R | FC | H | O | | | | | | | MO | O | M | | | GS | | | B 10-25 |
| 4 B | 15 | | | O | F | FM | V | MC | R | FC | H | V F | M | F | | H | K | W | MO | O | F | | | DS | | | C 30-50 |
| 5 C | 15 | | | O | F | VF | VF | MC | R | FC | H | F | M | F | | H | K | W | MO | O | VF | | | DS | | | D 80-100 E 140-160 |
| 6 | | | | | | | VF | MC | R | FC | H | F | M | F | | H | K | W | MO | O | | | | | | | F 190-210 |

SOIL PROFILE DESCRIPTION — Profile: PA 0001 Unit: L25b1 Status: 2

SHEET : 1825A4
LOCATION : Kakulwane Seloko (N. Plain), traverse 6 0.9 km W.
AUTHOR(S): A.Remmelzwaal K.Kgatlwane T.D.Mafoko
CLASSIFICATION FAO: Pellic Vertisol (1988) Pellic Vertisol (1974)
ST : Typic Pellustert
LANDFORM : lacustrine plain
TOPOGRAPHY: flat
SURF. CHAR: no sealing, cracks 5 cm wide, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees -
: Shrubs - Colophospermum mopane (dom.) Acacia nilotica Acacia gerrardii
: Grasses/forbs- Hyparrhenia hirta
PARENT MATERIAL: lacustrine
MOIST. COND: moist 0 - 25 , slightly moist 25 - 220 cm
SURF.STONES: common gravel
EROSION : nil

GRID : LK-360-742
COORD: 18-19-06-S 25-26-57-E
DATE : 03/04/84

LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: high gilgai

VEGETATION: open low shrub savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION : 1070 m

SMR: aquic

POSITION: intermediate part
SLOPE : 0 - 0.1%

GRASSCOVER: 30 - 70 %

GEOL.UNIT:
DRAINAGE : poorly drained

HUMAN INF: nil

REMARKS: After recent rains few cracks in topsoil, cracks in B hor. 3cm wide, less from 80cm. One month earlier many wide surface cracks. Augering from 100cm, photo.

SAMPLES: A: 0 - 10 B: 10 - 25 C: 30 - 50 D: 80 - 100 E: 140 - 160 F: 190 - 210

A1 0 - 3 cm 10YR 3/0.5 (moist) and 10YR 3.5/0.5 (dry), clay, strong medium and coarse granular structure, hard friable, very few medium and coarse rounded slightly weathered chert rock fragments, slightly calcareous, abrupt wavy boundary:

A2 3 - 10 cm 10YR 3/0.5 (moist) and 10YR 3.5/0.5 (dry), clay, moderate fine and medium subangular blocky structure, very hard firm to very firm, many fine and medium pores, very few medium and coarse rounded slightly weathered chert rock fragments, slightly calcareous, many roots, clear smooth boundary:

A3 10 - 25 cm 10YR 3/0.5 (moist) and 10YR 3.5/0.5 (dry), clay, moderate medium and coarse subangular and angular blocky structure, extremely hard very firm, common fine and medium pores, very few medium and coarse rounded slightly weathered chert rock fragments, moderately calcareous, many roots, gradual smooth boundary:

B1 25 - 65 cm 10YR 3/0.5 (moist) and 10YR 3.5/0.5 (dry), clay, moderate very coarse prismatic falling apart into strong coarse and very coarse angular blocky structure, extremely hard very firm, broken slickensides, few fine and medium pores, very few medium and coarse rounded slightly weathered chert rock fragments, very few fine hard calcareous white nodules, moderately calcareous, few roots, diffuse smooth boundary:

B2 65 - 175 cm 10YR 3.5/0.5 (moist) and 10YR 4/0.5 (dry), clay, moderate very coarse prismatic falling apart into strong coarse and very coarse wedge shaped angular blocky structure, extremely hard very firm, continuous intersecting slickensides, few very fine and fine pores, very few medium and coarse rounded slightly weathered chert rock fragments, few fine hard calcareous white nodules, moderately calcareous, very few roots, diffuse smooth boundary:

Bck 175 - 220 cm 10YR 4/0.5 (moist) and 10YR 4/0.5 (dry), clay, extremely hard very firm, very few medium and coarse rounded slightly weathered chert rock fragments, frequent fine hard calcareous white nodules, moderately calcareous,

SOIL PROFILE DESCRIPTION — Profile: PA 0001 Unit: L25b1 Status: 2

SHEET : 1825A4
LOCATION : Kakulwane Seloko (N. Plain), traverse 6 0.9 km W.
AUTHOR(S): A.Remmelzwaal K.Kgatlwane T.D.Mafoko
CLASSIFICATION FAO: Pellic Vertisol (1988) Pellic Vertisol (1974)
ST : Typic Pellustert
LANDFORM : lacustrine plain
TOPOGRAPHY: flat
SURF. CHAR: no sealing, cracks 5 cm wide, nil evidence of salt,
LAND USE: no apparent management system
SPECIES : Trees -
: Shrubs - Colophospermum mopane (dom.) Acacia nilotica Acacia gerrardii
: Grasses/forbs- Hyparrhenia hirta
PARENT MATERIAL: lacustrine
MOIST. COND: moist 0 - 25 , slightly moist 25 - 220 cm
SURF.STONES: common gravel
EROSION : nil

GRID : LK-360-742
COORD: 18-19-06-S 25-26-57-E
DATE : 03/04/84

LAND ELEMENT : not applicable
MICRO TOPOGRAPHY: high gilgai

VEGETATION: open low shrub savanna

ROCK TYPE:

ROCK OUTCROP: none

AGRO CLIM.ZONE: 1B1
ELEVATION : 1070 m

SMR: aquic

POSITION: intermediate part
SLOPE : 0 - 0.1%

GRASSCOVER: 30 - 70 %

GEOL.UNIT:
DRAINAGE : poorly drained

HUMAN INF: nil

REMARKS: After recent rains few cracks in topsoil, cracks in B hor. 3cm wide, less from 80cm. One month earlier many wide surface cracks. Augering from 100cm, photo.

SAMPLES: A: 0 - 10 B: 10 - 25 C: 30 - 50 D: 80 - 100 E: 140 - 160 F: 190 - 210

| HORIZON | DEPTH | COLOR | MOTTLES | TEXTURE | STRUCTURE | CONS | CUTANS | CEM | PORES | ROCK FRAGM | NODULES | CA | BIO | ROOTS | BOUND | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ab Si Ct Bo Co | <2mm %C | Gr Si Ty -> | | Q Th Na lo | | Ab Dia | Ab Si Sh We Na | Ab Ki Si Sh Ha Na Co | | Qu Ki | Qu Si | | |
| | | 10YR 3/0.5(m) | 0 | C | st mc gr | ha fr | 0 | | | vf mc r f ch | 0 | | 0 | | | |
| A1 | 0 - 3 | 10YR 3.5/0.5(d) | 0 | | | | 0 | 0 | | | 0 | sl | 0 | | a-w | |
| | | 10YR 3/0.5(m) | 0 | C | mo fm sb | vh fv | 0 | | m fm | vf mc r f ch | 0 | | 0 | m | | |
| A2 | 3 - 10 | 10YR 3.5/0.5(d) | 0 | | | | 0 | 0 | | | 0 | sl | 0 | | c-s | |
| | | 10YR 3/0.5(m) | 0 | C | mo mc sa | eh vm | 0 | | c fm | vf mc r f ch | 0 | | 0 | m | | |
| A3 | 10 - 25 | 10YR 3.5/0.5(d) | 0 | | | | 0 | 0 | | | 0 | mo | 0 | | g-s | |
| | | 10YR 3/0.5(m) | 0 | C | mo vc pr > | eh vm | b s | | f fm | vf mc r f ch | vf n f h k w | | 0 | f | | |
| B1 | 25 - 65 | 10YR 3.5/0.5(d) | 0 | | st cv ab | | | 0 | | | | mo | 0 | | d-s | |
| | | 10YR 3.5/0.5(m) | 0 | C | mo vc pr > | eh vm | c si | | f ff | vf mc r f ch | f n f h k w | | 0 | vf | | |
| B2 | 65 - 175 | 10YR 4/0.5(d) | 0 | | st cv aw | | | 0 | | | | mo | 0 | | d-s | |
| | | 10YR 4/0.5(m) | 0 | C | | eh vm | | | | vf mc r f ch | fq n f h k w | | 0 | | | |
| Bck | 175 - 220 | 10YR 4/0.5(d) | 0 | | | | | 0 | | | | mo | 0 | | - | |

## APPENDIX B. Location codes (see Map 2)

BE Bobonong East
BS Bobonong South
BO Bokspits

D Dinokwe
DI Dibete
DE Deception
DU Dukwe

F Francistown

G Gaborone
GH Good Hope
GZ Ghanzi
GW Gweta
GO Gomare

HU Hukuntsi
HA Hanahai

JW Jwaneng

KN Kanye North
KS Kanye South
KA Kang
KO Kokong
KU Kutse

L Lobatse
LP Lephepe
LK Letlhakane
LI Linyanti

M Mahalapye
ME Molepolole East
MW Molepolole West
MO Mochudi
MA Maun
MC Machaneng
MS Mmashoro
MT Matsitama
MB Mabuasehube

N Nata
NC Ncojane
NO Nosop
NX Nxai

O Orapa
OD Oliphants Drift
OW Okwa

PN Palapye North
PS Palapye South
PM Pitsane Molopo
PA Pandamatenga

QU Quoxo

R Ramotswa
RA Rakops
RM Ramokgwebana

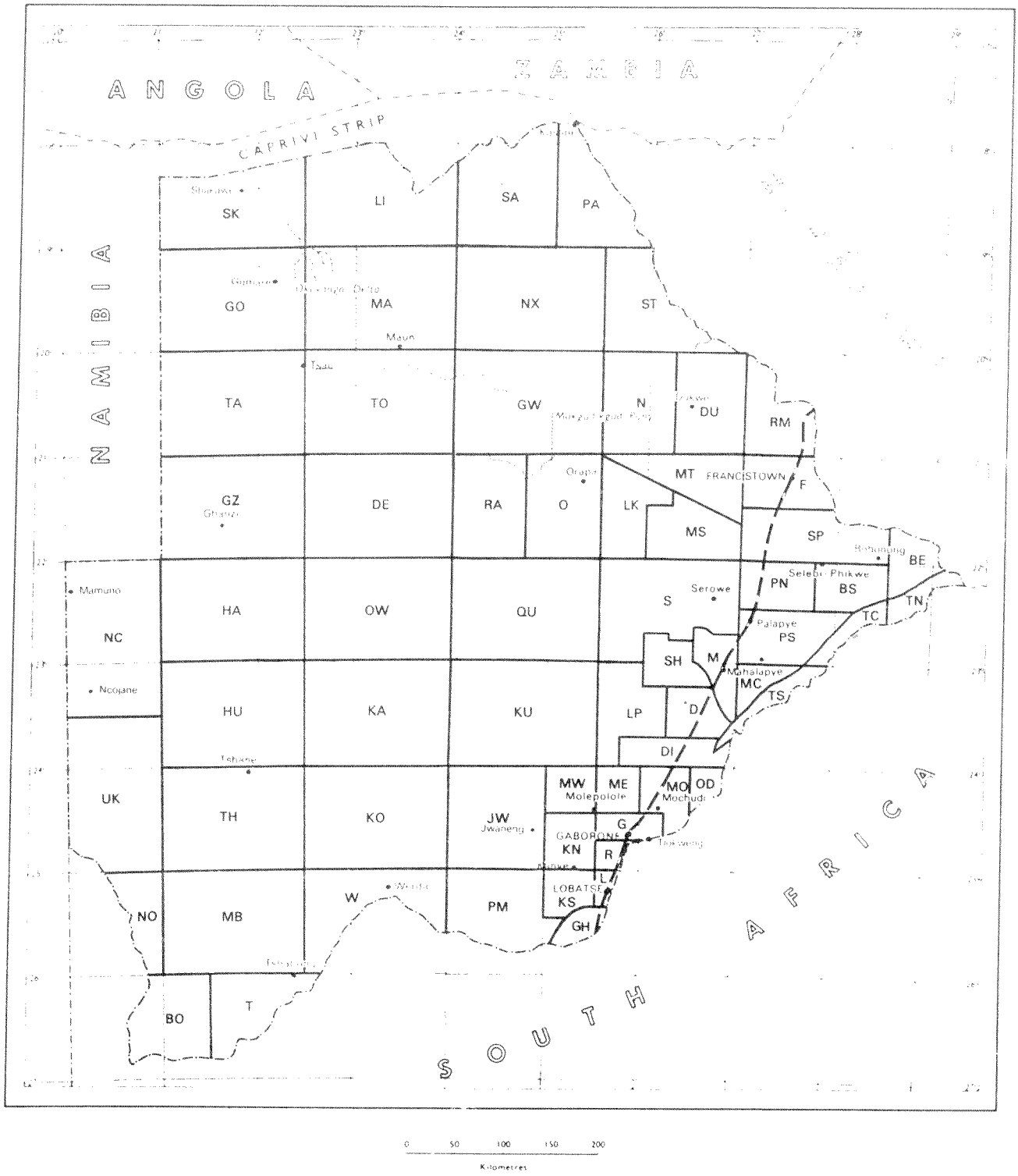
S Serowe
SP Selebi Phikwe
SH Shoshong
SA Savuti
SK Shakawe
ST Stoffels Pan

T Tshabong
TS Tuli Block South
TC Tuli Block Central
TN Tuli Block North
TO Toteng
TA Tsau
TH Tshane

UK Ukwi

W Werda

Map 2. Location codes



## APPENDIX C. Author codes

| | |
|---|---|
| GB | G. Baert (FAO) |
| JIB | J.I. Breyer (UB) |
| RB | R. Breitbart (FAO) |
| PB | P. Bronbacher (RUU) |
| ACP | A. Cavaliere Parzaneze (FAO) |
| OD | O. Dikinya (MOA) |
| DJE | D.J. Eldridge (MOA) |
| JH | J. Huesken (FAO) |
| PJ | P. Jamagne (FAO) |
| WDJ | W.D. Joshua (FAO) |
| RK | R. Kelebemang (MOA) |
| CIK | C.I. Ketlogetswe (MOA) |
| KK | K. Kgatlwane (MOA) |
| BK | B. Kopelo (MOA) |
| DK | D. Kwape (MOA) |
| LSL | L.S. Lekoma (MOA) |
| JM | J. Maembolwa (MOA) |
| TDM | T.D. Mafoko (MOA) |
| AM | A. Markus (UVA) |
| MDM | M.D. Mays (USDA) |
| BGM | B.G. Moganane (MOA) |
| FON | F.O. Nachtergaele (FAO) |
| MP | M. Paul (FAO) |
| ABP | A.B. Price (USDA) |
| FP | F. Pule (MOA) |
| AR | A. Remmelzwaal (FAO) |
| GJR | G.J. Rhebergen (FAO) |
| GMS | G.M. Segonetso (MOA) |
| WS | W. Siderius (FAO) |
| CAS | C.A. Sinnige (UVA) |
| GJS | G.J.Staring (FAO) |
| ET | E. Telekelo (MOA) |
| JHV | J.H. Venema (FAO) |
| KV | K. Verbeek (FAO) |
| EVW | E. Van Waveren (FAO) |
| PDW | P. De Wit (FAO) |

Abbreviations:

| | |
|---|---|
| FAO | Food and Agriculture Organization of the United Nations |
| MOA | Ministry of Agriculture Botswana |
| USDA | United States Department of Agriculture |
| UB | University of Botswana |
| UVA | University of Amsterdam |
| RUU | University of Utrecht |

## APPENDIX D.1 FAO Soil Unit codes (1974)

**A Acrisols**
AF Ferric Acrisol
AFA Arenic Ferric Acrisol
AG Gleyic Acrisol
AH Humic Acrisol
AO Orthic Acrisol
AP Plinthic Acrisol

**B Cambisols**
BA Calcaric Cambisol
BC Chromic Cambisol
BD Dystric Cambisol
BE Eutric Cambisol
BF Ferralic Cambisol
BG Gleyic Cambisol
BH Humic Cambisol
BK Calcic Cambisol
BV Vertic Cambisol
BX Gelic Cambisol

**C Chernozems**
CG Glossic Chernozem
CH Haplic Chernozem
CK Calcic Chernozem
CL Luvic Chernozem
CLG Gleyic Luvic Chernozem
CLK Calcic Luviv Chernozem

**D Podzoluvisols**
DD Dystric Podzoluvisol
DE Eutric Podzoluvisol
DG Gleyic Podzoluvisol

**E Rendzinas**

**F Ferralsols**
FA Acric Ferralsol
FH Humic Ferralsol
FO Orthic Ferralsol
FP Plinthic Ferralsol
FR Rhodic Ferralsol
FX Xanthic Ferralsol

**G Gleysols**
GK Calcic Gleysol
GKV Vertic Calcic Gleysol
GD Dystric Gleysol
GE Eutric Gleysol
GEV Vertic Eutric Gleysol
GH Humic Gleysol
GM Mollic Gleysol
GMV Vertic Mollic Gleysol
GP Plinthic Gleysol
GX Gelic Gleysol

**H Phaeozems**
HC Calcaric Phaeozem
HG Gleyic Phaeozem
HH Haplic Phaeozem
HL Luvic Phaeozem

**I Lithosol**

**J Fluvisols**
JC Calcaric Fluvisol
JD Dystric Fluvisol
JDA Arenic Dystric Fluvisol
JE Eutric Fluvisol
JEA Arenic Eutric Fluvisol
JT Thionic Fluvisol

**K Kastanozems**
KH Haplic Kastanozem
KK Calcic Kastanozem
KL Luvic Kastanozem

**L Luvisols**
LA Albic Luvisol
LAA Arenic Albic Luvisol
LAK Calcic Albic Luvisol
LC Chromic Luvisol
LF Ferric Luvisol
LFA Arenic Ferric Luvisol
LG Gleyic Luvisol
LGA Arenic Gleyic Luvisol
LGK Calcic Gleyic Luvisol
LGV Vertic Gleyic Luvisol
LK Calcic Luvisol
LKA Arenic Calcic Luvisol
LKC Chromic Calcic Luvisol
LO Orthic Luvisol
LOA Arenic Orthic Luvisol
LP Plinthic Luvisol
LV Vertic Luvisol

**M Greyzems**
MG Gleyic Greyzem
MO Orthic Greyzem

**N Nitosols**
ND Dystric Nitosol
NDA Arenic Dystric Nitosol
NE Eutric Nitosol
NEA Arenic Eutric Nitosol
NEK Calcic Eutric Nitosol
NH Humic Nitosol

**O Histosols**
OD Dystric Histosol
OE Eutric Histosol
OX Gelic Histosol

**P Podzols**
PF Ferric Podzol
PG Gleyic Podzol
PH Humic Podzol
PL Leptic Podzol
PO Orthic Podzol
PP Placic Podzol

**Q Arenosols**
QA Albic Arenosol
QB Cambic Arenosol
QC Calcaric Arenosol
QD Dystric Arenosol
QE Eutric Arenosol
QF Ferralic Arenosol
QK Calcic Arenosol
QL Luvic Arenosol
QP Petrocalcic Arenosol

**R Regosols**
RC Calcaric Regosol
RD Dystric Regosol
RE Eutric Regosol
REA Arenic Eutric Regosol
RX Gelic Regosol

**S Solonetz**
SG Gleyic Solonetz
SM Mollic Solonetz
SO Orthic Solonetz

**T Andosols**
TH Humic Andosol
TM Mollic Andosol
TO Ochric Andosol
TV Vitric Andosol

**U Rankers**

**V Vertisols**
VC Chromic Vertisol
VP Pellic Vertisol

**W Planosols**
WD Dystric Planosol
WE Eutric Planosol
WH Humic Planosol
WM Mollic Planosol
WS Solodic Planosol
WX Gelic Planosol

**X Xerosols**
XH Haplic Xerosol
XK Calcic Xerosol
XL Luvic Xerosol
XLA Arenic Luvic Xerosol
XLK Calcic Luvic Xerosol
XLX Arenic Calcic Luvic Xerosol
XY Gypsic Xerosol

**Y Yermosols**
YH Haplic Yermosol
YK Calcic Yermosol
YL Luvic Yermosol
YT Takyric Yermosol
YY Gypsic Yermosol

**Z Solonchaks**
ZEA Arenic Eutric Solonchak
ZG Gleyic Solonchak
ZM Mollic Solonchak
ZO Orthic Solonchak
ZOA Arenic Orthic Solonchak
ZT Takyric Solonchak

APPENDIX D.2 FAO Soil Unit Codes (1988)

**FL Fluvisols**
FLE Eutric Fluvisol
FLC Calcaric Fluvisol
FLD Dystric Fluvisol
FLM Mollic Fluvisol
FLU Umbric Fluvisol
FLT Thionic Fluvisol
FLS Salic Fluvisol

**GL Gleysols**
GLE Eutric Gleysol
GLK Calcic Gleysol
GLD Dystric Gleysol
GLA Andic Gleysol
GLM Mollic Gleysol
GLU Umbric Gleysol
GLT Thionic Gleysol
GLI Gelic Gleysol

**RG Regosols**
RGE Eutric Regosol
RGC Calcaric Regosol
RGY Gypsic Regosol
RGD Dystric Regosol
RGU Umbric Regosol
RGI Gelic Regosol

**LP Leptosols**
LPE Eutric Leptosol
LPD Dystric leptosol
LPK Rendzic Leptosol
LPM Mollic Leptosol
LPU Umbric leptosol
LPQ Lithic Leptosol
LPI Gelic leptosol
LPC Calcaric Leptosol

**AR Arenosols**
ARH Haplic Arenosol
ARB Cambic Arenosol
ARL Luvic Arenosol
ARO Ferralic Arenosol
ARA Albic Arenosol
ARK Calcic Arenosol
ARC Calcaric Arenosol
ARG Gleyic Arenosol

**AN Andosols**
ANH Haplic Andosol
ANM Mollic Andosol
ANU Umbric Andosol
ANZ Vitric Andosol
ANG Gleyic Andosol
ANI Gelic Andosol

**VR Vertisols**
VRY Gypsic Vertisol
VRD Dystric Vertisol
VRX Chromic Vertisol
VRP Pellic Vertisol

**CL Calcisols**
CLH Haplic Calcisol
CLL Luvic Calcisol
CLP Petric Calcisol
CLJ Stagnic Calcisol

**GY Gypsisols**
GYH Haplic Gypsisol
GYK Calcic Gypsisol
GYL Luvic Gypsisol
GYP Petric Gypsisol

**SN Solonetz**
SNH Haplic solonetz
SNM Mollic Solonetz
SNK Calcic Solonetz
SNY Gypsic Solonetz
SNJ Stagnic Solonetz

**SC Solonchaks**
SCH Haplic Solonchak
SCM Mollic Solonchak
SCK Calcic Solonchak
SCY Gypsic Solonchak
SCN Sodic Solonchak
SCG Gleyic Solonchak
SCI Gelic Solonchak

**KS Kastanozems**
KSH Haplic Kastanozem
KSL Luvic Kastanozem
KSK Calcic Kastanozem
KSY Gypsic Kastanozem

**CH Chernozems**
CHH Haplic Chernozem
CHK Calcic Chernozem
CHL Luvic Chernozem
CHW Glossic Chernozem
CHG Gleyic Chernozem

**PH Phaeozems**
PHG Gleyic Pheaozem
PHH Haplic Phaeozem
PHC Calcaric Phaeozem
PHJ Stagnic Phaeozem
PHL Luvic Phaeozem

**GR Greyzems**
GRH Haplic Greyzem
GRG Gleyic Greyzem

**LV Luvisols**
LVH Haplic Luvisol
LVF Ferric Luvisol
LVX Chromic Luvisol
LVK Calcic Luvisol
LVJ Stagnic Luvisol
LVG Gleyic Luvisol

**PL Planosols**
PLE Eutric Planosol
PLD Dystric Planosol
PLM Mollic Planosol
PLU Umbric Planosol
PLI Gelic Planosol

**PD Podzoluvisols**
PDE Eutric Podzoluvisol
PDD Dystric Podzoluvisol
PDJ Stagnic Podzoluvisol
PDG Gleyic Podzoluvisol
PDI Gelic Podzoluvisol

**PZ Podzols**
PZH Haplic Podzol
PZB Cambic Podzol
PZF Ferric podzol
PZC Carbic Podzol
PZG Gleyic Podzol
PZI Gelic Podzol

**LX Lixisols**
LXH Haplic Lixisol
LXF Ferric Lixisol
LXP Plinthic Lixisol
LXA Albic Lixisol
LXJ Stagnic Lixisol
LXG Gleyic Lixisol

**AC Acrisols**
ACH Haplic Acrisol
ACF Ferric Acrisol
ACU Humic Acrisol
ACP Plinthic Acrisol
ACG Gleyic Acrisol

**AL Alisols**
ALH Haplic Alisol
ALF Ferric Alisol
ALU Humic Alisol
ALP Plinthic Alisol
ALJ Stagnic Alisol
ALG Gleyic Alisol

**NT Nitisols**
NTH Haplic Nitisol
NTR Rhodic Nitisol
NTU Humic Nitisol

**FR Ferralsols**
FRH Haplic Ferralsol
FRX Xanthic Ferralsol
FRR Rhodic Ferralsol
FRU Humic Ferralsol
FRG Geric Ferralsol
FRP Plinthic Ferralsol

**PT Plinthosols**
PTE Eutric Plinthosol
PTD Dystric Plinthosol
PTU Humic Plinthosol
PTA Albic Plinthosol

**CM Cambisols**
CME Eutric Cambisol
CMD Dystric Cambisol
CMU Humic Cambisol
CMC Calcaric Cambisol
CMX Chromic Cambisol
CMV Vertic Cambisol
CMO Ferralic Cambisol
CMG Gleyic Cambisol
CMI Gelic Cambisol
CMJ Stagnic Cambisol

**AT Anthrosols**
ARA Aric Anthrosol
ATC Cumulic Anthrosol
ATF Fimic Anthrosol
ATU Urbic Anthrosol

**HS Histosols**
HSL Folic Histosol
HSS Terric Histosol
HSF Fibric Histosol
HST Thionic Histosol
HSI Gelic Histosol

**D3. Third Level Codes**

AB Abrupti
AB1 Albi-Abrupti
AB2 Calci-Abrupti
AL Albi
AG Argi
AG1 Dystri-Argi
AG2 Hypo-Argi
AR Areni
AR1 Pale-Areni
AR2 Rhodi-Areni
CA Calcari
CA1 Hyper-Calcari
CA2 Hypo-Calcari
CH Chromi
CU Cumuli
DU Duri
DU1 Calci-Duri
DU2 Sodi-Duri
DY Dystri
EP Epi
EU Eutri
FE Ferri
FL Ferrali
HO Hypo
HO1 Epi-Hypo
HY Hyper
HY1 Epi-Hyper
HY2 Stagni-Hyper
GL Gleyi
GR Grumi
GY Gypsi
HC Hypercalci
HC1 Epi-Hypercalci
HC2 Sodi-Hypercalci
KC Calci
KC1 Areni-Calci
KC2 Epi-Calci
KC3 Grumi-Calci
KC4 Sodi-Calci
KC5 Sali-Calci
KC6 Argi-Calci
KC7 Hypo-Calci
LA Lamelli
LI Lithi
LI1 Hypercalci-Stagni Lithi
LU Luvi
LU1 Hypercalci-Luvi
LU2 Hypercalci-Stagni Luvi
MA Mazi
MO Molli
NI Niti
OR Orthi
PA Pale
PA1 Rhodi-Pale
PA2 Chromi-Pale
PC Petrocalci
PC1 Epi-Petrocalci
PC2 Areni-Petrocalci
PC3 Grumi-Petrocalci
PC4 Sodi-Petrocalci
PC5 Rhodi-Petrocalci
PE Petri
PE1 Epi-Petri
PE2 Areni-Petri
RH Rhodi
SA Sali
SA1 Hypo-Sali
SO Sodi
SO1 Sali-Sodi
SO2 Hypo-Sodi
ST Stagni
ST1 Epi-Hypercalci Stagni
ST2 Epi-Petrocalci Stagni
ST3 Hypo-Stagni
TA Takyri
UM Umbri
VE Verti
VE1 Calci-Verti
VE2 Petrocalci-Verti

APPENDIX E.1. Soil Taxonomy Great Group codes (1987)

**Alfisols**
ABB Paleboralf
ABE Eutroboralf
ABF Fragiboralf
ABG Glossoboralf
ABN Natriboralf
ABO Cryoboralf
ADA Hapludalf
ADB Paleudalf
ADC Agrudalf
ADF Fragiudalf
ADG Glossudalf
ADI Ferrudalf
ADK Kandiudalf
ADN Natrudalf
ADR Rhodudalf
AGF Fraglossudalf
AQD Duraqualf
AQF Fragiaqualf
AQG Glossaqualf
AQK Kandiaqualf
AQL Plinthaqualf
AQM Umbraqualf
AQN Natraqualf
AQO Ochraqualf
AQW Albaqualf
AUA Haplustalf
AUB Paleustalf
AUD Durustalf
AUH Kanhaplustalf
AUK Kandiustalf
AUL Plinthustalf
AUN Natrustalf
AUR Rhodustalf
AXA Haploxeralf
AXB Palexeralf
AXD Durixeralf
AXF Fragixeralf
AXL Plinthoxeralf
AXN Natrixeralf
AXR Rhodoxeralf

**Aridisols**
DOB Paleorthid
DOD Durorthid
DOG Gypsiorthid
DOK Calciorthid
DOM Camborthid
DOS Salorthid
DRA Haplargid
DRB Paleargid
DRD Durargid
DRJ Nadurargid
DRN Natrargid

**Entisols**
EOC Cryorthent
EOD Udorthent
EOP Torriorthent
EOT Troporthent
EOU Ustorthent
EOX Xerorthent
EQA Haplaquent
EQC Cryaquent
EQI Sulfaquent
EQS Psammaquent
EQT Tropaquent
EQV Fluvaquent
EQW Hydraquent
ER Arent
ESC Cryopsamment
ESD Udipsamment
ESP Torripsamment
EST Tropopsamment
ESU Ustipsamment
ESX Xeropsamment
ESZ Quartzipsamment
EVC Cryofluvent
EVD Udifluvent
EVP Torrifluvent
EVT Tropofluvent
EVU Ustifluvent
EVX Xerofluvent

**Histosols**
HAC Cryosaprist
HAM Medisaprist
HAR Borosaprist
HAT Troposaprist
HEB Borohemist
HEC Cryohemist
HEI Sulfihemist
HEL Luvihemist
HEM Medihemist
HEO Sulfohemist
HET Tropohemist
HIB Borofibrist
HIC Cryofibrist
HIL Luvifibrist
HIM Medifibrist
HIS Sphagnofibrist
HIT Tropofibrist
HLB Borofolist
HLC Cryofolist
HLT Tropofolist

**Inceptisols**
IG Plaggept
IMA Haplumbrept
IMC Cryumbrept
IMF Fragiumbrept
IMX Xerumbrept
INC Cryandept
IND Durandept
INE Eutrandept
INP Placandept
INV Vitrandept
INW Hydrandept
INY Dystrandept
IOC Cryochrept
IOD Durochrept
IOE Eutrochrept
IOF Fragiochrept
IOU Ustochrept
IOX Xerochrept
IOY Dystrochrept
IQA Haplaquept
IQC Cryaquept
IQF Fragiaquept
IQH Humaquept
IQL Plinthaquept
IQN Andaquept
IQP Placaquept
IQS Sulfaquept
IQT Tropaquept
IQX Halaquept
ITE Eutropept
ITH Humitropept
ITS Sombritropept
ITU Ustropept
ITY Dystropept

**Mollisols**
MBA Haploboroll
MBB Paleboroll
MBC Cryoboroll
MBK Calciboroll
MBN Natriboroll
MBR Argiboroll
MBV Vermiboroll
MDA Hapludoll
MDB Paleudoll
MDR Argiudoll
MDV Vermudoll
MQA Haplaquoll
MQC Cryaquoll
MQD Duraquoll
MQK Calciaquoll
MQN Natraquoll
MQR Argiaquoll
MR Rendoll
MUA Haplustoll
MUB Paleustoll
MUD Durustoll
MUK Calciustoll

MUN Natrustoll
MUR Argiustoll
MUV Vermustoll
MWN Natralboll
MWR Argialboll
MXA Haploxeroll
MXD Durixeroll
MXK Calcixeroll
MXN Natrixeroll
MXR Argixeroll
MXP Palexeroll

**Oxisols**
ODA Hapludox
ODC Acrudox
ODE Eutrudox
ODK Kandiudox
ODS Sombriudox
OPA Haploperox
OPC Acroperox
OPE Eutroperox
OPK Kandiperox
OPS Sombriperox
OQA Haplaquox
OQC Acraquox
OQE Eutraquox
OQL Plinthaquox
OTA Haplotorrox
OTC Acritorrox
OTE Eutrotorrox
OUA Haplustox
OUC Acrustox
OUE Eutrustox
OUK Kandiustox
OUS Sombriustox

**Spodosols**
SHA Haplohumod
SHC Cryohumod
SHF Fragihumod
SHP Placohumod
SHT Tropohumod
SI Ferrod
SOA Haplorthod
SOC Cryorthod
SOF Fragiorthod
SOP Placorthod
SOT Troporthod
SQA Haplaquod
SQC Cryaquod
SQD Duraquod
SQF Fragiaquod
SQP Placaquod
SQS Sideraquod
SQT Tropaquod

**Ultisols**
UDA Hapludult
UDB Paleudult
UDF Fragiudult
UDL Plinthudult
UDR Rhodudult
UHA Haplohumult
UHB Palehumult
UHH Kandihaplohumult
UHK Kandihumult
UHL Plinthohumult
UHS Sombrihumult
UQB Paleaquult
UQF Fragiaquult
UQK Kandiaquult
UQL Plinthaquult
UQM Umbraquult
UQO Ochraquult
UQW Albaquult
UUA Haplustult
UUB Paleustult
UUH Kandihaplustult
UUK Kandiustult
UUL Plinthustult
UUR Rhodustult
UXA Haploxerult
UXB Palexerult

**Vertisols**
VDL Pelludert
VDR Chromudert
VP Torrert
VUL Pellustert
VUR Chromustert
VXL Pelloxerert
VXR Chromoxerert

**APPENDIX E.2. Soil Taxonomy Sub Group codes (1987)**

AA Typic
AB Abruptic
AB04 Abruptic Aridic
AB08 Abruptic Cryic
AB10 Abruptic Haplic
AB14 Abruptic Udic
AB16 Abruptic Xerollic
AC Acric
AC05 Acric Plinthic
AE Aeric
AE03 Aeric Arenic
AE05 Aeric Grossarenic
AE06 Aeric Mollic
AE09 Aeric Tropic
AE10 Aeric Umbric
AE12 Aeric Xeric
AL Albaquic
AL02 Albaquultic
AL04 Albic
AL08 Albic Glossic
AL09 Albic Alfic
AL10 Alfic
AL12 Alfic Arenic
AL13 Alfic Andeptic
AL16 Alfic Lithic
AN Andic
AN01 Andeptic
AN03 Andaquic
AN03 Andaquic
AN06 Andic Dystric
AN06 Andic Dystric
AN11 Andeptic Glos soboric
AN20 Andic Udic
AN22 Andic Ustic
AN24 Andaqueptic
AN24 Andaqueptic
AN25 Anionic
AN30 Anthropic
AQ Aqualfic
AQ02 Aquentic
AQ04 Aqueptic
AQ06 Aquic
AQ08 Aquic Arenic
AQ14 Aquic Duric
AQ16 Aquic Durorthidic
AQ18 Aquic Dystric
AQ24 Aquic Haplic
AQ26 Aquic Lithic
AQ31 Aquic Psammentic
AQ34 Aquollic
AQ36 Aquultic
AR Arenic
AR02 Arenic Aridic
AR04 Arenic Plinthaquic
AR06 Arenic Plinthic
AR07 Arenic Kandic
AR08 Arenic Rhodic
AR09 Arenic Kandic Rhodic
AR10 Arenic Ultic
AR11 Arenic Kanhaplic
AR12 Arenic Kanhaplic Rhodic
AR13 Arenic Petrocalcic
AR14 Arenic Umbric
AR15 Arenic Calciorthidic
AR16 Arenic Ustalfic
AR17 Arenic Ustochreptic
AR18 Arenic Ustollic
AR19 Arenic Petroferric
AR20 Arenic Petroferric Rhodic
AR21 Arenic Paleorthidic
AR22 Argiaquic
AR24 Argiaquic Xeric
AR26 Argic
AR28 Argic Lithic
AR30 Argic Pachic
AR32 Argic Vertic
AR34 Aridic
AR34 Aridic
AR36 Aridic Calcic
AR36 Aridic Calcic
AR42 Aridic Duric
AR42 Aridic Duric
AR50 Aridic Pachic
AR52 Aridic Petrocalcic
BO Boralfic
BO02 Boralfic Lithic
BO04 Boralfic Udic
BO06 Borollic
BO08 Borollic Glossic
BO10 Borollic Lithic
BO12 Borollic Vertic
CA Calcic
CA04 Calcic Pachic
CA06 Calciorthidic
CA10 Calcixerollic
CA20 Cambic
CH Chromic
CH06 Chromudic
CR Cryic
CR10 Cryic Lithic
CR14 Cryic Pachic
CU Cumulic
CU02 Cumulic Udic
CU04 Cumulic Ultic
DU Durargidic
DU02 Duric
DU08 Duroxerollic
DU10 Duroxerollic Lithic
DU11 Durochreptic
DU12 Durorthidic
DU14 Durorthidic Xeric
DY02 Dystric
DY03 Dystric Enthic
DY04 Dystric Fluventic
DY06 Dystric Lithic
DY08 Dystropeptic
EN Entic
EN02 Enthic Lithic
EN04 Eutropeptic
EN06 Enthic Ultic
EP Epiaquic
EP10 Epiaquic Orthoxic
EU Eutric
EU02 Eutrochreptic
EU04 Eutropeptic
FE Ferrudalfic
FI Fibric
FI02 Fibric Terric
FL02 Fluvaquentic
FL06 Fluventic
FL12 Fluventic Umbric
FR10 Fragiaquic
FR18 Fragic
GL02 Glossaquic
GL04 Glossic
GL10 Glossic Udic
GL12 Glossic Ustollic
GL14 Glossoboralfic
GL16 Glossoboric
GR Grossarenic
GR01 Grossarenic Entic
GR04 Grossarenic Plinthic
GR05 Grossarenic Petroferric
GR06 Grossarenic petroferric Rhodic
GR07 Grossarenic Kandic
GR08 Grossarenic Kandic Rhodic
GR09 Grossarenic Kanhaplic
GR10 Grossarenic Kanhaplic Rhodic
GR11 Grossarenic Rhodic
GR12 Grossarenic Petrocalcic
GR13 Grossarenic Ustollic
GR14 Grossarenic Ustalfic
GR15 Grossarenic Aridic
HA Haplaquodic

HA01 Haplaquic
HA02 Haplic
HA05 Haplohumic
HA07 Haploxerollic
HA09 Hapludic
HA12 Hapludollic
HA16 Haplustollic
HE Hemic
HE02 Hemic Terric
HI Histic
HI02 Histic Lithic
HI06 Histic Pergelic
HU Humic
HU02 Humic Lithic
HU05 Humic Pergelic
HU06 Humoxic
HU10 Humaqueptic
HU15 Humic Rhodic
HU20 Humic Xanthic
HY Hydric
HY02 Hydric Lithic
IN Inceptic
KA Kandic
KA02 Kandiudalfic
KA04 Kandiustalfic
KH Kanhaplic
LE Leptic
LI Limnic
LI02 Lithic
LI03 Lithic Petrocalcic
LI04 Lithic Mollic
LI05 Lithic Pergelic
LI06 Lithic Ruptic-Alfic
LI07 Lithic Ruptic-Argic
LI08 Lithic Ruptic-Entic Xerollic
LI09 Lithic Ruptic-Entic
LI10 Lithic Udic
LI11 Lithic Ruptic-xerorthentic
LI12 Lithic Ultic
LI13 Lithic Ruptic-Ultic
LI14 Lithic Umbric
LI15 Lithic Ruptic-Xerochreptic
LI16 Lithic Ustic
LI18 Lithic Ustollic
LI20 Lithic Vertic
LI22 Lithic Xeric
LI24 Lithic Xerollic
MO Mollic
NA06 Natric
OC Ochreptic
OR Orthidic
OR01 Orthic
OR02 Orthoxic
PA Pachic
PA02 Pachic udic
PA04 Pachic Ultic
PA06 Paleorthidic
PA08 Paleustollic
PA10 Palexerollic
PA20 Paralithic Vertic
PE Pergelic
PE01 Pergelic Ruptic-Histic
PE02 Pergelic Sideric
PE04 Petrocalcic
PE06 Petrocalcic Ustalfic
PE08 Petrocalcic Ustollic
PE14 Petrocalcic Xerollic
PE16 Petroferric
PE17 Petroferric Rhodic
PE20 Petrogypsic
PK Placic
PK10 Plaggeptic
PK12 Plaggic
PL Plinthaquic
PL04 Plinthic
PL06 Plinthudic
PS Psammaquentic
PS02 Psammentic
PS04 Psammentic Kandic
PS06 Psammentic Rhodic
PS08 Psammentic Kandic Rhodic
PS09 Psammentic Ustollic
PS10 Psammentic Ustalfic
QU Quartzipsammentic
RE Rendollic
RH Rhodic
RU02 Ruptic-Alfic
RU09 Ruptic-Lithic
RU11 Ruptic-Lithic-Entic
RU15 Ruptic-Lithic-Xerochreptic
RU17 Ruptic-Ultic
RU19 Ruptic-Vertic
SA Salorthidic
SA02 Sapric
SA04 Sapric Terric
SI Sidfric
SO Sombric
SO04 Sombrihumic
SP Sphagnic
SP02 Sphagnic Terric
SP04 Spodic
SU Sulfic
TE Terric
TH04 Thapto-Histic
TH06 Thapto-Histic Tropic
TO Torrertic
TO02 Torrifluventic
TO04 Torriorthentic
TO06 Torripsammentic
TO10 Torroxic
TR Tropaquodic
TR02 Tropeptic
TR04 Tropic
UD Udertic
UD01 Udalfic
UD02 Udic
UD03 Udollic
UD05 Udorthentic
UD10 Udoxic
UL Ultic
UM Umbreptic
UM02 Umbric
US Ustalfic
US02 Usteric
US04 Ustic
US06 Ustochreptic
US08 Ustollic
US12 Ustoxic
VE Vermic
VE02 Vertic
XA Xanthic
XE Xeralfic
XE02 Vertic
XE02 Xerertic
XE04 Xeric
XE08 Xerollic

## APPENDIX E.3. Soil Taxonomy Family Codes (1987)

### Mineralogy

03 allitic
05 carbonatic
08 coprogenous
09 chloritic
10 diatomaceous
12 ferrihumic
14 ferritic
16 ferruginous
18 gibbsitic
20 glauconitic
22 gypsic
24 halloysitic
26 illitic
27 illitic(calcareous)
28 kaolinitic
30 marly
32 micaceous
34 mixed
35 mixed(calcareous)
37 montmorrilonitic
38 montmorrilonitic (calcareous)
40 oxidic
44 serpentinitic
46 siliceous
48 sesquic
50 vermiculitic

### Soil Temperature Regime

TH thermic
IT isothermic
HT hyperthermic
IH isohyperthermic

### Texture

003 cindery
004 cindery over sandy
005 ashy
006 cindery over loamy
007 ashy over cindery
008 ashy over loamy
009 ashy skeletal
010 medial
011 medial skeletal
012 medial o. cindery
013 ashy over loamy skeletal
014 medial o.clayey
015 cindery over medial skeletal
016 medial o.fragmental
018 medial o.loamy
019 ashy over medial
020 medial o.loamy skeletal
022 medial over sandy
024 medial o.thixotropic
026 thixotropic
027 thixotropic skeletal
028 thixotropic o.fragmental
030 thixotropic o. sandy (sk)
032 thixotropic o.loamy skel.
034 thixotropic over loamy
036 fragmental
044 sandy skeletal
046 sandy skeletal o. loamy
050 loamy skeletal
051 loamy skeletal o.fragment
052 loamy skeletal o.sandy
054 loamy skeletal o. clayey
055 loamy skeletal or clayey skeletal
056 clayey skeletal
058 clayey-skeletal o.sandy
062 sandy
063 sandy or sandy skeletal
064 sandy over clayey
066 sandy over clayey
068 loamy
072 loamy over sandy(skel)
080 coarse loamy
082 coarse loamy o.fragmental
084 coarse loamy o.sandy (sk)
086 coarse loamy o.clayey
088 coarse silty
092 coarse silty o.sandy
094 coarse silty o.clayey
096 fine loamy
097 fine loamy o.cindery
098 fine loamy o.fragmental
100 fine loamy o.sandy (skel)
102 fine loamy o.clayey
106 fine silty
108 fine silty o.fragmental
110 fine silty o.sandy
112 fine silty o.clayey
114 clayey
116 clayey over fragmental
118 clayey over sandy
120 clayey o.loamy skeletal
122 clayey over fine silty
124 clayey over loamy
126 fine
134 very fine

### Reaction

AL allic
NC noncalcareous
AC acid
NA nonacid
EU euic
DY dysic

## APPENDIX F. Vegetation species codes

### F.1. Trees and shrubs

| | |
|---|---|
| ABL | Abutilon lyciodes |
| AC | Acacia sp. |
| AAL | Acacia albida |
| AAM | Acacia arenaria |
| AAT | Acacia ataxacantha |
| ABU | Acacia burkei |
| ACA | Acacia caffra |
| AER | Acacia erioloba |
| AEB | Acacia erubescens |
| AFL | Acacia fleckii |
| AGA | Acacia galpinii |
| AGE | Acacia gerrardii |
| AGR | Acacia grandicornuta |
| AHA | Acacia haematoxylon |
| AHE | Acacia hebeclada |
| AHR | Acacia hereroensis |
| AKA | Acacia karroo |
| AKI | Acacia kirkii |
| ALU | Acacia luederitzii var.luederitzii |
| ALR | Acacia luederitzii var.retinens |
| AME | Acacia mellifera |
| ANE | Acacia nebrownii |
| ANG | Acacia nigrescens |
| ANL | Acacia nilotica |
| APE | Acacia permixta |
| APO | Acacia polyacantha |
| ARH | Acacia rehmanniana |
| ARO | Acacia robusta |
| ASC | Acacia schweinfurthii |
| ASE | Acacia senegal var.feiorachis |
| ASR | Acacia senegal var.rostata |
| ASI | Acacia sieberana |
| AST | Acacia stuhlmanii |
| ATE | Acacia tenuispina |
| ATO | Acacia tortilis subs. heterocantha |
| ATS | Acacia tortilis subs. spirocarpa |
| AXA | Acacia xanthophloea |
| ADD | Adansonia digitata |
| AFQ | Afzelia quanzensis |
| AL | Albizia sp. |
| ALV | Albezia versicolor |
| ALA | Albizia anthelmintica |
| ALH | Albizia harveyi |
| AOM | Aloe marlothii |
| BBH | Babiana hypogea |
| BKP | Baikiaea plurijuga |
| BPM | Baphia massaiensis |
| BPO | Baphia obovato |
| BUP | Bauhinia petersiana |
| BUT | Bauhinia tonningii |
| BQM | Bequaertiodendron megalismontanum |
| BED | Berchemia discolor |
| BOS | Bolusanthus speciosus |
| BSA | Boscia albitrunca |
| BSF | Boscia foetida subsp. rehmanniana |
| BSM | Boscia mossambicensis |
| BRB | Brachystegia boehmii |
| BRS | Brachystegia spiciformis |
| BIM | Bridelia mollis |
| BUA | Burkea africana |
| CSB | Carissa bispinosa |
| CAA | Cassia abbriviata |
| CTA | Catophractes alexandri |
| CLM | Colophospermum mopane |
| COB | Combretum albopunctatum |
| COA | Combretum apiculatum |
| COG | Combretum elaegnoides |
| COE | Combretum erythrophyllum |
| COF | Combretum fragrans |
| COH | Combretum hereroense |
| COI | Combretum imberbe |
| COL | Combretum molle |
| COM | Combretum mossambicense |
| COZ | Combretum zeyheri |
| CM | Commiphora sp. |
| CMA | Commiphora africana |
| CML | Commiphora angolensis |
| CME | Commiphora edulis |
| CMO | Commiphora mollis |
| CMM | Commiphora mossambicensis |
| CMG | Commiphora pyracanthoides subsp. glandulosa |
| CMP | Commiphora pyracanthoides subsp.pyracanthoides |
| CMS | Commiphora schimperi |
| CR | Croton sp. |
| CRG | Croton gratissimus |
| CRM | Croton megalobotrys |
| CRY | Croton menyharthii |
| DAE | Dialium engleranum |
| DRC | Dichrostachys cinerea |
| DPL | Diospyros lycioides |
| DPM | Diospyros mespiliformis |
| DSC | Diplorhynchus condylocarpon |
| DMR | Dombeya rotundifolia |
| EHA | Ehretia amoena |
| EHR | Ehretia rigida |
| ELG | Elephantorrhiza goetzei |
| ELB | Elephantorrhizia burkei |
| ENC | Entandrophragma caudatum |
| EYA | Erythrophleum africanum |
| EUD | Euclea divinorum |
| EUN | Euclea natalensis |
| EUU | Euclea undulata |
| EP | Euphorbia sp. |
| FAS | Fauria saligna |
| FIC | Ficus capensis |
| FIO | Ficus soldanella |
| FIS | Ficus sycomorus |
| FIV | Ficus verruculosa |
| FRO | Friesodietsia obovato |

| | |
|---|---|
| GAL | Garcinia livingstonei |
| GDR | Gardenia resinflua |
| GDV | Gardenia volkensii |
| GR | Grewia sp. |
| GRB | Grewia bicolor |
| GRF | Grewia flava |
| GRV | Grewia flavescens |
| GRM | Grewia monticola |
| GRO | Grewia occidentalis |
| GRR | Grewia retinervis |
| GRS | Grewia subspathulata |
| GUC | Guibourtia coleosperna |
| HY | Hyphaene sp. |
| HYC | Hyphaene natalensis |
| HYV | Hyphaene ventricosa |
| JUG | Julbernardia globiflora |
| KGA | Kigelia africana |
| KI | Kirkia sp. |
| KIA | Kirkia acuminata |
| LAD | Lannea descolor |
| LAS | Lannea stuhlmannii |
| LOC | Lonchocarpus capassa |
| LON | Lonchocarpus nelsii |
| LY | Lycium sp. |
| LYA | Lycium arenicolum |
| MEA | Maerua angolensis |
| MRA | Markhamia acuminata |
| MAH | Maytenus heterophylla subsp.heterophylla |
| MAS | Maytenus senegalensis |
| MAT | Maytenus tenuispina |
| MIZ | Mimusops zegheri |
| MUS | Mundulea sericea |
| OAP | Ochna pulchra |
| OLA | Olea africana |
| OSM | Ostiospermum muricatum |
| OTS | Ostryoderrus stuhmannii |
| OZP | Ozoroa paniculosa |
| PAC | Pappea capensis |
| PVZ | Pavetta zeyheri |
| PEA | Peltophorum africanum |
| PXR | Phoenix redinata |
| PHR | Phyllanthus reticulatus |
| PIT | Piliostigma tonningii |
| PPO | Popowia obovata |
| POH | Pouzalzia hypoleuca |
| PRG | Protea gaguedi |
| PTA | Pterocarpus angolensis |
| RGB | Rhigozum brevispinosum |
| RGT | Rhigozum trichotomum |
| RH | Rhus sp. |
| RHA | Rhus lancea |
| RHL | Rhus leptodictya |
| RHU | Rhus lucens |
| RHP | Rhus pyroides |
| RHT | Rhus tenuinervis |
| RIR | Ricinodendron rautanenii |
| SCC | Sclerocarya caffra |
| SAB | Scotia brachypetala |
| SEL | Securidaca longi-pedunculata |
| SRV | Securinega virosa |
| SSL | Sesamothamnus lugardii |
| SO | Solanum sp. |
| SPA | Spirostachys africana |
| STA | Steganotaenia araliacea |
| STC | Strychnos cocculoides |
| STP | Strychnos pungens |
| SWM | Swartzia madagascariensis |
| SYG | Syzyguim guinecense var. barotsense |
| TAC | Tarchonanthus camphoratus |
| TES | Tephrosia sericea |
| TMP | Terminalia prunioides |
| TMR | Terminalia randii |
| TMS | Terminalia sericea |
| VAL | Vangueria infausta |
| VIZ | Vitex zeyheri |
| XAZ | Xanthocercis zambesiaca |
| XIA | Ximenia americana |
| XIC | Ximenia caffra |
| ZIM | Ziziphus mucronata |

**F.2. Grasses**

| | |
|---|---|
| ANA | Andropogon amplectens |
| ANE | Andropogon eucomus |
| ATA | Antephora argentea |
| ATP | Antephora pubescens |
| AR | Aristida sp. |
| ARB | Aristida brevifolia |
| ARC | Aristida ciliata |
| ARA | Aristida congesta |
| ARM | Aristida meridionalis |
| ARN | Aristida namaquensis |
| ARS | Aristida stipitata |
| ARU | Aristida uniplumis |
| BTR | Bothriochloa radicans |
| BRD | Brachiaria deflexa |
| BRM | Brachiaria marlothii |
| BRN | Brachiaria nigropedata |
| CEC | Cenchrus ciliaris |
| CH | Chloris sp. |
| CHG | Chloris gayana |
| CHM | Chloris myrostachya |
| CHV | Chloris virgata |
| CSM | Chrysopogon montanus |
| CYE | Cymbopogon excavatus |
| CYM | Cymbopogon marginatus |
| CYP | Cymbopogon plurinodes |
| CND | Cynodon dactylon |
| DAA | Dactyloctenium aegyptium |
| DAG | Dactyloctenium gigantium |
| DNG | Danthonia glauca |
| DCA | Dichanthium annulatum |
| DCP | Dichanthium papillosum |
| DI | Digitaria sp. |
| DIE | Digitaria eriantha |
| DIM | Digitaria milanjiana |
| DIP | Digitaria pentzii |

| | |
|---|---|
| DIV | Digitaria pentzii var. stolonifera |
| DIS | Digitaria setivalva |
| ECH | Echinochloa holubii |
| ECP | Echinochloa pyramidalis |
| ELA | Eleusine africa |
| EYA | Elyonurus argenteus |
| ENC | Enneapogon cenchroides |
| ENS | Enneapogon scoparium |
| ER | Eragrostis sp. |
| ERA | Eragrostis atherstonii |
| ERB | Eragrostis biflora |
| ERC | Eragrostis ciliaris |
| ERF | Eragrostis colifera |
| ERD | Eragrostis denudata |
| ERE | Eragrostis echinochloidea |
| ERG | Eragrostis gummiflua |
| ERL | Eragrostis lehmannniana |
| ERP | Eragrostis pallens |
| ERR | Eragrostis rigidior |
| ERO | Eragrostis rotifer |
| ERS | Eragrostis superba |
| EUP | Eustachys paspaloides |
| FIA | Fingerhuthia africana |
| HEC | Heteropogon contortus |
| HPF | Hyparrhenia filipendula |
| HPH | Hyparrhenia hirta |
| HYD | Hyperthelia dissoluta |
| IMC | Imperata cylindrica |
| ISB | Ischaemum brachyatherum |
| MEA | Megaloprotachne albescens |
| ODP | Odyssea paucinervis |
| ORC | Oropetium capense |
| PA | Panicum sp. |
| PAC | Panicum coloratum |
| PAK | Panicum kalaharense |
| PAL | Panicum lanides |
| PAM | Panicum maximus |
| PAE | Panicum meyerianum |
| PAN | Panicum novemnerve |
| PAR | Panicum repens |
| PEP | Pennisetum purpureum |
| PRP | Perotis patens |
| PHC | Phragmites communis |
| POS | Pogonarthria squarrosa |
| RHR | Rhynchelytrum repens |
| RHV | Rhynchelytrum villosum |
| SCB | Schmidtia bulbosa |
| SCK | Schmidtia kalahariensis |
| SCP | Schmidtia pappophoroides |
| SEP | Setaria pallide-fusca |
| SES | Setaria sphacelata |
| SEV | Setaria verticillata |
| SOV | Sorghum verticilliflorum |
| SPV | Sporobolus festivus |
| SPF | Sporobolus fimbriatus |
| SPI | Sporobolus ioclados |
| SPP | Sporobolus pyramidalis |
| SPR | Sporobolus rangei |
| SPS | Sporobolus spicatus |
| STU | Stipachrostis uniplumus |
| STA | Stipagrostis amabilis |
| STS | Stipagrostis stipitata |
| THT | Themada triandra |
| TGB | Tragus berteronianus |
| TGR | Tragus racemosus |
| TCM | Tricholaena monachne |
| TNG | Trichoneuro grandiglumis |
| TPA | Tripogon abyssinicus |
| TRA | Triraphis andropogonoides |
| TRS | Triraphis schlechteri |
| URS | Urelytrum squarrosum |
| UCD | Urochloa bolbodes |
| UCR | Urochloa brachyura |
| UCM | Urochloa mosambiscensis |
| UCT | Urochloa trichopus |

**F.3. Forbs**

| | |
|---|---|
| AL | Aloe spp. |
| ALL | Aloe littoralis |
| ASF | Asclepias fruticosa |
| AM | Amaranthus spp. |
| AP | Asparagus spp. |
| AGM | Argemone mexicana |
| BAE | Bauhinia esculenta |
| BO | Boophone spp. |
| BLG | Blumea gariepina |
| CAI | cassea italica |
| CIP | Ciniclia polycephala |
| CPD | Ceasalpinia decapetala |
| CRS | Crotolaria spastioides |
| DPG | Dipeadi glaucum |
| DTS | Datura stramonium |
| DTF | Datura ferox |
| GE | Geigeria sp. |
| GNP | Gnidia polycephola |
| HAP | Harpagophytum procumbens |
| IN | Indigoferra spp. |
| OTB | Otoplera burchelli |
| PGE | Pergularia extensa |
| SA | Sansevieria sp. |
| SB | Sesbania spp. |
| SRV | Sarcostemma vinimale |
| SOI | Solanum incanum |
| SOK | Solanum kwebense |
| SON | Solanum nigrens |
| TAM | Tagetes minuta |
| TBT | Tribulus terrestris |
| XAS | Xanthium spinosum |

## APPENDIX G. Geological unit codes

| | |
|---|---|
| Q | Quaternary deposits |
| KAL | Kalahari beds |
| K | Karoo supergroup |
| KS | Stormberg group |
| KL | Lebung group |
| KLN | Ntane formation (Cave Sandstone) |
| KLT | Tlhabala formation |
| KLD | Dukwi formation |
| KE | Ecca group and undifferentiated lower Karoo |
| D | Damara sequence |
| DO | Otavi group |
| DS | Swakop group |
| O | Olifantshoek sequence |
| OG | Ganzi group |
| ON | Nami group |
| ONK | Kgwebe formation |
| W | Waterberg supergroup |
| WP | Palapye group |
| WPS | Shoshong formation |
| WPL | Lotsane formation |
| WPT | Tswapong formation |
| WPM | Moeng formation |
| WSE | Selika formation |
| WV | Waterberg undifferentiated |
| T | Transvaal supergroup |
| V | Ventersdorp supergroup |
| B | Basement complex |
| BM | Mahalapye migmatite |
| BG | Gaborone granite |
| BKV | Kanye volcanics formation |
| INT | Intrusives |

## APPENDIX H. Key to the General Soil Legend of Botswana

**Note:** This key contains abridged soil unit descriptions only, full descriptions are given in Remmelzwaal (1988)

## A Soils on Alluvial Deposits

| | DEPTH | DRAIN | TEXT | COLOUR | TOPO | UNIT | REMARKS |
|---|---|---|---|---|---|---|---|
| **HISTOSOLS** | | | | | | | |
| Dystric | > 150 | V | SCL-SIL | 10YR 2/0 -10YR 2/1 | F | A26 | overl.sandy subsoil |
| Eutric | > 150 | V | SCL-SIL | 10YR 2/0 -10YR 2/1 | F | A27 | overl. sandy subsoil |
| **VERTISOLS** | | | | | | | |
| Pellic, partly sodic | > 100 | P-I | C | 10YR 3/1 -2.5Y4/1.5 | F-A | A1 | |
| Chromic | > 100 | I | CL-C | 10YR 4/2 -2.5YR 5/4 | F-G | A2 | |
| **FLUVISOLS** | | | | | | | |
| Calcaric, partly sodic | >100 | P-I | L-C | 2.5Y 4/1 -10YR 3/2 | F | A23 | |
| Arenic Calcaric, partly sodic | >100 | P-I | LS | 2.5Y 4/1 -10YR 3/2 | F | A23a | |
| Dystric | >150 | P | SL-SICL | 10YR 2/0 -10YR 4/2 | | A25 | often overlying (L)S |
| Dystric | >150 | V | SL-SCL | 10YR 2/0 -10YR 4/1 | F | A25b | mostly with Histic <50CM,overlying sand |
| Arenic Dystric | >150 | P | S-LS | 10YR 2/0 -10YR 4/2 | | A25a | |
| Eutric | >150 | V-I | SL-C | 10YR 2/0 -2.5Y 4/2 | F | A24 | |
| Eutric, partly saline | >150 | P-I | SIL-SIC | 10YR 2/0 -10YR 4/2 | F | A24d | often overlying (L)S |
| Eutric, clayey | >150 | P | S-LS | 10YR 6/3 -7.5YR 5/4 | | A24e | |
| Arenic Eutric | >150 | P | S-LS | 10YR 8/1 -7.5YR 5/4 | F | A24a | in channels |
| Arenic eutric | >150 | V-I | S-LS | 10YR 4/2 -2.5Y 2/0 | F | A24b | |
| Arenic Eutric | >150 | P-I | SL-SC | 10YR 2/0 -10YR 4/2 | F | A24c | |
| **SOLONCHAKS** | | | | | | | |
| Gleyic | > 150 | P-I | FS-L | 10YR 5/2 -10YR 6/2 | F-A | A29 | |
| Orthic | > 150 | P-I | L-SICL | 2.5Y 5/2 -10YR 5/2 | F-A | A28 | |
| **GLEYSOLS** | | | | | | | |
| Mollic | >100 | P-I | L-C | 10YR 2/0 -2.5Y 5/1 | F | A42b | Diatom.earth <50cm |
| Calcic Mollic | >100 | P-I | L-C | 10YR 2/0 -2.5Y 5/1 | F | A42c | |
| Vertic Mollic | >100 | P-I | L-C | 10YR 2/0 -2.5Y 5/1 | F | A42 | |
| Vertic Mollic | >100 | P-I | L-C | 10YR 2/0 -2.5Y 5/1 | F | A42a | overlying white fine sand < 100cm |
| Calcic | >100 | P-I | SC-C | 10YR 3/1 -2.5Y 3/1 | F | A30 | |
| Eutric | >150 | P-I | SCL-C | 10YR 2/0 -2.5Y 4/2 | F | A31a | |
| Eutric, partly sodic | >100 | P-I | SC-C | 10YR 3/1 -2.5Y 3/1 | F | A31 | |
| Eutric, partly sodic | >100 | P-I | SL | 10YR 3/1 -2.5Y 3/1 | F | A31b | |
| **ARENOSOLS** | | | | | | | |
| Luvic | > 150 | M-W | FS-LS | 2.5Y 4/2 -7.5YR 5/4 | F | A41 | massive |
| Petrocalcic | 50-125 | M-W | S-LS | 10YR 4/2 -10YR 5/8 | F-U | A21a | |
| Calcic | > 50 | M-W | S-LS | 10YR 4/2 -10YR 5/8 | F-U | A21 | |
| Calcaric | > 50 | M-W | S-LS | 10YR 5/2 -10YR 5/8 | F-U | A20 | |
| Ferralic | > 100 | W-S | S-LS | 10YR 5/4 -2.5YR 3/6 | F-G | A19 | |
| Cambic | > 100 | W-S | S-LS | 10YR 3/3 -7.5YR 5/8 | F-G | A22a | on natural levees |
| Cambic | > 100 | M-W | FS-LFS | 10YR 3/2 -10YR 5/8 | | A22b | |
| Eutric | > 100 | W-S | S-LS | 10YR 3/3 -7.5YR 5/8 | F-G | A22 | on natural levees |
| Eutric | > 100 | M-W | S-LS | 7.5YR 5/4-10YR 8/1 | F-U | A40 | |
| Eutric | > 100 | M-W | S-LS | 7.5YR 5/4-10YR 8/1 | F-U | A40a | massive |
| Eutric | > 100 | M-W | S-LS | 7.5YR 5/4-10YR 8/1 | F-U | A40b | on ridges |
| Eutric,clayey | > 100 | M-W | S-LS | 7.5YR 4/4-10YR 8/1 | F-U | A40c | |
| **REGOSOLS** | | | | | | | |
| Calcaric | > 100 | M-W | SL-FSL | 7.5YR 5/2-10YR 5/8 | F-G | A35 | |
| Eutric, shallow petric | 50-150 | W-S | LS-SL | 10YR 3/3 -2.5YR 5/4 | F-G | A34 | |
| **PLANOSOLS** | | | | | | | |
| Solodic | > 100 | P-I | SC-C | 10YR 4/2 -10YR 3/6 | F-A | A6 | |
| **SOLONETZ** | | | | | | | |
| Gleyic, partly saline | > 100 | P-I | SCL-C | 10YR 3/1 -2.5Y 5/2 | F | A5 | |
| Orthic, partly saline | > 100 | I-M | SCL-C' | 2.5Y 3/2 -7.5YR 5/8 | F-G | A5b | |
| **CHERNOZEMS** | | | | | | | |
| Gleyic Luvic | >100 | I | CL-C | 10YR 2/0 -2.5Y 5/2 | F | A48 | |
| Calcic | > 50 | I | SC | 10YR 3/1 -2.5Y 4/2 | A | A43 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PHEAOZEMS** | | | | | | | |
| Gleyic | >100 | P-I | CL-C | 10YR 2/0 -2.5Y 5/2 | F-A | A47 | |
| Luvic | > 50 | M-W | SL-SC | 10YR 5/3 - 5YR 5/8 | | A45 | |
| Luvic | > 50 | I | SL-SC | 10YR 3/2 - 2.5Y 3/2 | | A45a | |
| Haplic | > 50 | M-W | SL-SC | 10YR 5/3 - 5YR 5/8 | | A46 | |
| **XEROSOLS** | | | | | | | |
| Luvic | > 100 | M-W | SL-SCL | 10YR 3/4 -2.5YR 4/6 | F-U | A36 | |
| Calcic Luvic | > 100 | I-M | SCL-C | 10YR 3/3 -7.5YR 5/8 | F-G | A37 | |
| Calcic Luvic | > 100 | M-W | SL-SCL | 5YR 4/6 -10YR 5/8 | | A37a | terraces |
| Calcic Luvic,petrocalcic | > 100 | M-W | SL-SCL | 5YR 4/6 -10YR 5/8 | | A37c | |
| Arenic Calcic Luvic | > 100 | M-W | SL-SCL | 5YR 4/6 -10YR 5/8 | | A37b | on natural levees |
| Arenic Calcic Luvic,petrocalcic | >100 | M-W | SL-SCL | 5YR 4/6 -10YR 5/8 | | A37d | on natural levees |
| Calcic | > 100 | I-M | SCL-C | 10YR 3/3 -7.5YR 5/8 | F-G | A38 | |
| Haplic | 100-150 | I-W | SCL-SC | 10YR 5/3 -5YR 5/8 | F-U | A39 | |
| **NITOSOLS** | | | | | | | |
| Arenic Dystric | > 150 | W | LS-SL | 2.5YR 4/6-7.5YR 7/8 | A-U | A17 | |
| Eutric | > 150 | M-W | SL-SCL | 2.5YR 3/6-7.5YR 5/8 | A-U | A16 | |
| Arenic Eutric | > 150 | W | LS-SIL | 2.5YR 4/6 7.5YR 7/8 | G | A16b | gently sloping terraces |
| Calcic Eutric | > 150 | I-M | SCL-SC | 7.5YR 4/2-2.5YR 3/6 | F-A | A16a | |
| **ACRISOLS** | | | | | | | |
| Ferric | 50-150 | M-W | SL-SCL | 7.5YR 4/6-2.5YR 5/8 | U | A18 | |
| **LUVISOLS** | | | | | | | |
| Gleyic, partly sodic | > 100 | P-I | SCL-C | 10YR 4/1 -2.5Y 5/2 | F | A7 | |
| Gleyic, partly sodic | > 100 | P-I | SL | 10YR 4/1 -2.5Y 5/2 | F | A7a | |
| Calcic Gleyic, partly sodic | > 100 | P-I | SL-SC | 10YR 4/1 -2.5Y 5/2 | F | A7b | |
| Albic | >100 | I-M | LS-SL | 10YR 4/2 -10YR 6/3 | F-G | A44 | massive |
| Vertic | > 100 | I-M | SCL-C | 10YR 4/2 -5YR 5/4 | F-G | A8 | |
| Calcic | > 100 | I-M | SCL-C | 2.5Y 4/2 -10YR 5/8 | F-G | A9 | |
| Calcic, petrocalcic | 50-100 | I-M | SCL-C | 2.5Y 4/2 -10YR 5/8 | F-G | A9b | |
| Calcic, sodic/saline | > 100 | I | SCL-C | 10YR 4/2 -2.5Y 4/2 | F | A9c | partly strongly sodic |
| Arenic Calcic | 50-150 | I-M | SL-SCL | 10YR 3/2 -2.5Y 3/2 | F-G | A9a | |
| Chromic Calcic,partly petrocalcic | > 50 | M | SL-SCL | 7.5YR 4/6-5/YR 5/8 | F-U | A10 | |
| Chromic | 50-150 | M-W | SL-SCL | 2.5YR 3/6-7.5YR 5/8 | A-U | A13 | |
| Chromic | 50-150 | M | SCL-SC | 2.5YR 3/6-7.5YR 5/8 | F-G | A13a | massive |
| Chromic, petric | 50-150 | W | SL-SCL | 7.5YR 4/6-2.5YR 5/8 | F-U | A13b | |
| Ferric | > 50 | M-W | SL-SC | 7.5YR 4/6-2.5YR 5/8 | F-U | A11 | |
| Ferric, petric/petroferric | 50-100 | M | SL-SCL | 10YR 5/3 -2.5YR 5/8 | | A11a | |
| Arenic Ferric | > 50 | W | LS-SL | 10YR 5/3 -5YR 5/8 | A-U | A12 | |
| Orthic | > 50 | M-W | SL-SC | 10YR 3/2 -10YR 5/8 | F-U | A14 | |
| Orthic | > 50 | I-M | SL-SC | 2.5Y 3/1 -10YR 5/2 | F-U | A14a | |
| Arenic Orthic | > 50 | W | LS-SCL | 10YR 6/3 -10YR 5/8 | F-U | A15 | |
| Arenic Orthic | > 50 | I-M | LS-SCL | 2.5Y 3/1 -10YR 5/2 | F-U | A15a | |
| **CAMBISOLS** | | | | | | | |
| Gleyic | >150 | I | SL-SC | 10YR 3/2 - 2.5Y 3/2 | F | A32 | incl. SIL; often overlying (L)FS |
| Vertic | > 100 | I | SCL-C | 10YR 4/2 -2.5YR 4/2 | F-G | A3 | |
| Calcaric | >50 | I-M | SL-SC | 2.5Y 4/2 -7.5YR 5/4 | F-G | A4 | |
| Calcic | >100 | I | SCL-C | 10YR 6/1 -2.5YR 5/2 | F-A | A4a | massive, strongly calcareous <50cm |
| Calcic | >50 | I-M | CL-C | 2.5Y 4/2 -7.5YR 5/4 | F-G | A4b | |
| Calcic | >50 | M | SL-SCL | 2.5Y 4/2 -7.5YR 5/4 | F-U | A4c | |
| Calcic, petrocalcic | 50-100 | I-M | SL-C | 2.5YR 4/2-7.5YR 5/4 | A-U | A4d | |
| Eutric | >150 | W | SL | 7.5YR 3/2- 10YR 5/4 | F-G | A33 | on natural levees |
| Eutric, partly sodic | >100 | I | CL | 10YR 4/2 - 2.5Y 4/2 | F | A33a | |

## B Soils on Basic Igneous and Metamorphic Rocks

| | DEPTH | DRAIN | TEXT | COLOUR | TOPO | UNIT | REMARKS |
|---|---|---|---|---|---|---|---|
| **VERTISOLS** | | | | | | | |
| Pellic,partly sodic/petric | 50-150 | P-I | C | 2.5Y 2/0-10YR 3/1.5 | A | B9 | |
| Chromic,partly petric | 50-150 | I | SC-C | 5YR 2.5/2-10YR 4/3 | A | B8 | |
| **REGOSOLS** | | | | | | | |
| Calcaric, lithic/shallow petric | <50 | W-S | SL-CL | 7.5YR 3/2-2.5YR 5/4 | U-H | B1b | |
| Eutric,lithic | <50 | W-S | SL-CL | 7.5YR 3/2-2.5YR 5/4 | U-H | B1 | |
| Eutric,lithic/shallow petric | <50 | W-S | SL-CL | 7.5YR 3/2-2.5YR 5/4 | A | B1a | |
| **XEROSOLS** | | | | | | | |
| Luvic,petric/partly lithic | 25-100 | W | SCL-SC | 2.5YR 4/3-7.5YR 5/8 | U-R | B5c | |
| Calcic Luvic,petric/partly lithic | 25-100 | W | CL-C | 7.5YR 3/2-2.5YR 5/4 | U-R | B6c | |
| Calcic,petric/partly lithic | 25-100 | W | CL-C | 7.5YR 3/2-2.5YR 5/4 | U-R | B6d | |
| Haplic,petric/partly lithic | 25-100 | W | SCL-SC | 2.5YR 4/3-7.5YR 5/8 | U-R | B5d | |
| **NITOSOLS** | | | | | | | |
| Eutric | > 150 | M-W | SCL | 5YR 4/6 -2.5YR 5/8 | F-U | B7 | |
| **LUVISOLS** | | | | | | | |
| Calcic | 100-150 | M-W | SCL-C | 7.5YR 3/2-2.5YR 5/4 | U-R | B6 | on basalt |
| Calcic,petric/partly lithic | 25-100 | W | CL-C | 7.5YR 3/2-2.5YR 5/4 | U-R | B6a | on basalt |
| Chromic Calcic,partly petric | 50-150 | M-D | SCL | 5YR 4/3 -2.5YR 5/8 | A-U | B4 | on dolerite/diabase |
| Ferric | >150 | W | SCL-SC | 7.5YR 3/2- 7.YR 5/8 | A-U | B11 | on gabbro mainly |
| Chromic | 100-150 | M-W | SL-CL | 2.5YR 4/6-7.5YR 5/8 | A-U | B3 | on dolerite/diabase |
| Chromic | 100-150 | W | SCL-C | 2.5YR 4/3-7.5YR 5/8 | U-R | B5 | on basalt |
| Chromic,petric/partly lithic | 25-100 | W | SL-CL | 2.5YR 4/6-7.5YR 5/8 | A-R | B2 | on dolerite/diabase |
| Chromic,petric/partly lithic | 25-100 | W | SCL-SC | 2.5YR 4/3-7.5YR 5/8 | U-R | B5a | on basalt |
| Orthic,petric/partly lithic | 25-100 | M-W | SC-C | 10YR 3/2 -10YR 4/3 | A | B10 | |
| **CAMBISOLS** | | | | | | | |
| Calcic, petric/partly lithic | 25-100 | W | CL-C | 7.5YR 3/2-2.5YR 5/4 | U-R | B6b | |
| Chromic, petric/partly lithic | 25-100 | W | SCL-SC | 2.5YR 4/3-7.5YR 5/8 | U-R | B5b | |

## C (or LC) Soils on Highly Calcareous Materials

| | DEPTH | DRAIN | TEXT | COLOUR | TOPO | UNIT | REMARKS |
|---|---|---|---|---|---|---|---|
| **LITHOSOL** | 0- 10 | M-W | LS-CL | 2.5Y 4/2 -7.5YR 5/4 | F-U | C1 | |
| **ARENOSOLS** | | | | | | | |
| Petrocalcic, shallow petrocalcic | 10-50 | I-M | S-LS | 2.5Y 3/2- 7.5YR 5/6 | F-U | C3 | |
| Calcic | 50-100 | M-W | S-LS | 2.5Y 6/2 - 10YR 3/6 | F-U | C3b | |
| **REGOSOLS** | | | | | | | |
| Calcaric,shallow petrocalcic | 10-50 | I-W | SL-CL | 2.5Y 3/2 -7.5YR 5/4 | F-U | C2 | |
| **RENDZINA** shallow petrocalcic | 10-25 | I-W | SL-CL | 2.5Y 3/2 -7.5YR 5/4 | F-U | C1a | |
| petrocalcic | 25-100 | I-M | LS-SCL | 2.5Y 3/2 -7.5YR 5/4 | F | C10 | |
| **CHERNOZEMS** | | | | | | | |
| Calcic Luvic,partly petrocalcic | 25-100 | I | SC- C | 2.5Y 3/1 - 10YR 5/2 | F | C7 | |
| Gleyic Luvic,partly petrocalcic | 25-100 | P | CS- C | 2.5Y 3/0 - 10YR 5/1 | F | C8 | |
| Calcic, partly petrocalcic | 25-100 | I | SCL-C | 2.5Y 3/1 -7.5YR 5/4 | F | C9 | |
| **XEROSOLS** | | | | | | | |
| Calcic Luvic,partly petrocalcic | 25-100 | M-W | SL-CL | 10YR 3/4 - 5YR 5/8 | F-U | C5a | |
| Calcic Luvic,partly petrocalcic | 25-100 | I | SL SC | 2.5Y 3/1 -7.5YR 5/4 | F | C5c | |
| Calcic,partly petrocalcic | 25-100 | I-W | SL-CL | 2.5Y 3/1 -2.5YR 5/4 | F-U | C4a | |
| **LUVISOLS** | | | | | | | |
| Calcic, partly petrocalcic | 25-100 | M W | SL CL | 10YR 3/4 -5YR 5/8. | F-U | C5 | |
| Calcic,partly petrocalcic | 25-100 | I | SL SC | 2.5Y 3/1 -7.5YR 5/4 | F | C5b | |
| Calcic Gleyic,partly petrocalcic | 25-100 | P I | SCL C | 2.5Y 3/0 -10YR 5/2 | F | C6 | |
| **CAMBISOLS** | | | | | | | |
| Calcic, partly petrocalcic | 25-100 | I-W | SL-CL | 2.5Y 3/1 -2.5YR 5/4 | F-U | C4 | |

## D Soils on Fine Grained Sedimentary Rocks

| | DEPTH | DRAIN | TEXT | COLOUR | TOPO | UNIT | REMARKS |
|---|---|---|---|---|---|---|---|
| **REGOSOLS** | | | | | | | |
| Calcaric,shallow petric/ partly lithic | 10-100 | W | SL-CL | 2.5YR 4/4-10YR 5/8 | U-H | D1b | |
| Dystric, shallow petric/ partly lithic | 10-100 | W | SL-CL | 2.5YR 4/4 -10YR 5/8 | U-H | D1 | |
| Eutric,petric/partly lithic | 10-100 | M-W | SC-C | 2.5YR 4/4-10YR 5/8 | A-U | D1c | |
| Eutric,shallow petric/partly lithic | 10-100 | W | SL-CL | 2.5YR 4/4-10YR 5/8 | U-H | D1a | |
| **NITOSOLS** | | | | | | | |
| Eutric | >150 | M-W | SL-SCL | 2.5YR 4/6-2.5YR 5/8 | F-U | D10 | |
| **ACRISOLS** | | | | | | | |
| Ferric | >100 | W | SL | 5YR 4/6 - 5YR 5/8 | F-U | D3 | |
| Ferric, partly petric | 50-150 | M-W | SL-SCL | 10YR 6/3 - 5YR 5/8 | F-U | D4 | |
| Ferric, partly petroferric | > 50 | M | SCL-SC | 7.5YR 4/2-2.5YR 5/8 | F-G | D7c | massive |
| **LUVISOLS** | | | | | | | |
| Calcic | 100 150 | M | SCL-SC | 5YR 5/3 -10YR 3/6 | F-U | D9 | |
| Calcic,petrocalcic | 100-125 | M | SCL-SC | 5YR 5/3 -10YR 3/6 | F-U | D9a | |
| Ferric | > 100 | M-W | SL-SCL | 5YR 4/6 - 5YR 7/8 | F-G | D5b | |
| Ferric,petric/petroferric | 50-100 | W | SL | 10YR 5/3 - 5YR 5/8 | F-U | D2 | petric/petroferric within 75cm |
| Ferric,petric | 50-100 | M-W | SL-SCL | 2.5YR 4/4- 5YR 5/8 | U-H | D6 | |
| Ferric,partly petric | 50-150 | M-W | SL-SCL | 2.5YR 4/4-7.5YR 5/8 | F-G | D5 | petric >75cm deep |
| Ferric,partly petric/petro-ferric | 50-150 | M | SCL-SC | 7.5YR 3/2-5YR 5/8 | F-G | D7 | massive |
| Chromic | > 100 | M-W | SL-SCL | 5YR 4/6 - 5YR 7/8 | F-G | D5a | |
| Chromic | 100-150 | M | CL-SC | 5YR 4/6 - 2.5YR 5/8 | F-G | D7b | massive |
| Chromic | 100-150 | M | SCL-SC | 5YR 4/6 - 2.5YR 5/8 | F-U | D8 | |
| Orthic,partly petric | 100-150 | I-M | CL-SC | 7.5YR 3/2-10YR 5/8 | F-A | D7a | massive |

## G Soils on Acid Igneous and Metamorphic Rocks

| | DEPTH | DRAIN | TEXT | COLOUR | TOPO | UNIT | REMARKS |
|---|---|---|---|---|---|---|---|
| **LITHOSOLS** | 0-10 | W-S | S-LS | 10YR 5/2-7.5YR 4/4 | | G1e | |
| **ARENOSOLS** | | | | | | | |
| Albic,partly petroferric | 50-150 | I-M | S-LS | 10YR 7/1 -10YR 6/3 | F-G | G3 | massive |
| Ferralic,partly petroferric | >50 | W-S | S-LS | 7.5YR 4/6-5YR 5/8 | A-G | G4 | |
| **REGOSOLS** | | | | | | | |
| Calcaric,shallow petric | 50-100 | M-W | S-LS | 10YR 4/2 -2.5YR 4/4 | A-R | G1d | |
| Dystric,lithic | 10-50 | M-S | S-SL | 10YR 5/2 -5YR 5/8 | U-H | G1 | |
| Dystric,petric partly petroferric | 50-150 | M-W | LS | 10YR 4/2 -2.5YR 5/4 | A-U | G2 | petric/petroferric within 75cm |
| Dystric,shallow petric | 50-100 | M-W | S-LS | 10YR 4/2 -2.YR 4/4 | A-R | G1b | |
| Eutric,lithic | 10 50 | M-S | S-SL | 10YR 5/2 -5YR 5/8 | U-H | G1a | |
| Eutric,petric | 100-150 | M-W | LS | 10YR 4/2 -2.5YR 5/4 | A-U | G2a | petric within 75cm |
| Eutric,partly petric/ petroferric | 50-150 | I-M | SL | 10YR 7.1 -10YR 6/3 | F-G | G3a | |
| Eutric,shallow petric | 50-100 | M-W | S-LS 1 | 10YR 4/2 -2.5YR 4/4 | A-R | G1c | |
| **PLANOSOLS** | | | | | | | |
| Solodic | >100 | P-I | SC-C | 7.5YR 4/6-10YR 5/8 | F-G | G15 | |
| **SOLONETZ** | | | | | | | |
| Gleyic | >100 | P-I | SCL-SC | 2.5Y 4/0 -10YR 5/2 | F-A | G16 | |
| **XEROSOLS** | | | | | | | |
| Luvic,partly petric | > 50 | M-W | SL-SC | 5YR 4/6 - 2.5YR 5/8 | | G8a | petric deeper 75cm |
| Luvic,partly petric/ petroferric | 50-150 | M | SCL-C | 5YR 4/6 -2.5YR 5/8 | A-U | G6b | ferric;petric/petro ferric deeper 75cm |
| Luvic,shallow petric/ petroferric | 50-100 | M-W | SL-SCL | 10YR 5/2 -2.5YR 4/8 | U | G2e | petric/petroferric within 75cm |
| Calcic Luvic | 50-150 | I-W | SL-SC | 10YR 4/1 -2.5YR 3/4 | F-U | G13b | |
| **NITOSOLS** | | | | | | | |
| Eutric | > 150 | M-W | SCL-SC | 2.5YR 3/6-5YR 5/8 | A-G | G14 | on pediments mainly |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **ACRISOLS** | | | | | | | |
| Ferric,partly petric/ petroferric | 50-150 | M-W | SL-SC | 10YR 3/4-5YR 5/8 | A-U | G5 | |
| **LUVISOLS** | | | | | | | |
| Plinthic | 100-150 | I-M | SL-SCL | mottled | F-G | G11 | |
| Gleyic | 50-150 | P-I | SL-C | 2.5Y 4/1 -10YR 5/2 | F | G12 | |
| Calcic | 50-150 | I-W | SL-SC | 10YR 4/2 -2.5YR 3/4 | F-U | G13 | |
| Calcic,petrocalcic | 50-100 | I-W | SL-SC | 10YR 4/1 -2.5YR 3/4 | F-U | G13a | |
| Ferric | >100 | M | SCL-C | 5YR 4/6 -7.5YR 5/8 | A | G10b | |
| Ferric,partly petric/ petroferric | 50-150 | M | CL-C | 5YR 4/6 -2.5YR 5/8 | A-U | G6a | petric/petroferric deeper than 75cm |
| Ferric,petroferric | 50-150 | I-M | SL-SCL | 10YR 4/2 -7.5YR 5/4 | F-G | G7a | massive |
| Ferric,shallow petric/petric/ petroferric | 50-100 | M-W | SL-SCL | 10YR 5/2 -2.5YR 4/8 | U | G2d | petric/petroferric within 75cm |
| Ferric,shallow petric/petric/ petroferric | 50-100 | M-W | SC-C | 10YR 5/2 -2.5YR 4/8 | U | G2f | petric/petroferric within 75cm |
| Arenic Ferric,partly petric/ petroferric | 50-150 | M-W | LS-SL | 5YR 4/6 -2.5YR 5/8 | A-U | G6 | petric/petroferric deeper than 75cm |
| Chromic | >100 | M-W | SCL-SC | 5YR 4/6-2.5YR 3/6 | A-U | G9 | |
| Chromic | >100 | M | SCL-C | 5YR 4/6-7.5YR 5/8 | A | G10 | |
| Chromic, petric | 50-150 | M-W | SL-SCL | 5YR 4/6-2.5YR 5/8 | A-U | G8 | petric deeper 75cm |
| Chromic,shallow petric/petric | 50-100 | M-W | SL-SCL | 7.5YR 4/6-2.5YR 5/8 | A-U | G2c | petric within 75cm |
| Orthic | >100 | I | SCL-C | 7.5YR 3/2-7.5YR 4/4 | A | G10a | |
| Orthic, petric | 50-150 | I-M | SL-SCL | 10YR 4.2 -7.5YR 5/4 | F-G | G7 | massive |
| **CAMBISOLS** | | | | | | | |
| Ferralic,petric | 50-150 | M-W | SL | 10YR 4/3-5YR 5/8 | A-U | G2b | petric within 75cm |

## L (and AL) Soils on Lacustrine Deposits

| | DEPTH | DRAIN | TEXT | COLOUR | TOPO | UNIT | REMARKS |
|---|---|---|---|---|---|---|---|
| **VERTISOLS** | | | | | | | |
| Pellic, partly sodic | > 100 | I | C | 2.5Y 2/0-10YR 4/1.5 | F | L25 | |
| Pellic, partly sodic | > 100 | P-I | C | 2.5Y 2/0-10YR 4/1.5 | F | L25a | |
| Pellic, partly sodic | > 100 | P | C | 2.5Y 2/0-10YR 4/1.5 | F | L25b | |
| Pellic, petric/partly sodic | > 100 | P-I | C | 2.5Y 2/0-10YR 4/1.5 | F | L25c | |
| **FLUVISOLS** | | | | | | | |
| Calcaric,saline | > 150 | V-P | CS-C | 5Y 4/2 -2.5Y 6/4 | F | L8a | high salinity |
| Calcaric,partly saline/sodic | > 150 | V-P | CS-C | 5Y 4/2 -2.5Y 6/4 | F | L8 | stratified sands, silts, clays |
| Eutric | > 150 | V-P | CS-C | 5Y 2/0 -2.5Y 6/4 | F | L9 | stratified sands, silts, clays |
| **SOLONCHAKS** | | | | | | | |
| Gleyic | > 150 | V-P | SIL-SICL | 10YR 3/2 - 5Y 5/6 | F | L1 | |
| Gleyic | > 150 | V-P | SIC-C | 7.5GY 5/1- 10G 6/1 | F | L2 | |
| Gleyic, duripan | > 150 | V-P | SIL-C | 10YR 3/2 - 10G 6/1 | F | L2a | |
| Takyric | > 150 | P | L-C | 10YR 3/2-5Y 6/2 | F | L3 | |
| Orthic | > 100 | P | SIL-SICL | 10YR 7/1-10YR 6/4 | A | L4 | |
| Arenic orthic | > 100 | P-M | FS-LFS | 2.5Y 8/4-2.5Y 5/6 | F-G | L5 | |
| **GLEYSOLS** | | | | | | | |
| Dystric | > 150 | P-I | L-C | 2.5Y 2/0-10YR 3/1 | F | L38 | |
| Eutric,partly sodic | > 150 | P-I | SC-C | 2.5Y 3/0-10YR 6/1 | F | L7 | |
| Vertic Eutric | > 100 | P-I | C | 2.5Y 3/0-10YR 4/1 | F | L27 | |
| Calcic,partly sodic | > 150 | P-I | SC-C | 2.5Y 3/0-10YR 6/1 | F | L6 | |
| Calcic,partly sodic | > 100 | P-I | L-C | 2.5Y 3/0-10YR 6/1 | F | L6a | overlying white fine sands <100cm |
| Calcic,partly sodic | > 100 | P-I | L-C | 2.5Y 3/0-10YR 6/1 | F | L6b | overlying diatom. earth <50cm |
| Vertic Calcic,partly petrocalcic | 50-150 | P-I | C | 2.5Y 3/0-10YR 4/1 | F | L26 | |
| Mollic | > 150 | P-I | L-C | 2.5Y 2/0-10YR 3/1 | F | L37 | B.S. >50% |
| Mollic | > 150 | P-I | L-C | 2.5Y 2/0-10YR 3/1 | F | L37a | B.S. <50% in some part of subsoil |
| Calcic Mollic | > 150 | P-I | L-C | 2.5Y 2/0-10YR 3/1 | F | L37b | |
| Vertic Mollic | > 150 | V-I | C | 2.5Y 2/0-10YR 3/1 | F | L37c | |
| Vertic Molic,petric | > 150 | V-I | C | 2.5Y 2/0-10YR 3/1 | F | L37d | |
| **ARENOSOLS** | | | | | | | |
| Albic | > 150 | W-S | S-LS | 10YR 7/1-10YR 6/3 | G | L39 | |
| Luvic | > 150 | M-W | FS-LFS | 10YR 3/2-10YR 5/3 | F-G | L40 | |

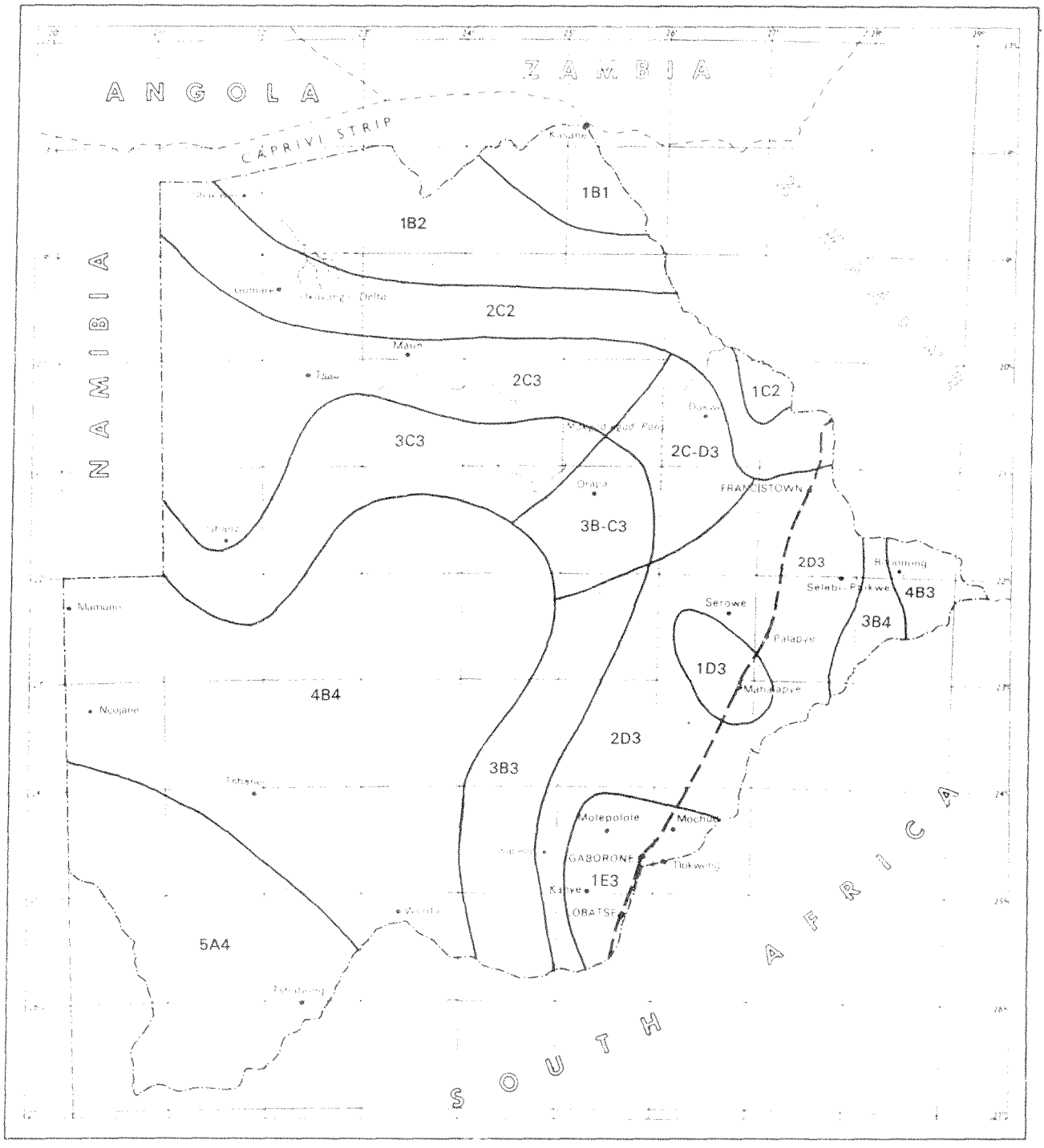
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Petrocalcic | 50-125 | M-S | FS-LFS | 10YR 6/2-10YR 8/4 | F-G | L12 | calcareous 0-50cm thick calcrete |
| Petrocalcic | 50-125 | M-S | FS-LFS | 10YR 6/2-10YR 8/4 | F-G | L12a | calcareous 0-50cm intercalated calcr. |
| Petrocalcic | 50-125 | M-S | FS-LFS | 10YR 3/2-10YR 8/4 | F-G | L12b | noncalc.0-50cm thick calcrete |
| Calcic,partly sodic | > 100 | M-W | FS-LFS | 10YR 4/1-10YR 6/3 | F-U | L11 | calcareous 0-50cm |
| Calcic,partly sodic | > 100 | M-W | FS-LFS | 10YR 4/1-10YR 6/3 | F-U | L11a | non calc. 0-50cm |
| Calcic,clayey | > 100 | M-W | FS-LFS | 10YR 4/1-10YR 6/3 | F-U | L11b | calcareous 0-50cm |
| Calcaric | > 100 | M-W | FS-LFS | 10YR 4/1-10YR 6/3 | U | L10 | |
| Ferralic | > 100 | S | FMS-LS | 10YR 4/2-10YR 6/3 | A-G | L44 | over petroferric |
| Ferralic,petroferric/shallow petroferric | 25-100 | W | FMS | 10YR 3/2-10YR 6/3 | A | L44a | |
| Eutric | > 150 | W-S | FS-LFS | 2.5Y 4/0-10YR 6/3 | F-U | L16 | non calc. 0-100cm |
| Eutric | > 150 | W-S | FS-LFS | 2.5Y4/0 -10YR 6/3 | F-U | L16a | calcareous 50-100cm |
| **REGOSOLS** | | | | | | | |
| Calcaric | > 100 | M-W | SL-SICL | 10YR 5/2-2.Y 5/2 | F-G | L13 | |
| Calcaric, duripan | > 100 | M-W | SL-SICL | 10YR 5/2-2.5Y 5/2 | F-U | L13a | |
| Eutric | > 100 | I-W | FSL | 2.5Y 3/2-7.5YR 5/4 | F-G | L17 | |
| Eutric,shallow petric/ petroferric | 25-50 | M | SL-C | 10YR 3/2-10YR 5/8 | A | L45 | |
| **PLANOSOLS** | | | | | | | |
| Eutric | > 100 | I | SCL-C | 10YR 5/3-10YR 3/6 | F-G | L41 | |
| Solodic,partly saline | > 100 | P-I | SCL-C | 2.5Y 3/1-10YR 4/2 | | L42 | |
| **SOLONETZ** | | | | | | | |
| Orthic, saline | > 150 | P-I | SICL-C | 10YR 6/3-5Y 5/6 | F | L21 | |
| **CHERNOZEMS** | | | | | | | |
| Luvic | > 100 | I-M | SL -C | 2.5Y 4/0-10YR 5/2 | F | L35 | |
| Gleyic Luvic,partly sodic | > 100 | P-I | SCL-C | 2.5Y 3/0-10YR 4/1 | F | L35a | |
| Calcic,partly sodic | > 100 | P-I | SCL-C | 10YR 3/1-10YR 5/2 | F | L36 | |
| **XEROSOLS** | | | | | | | |
| Luvic | > 100 | I | SCL-C | 10YR 3/2-2.5Y 4/4 | F | L22c | |
| Arenic Luvic | > 100 | I-M | LS-SCL | 2.5Y 3/2-10YR 3/2 | F | L22d | |
| Calcic Luvic | > 150 | I | SCL-C | 2.5Y 3/2-10YR 5/3 | F | L24g | |
| Calcic Luvic,petrocalcic | 50-100 | I | SCL-C | 2.5Y 3/2-10YR 5/3 | F-G | L24e | |
| Arenic Calcic Luvic | > 50 | I-M | LS-SCL | 2.5Y 5/2-10YR 3/2 | F | L24f | |
| Arenic Calcic Luvic,partly Petrocalcic | > 50 | I-M | LS-SCL | 2.5Y 5/2-10YR 3/2 | F | L24d | |
| Calcic | > 100 | M-W | FSL-CL | 10YR 5/2-2.5Y 5/2 | F | L14 | |
| Calcic,duripan | > 100 | M-W | FSL-CL | 10YR 5/2-2.5Y 5/2 | F | L14a | |
| Calcic,petrocalcic | 50-100 | M-W | FSL-SIL | 2.5Y 5/2-10YR 6/3 | F | L15a | |
| **NITOSOLS** | | | | | | | |
| Arenic Eutric | > 150 | I-M | LS-SCL | 5YR 4/6-10YR 5/8 | F-G | L31 | |
| **ACRISOLS** | | | | | | | |
| Arenic Ferric | > 150 | M-W | LS-SCL | 10YR 4/3 5YR-5/8 | G | L33 | |
| **LUVISOLS** | | | | | | | |
| Gleyic,partly saline/sodic | > 100 | P-I | SCL-C | 2.5Y 4/0-10YR 5/2 | | L23 | |
| Gleyic,petric partly sodic/ saline | 50-100 | P-I | SCL-C | 2.5Y 4/0-10YR 5/2 | | L23a | |
| Arenic Gleyic | > 100 | I | SCL-C | 2.5 4/0 -10YR 5/2 | | L30 | |
| Calcic Gleyic,partly petro-calcic | > 100 | P-I | SCL-C | 2.5 4/0 -10YR 5/2 | F | L28 | |
| Vertic Gleyic,partly petric | 50-100 | I | SC-C | 2.5Y 4/0-10YR 5/2 | | L29 | |
| Albic | > 100 | I-M | LS-SL | 10YR 4/2-10YR 6/3 | F-G | L43 | massive |
| Calcic Albic,partly sodic | > 100 | I-M | LS-SL | 10YR 3/2-10YR 6/3 | F-G | L43a | |
| Calcic | > 150 | I | SCL-C | 2.5Y 3/2-10YR 5/3 | F-G | L24 | |
| Calcic,petrocalcic | 50-100 | I | SCL-C | 2.5 3/2 -10YR 5/3 | F-G | L24b | |
| Calcic,partly saline/sodic | > 150 | I | SCL-C | 2.5Y 3/2-10YR 5/3 | F-G | L24a | |
| Arenic Calcic,partly petro-calcic | > 50 | I-M | LS-SCL | 2.5Y 5/2-10YR 5/3 | | L24c | |
| Ferric,partly petroferric | 50-150 | I-M | SCL-C | 10YR 4/3-5YR 5/8 | F-G | L34 | |
| Arenic Ferric | > 150 | M-W | LS-SCL | 10YR 4/3-5YR 5/8 | G | L32 | |
| Orthic | > 100 | I | SCL-C | 10YR 3/2-2.5Y 4/4 | F | L22 | |
| Orthic,shallow petric/petric | 50-100 | I | SCL-C | 10YR 3/2 2.5Y 4/4 | F | L22b | |
| Arenic Orthic | > 100 | I-M | LS-SCL | 2.5Y 3/2-10YR 5/3 | F | L22a | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **CAMBISOLS** | | | | | | |
| Gleyic | > 150 | I | SCL-C | 2.5Y 3/2-10YR 3/3 | F | L18 |
| Calcaric | > 100 | I | SCL-C | 2.5Y 3/2-7.5YR 5/4 | F | L19 |
| Calcic | > 100 | I-M | SCL-C | 2.5Y 3/2-7.5YR 5/4 | F | L20 |
| Calcic,petrocalcic | 50-100 | M-W | FSL-SIL | 2.5Y 5/2-10YR 6/3 | F | L15 |

## S (and KS,LS) Soils on Coarse Grained Sedimentary Rocks

| | DEPTH | DRAIN | TEXT | COLOUR | TOPO | UNIT | REMARKS |
|---|---|---|---|---|---|---|---|
| **ARENOSOLS** | | | | | | | |
| Albic | >100 | W-S | S-LS | 10YR 6/3 -10YR 5/8 | F-U | S2 | |
| Luvic | >100 | W-S | FMS-LFS | 10YR 5/8 -10R 4/6 | F-U | S5a | |
| Luvic | >100 | W-S | FMS-LFS | 2.5Y 4/2 -7.5YR 5/4 | F-U | S5b | |
| Luvic | >100 | S-E | FMS-LFS | 10YR 5/8 -10R 4/6 | U-R | S6a | dunes,hills |
| Luvic | >100 | S-E | FMS-LFS | 2.5Y 4/2 -7.5YR 5/4 | U-R | S6b | dunes,hills |
| Petrocalcic | >50 | W-S | S-LS | 10YR 5/2 -5YR 4/8 | F-U | S13a | |
| Calcic | > 50 | W-S | S-LS | 10YR 5/2 -5YR 4/8 | F-U | S13 | |
| Calcaric | >100 | W-S | FMS-LFS | 10YR 5/8 -5YR 7/6 | F-U | S15 | |
| Ferralic | 50-100 | S | S-LS | 10YR 8/8 -5YR 2.5/2 | U-H | S1a | |
| Ferralic | >100 | W-S | FS-FMS | 10YR 5/6 -5YR 5/8 | F-U | S3 | |
| Ferralic | >100 | W-S | FS-FMS | 3.5YR 5/6-10R 4/8 | F-U | S3a | |
| Ferralic | >100 | S | CS-LS | 10YR 6/8 -2.5YR 4/4 | F-U | S4 | |
| Ferralic | >100 | W-S | FMS-LFS | 10YR 5/8 -10R 4/6 | F-U | S5 | |
| Ferralic | >100 | S-E | FMS-LFS | 10YR 5/8 -10R 4/6 | U-R | S6 | dunes,hills |
| Ferralic, lithic | 0-25 | E | S-LS | 10YR 5/4 -5YR 4/8 | U-H | S1 | |
| Cambic | >100 | W-S | S-LFS | 7.5YR 5/8-10R 4/6 | F-U | S18 | |
| Dystric | >100 | S | FMS-LFS | 2.5Y 4/2 -10YR 6/4 | F-U | S16 | |
| Eutric | >100 | W-S | FMS-LFS | 2.5Y 4/2 -10YR 6/4 | F-U | S17 | noncalc. 50-100cm |
| Eutric | >100 | W-S | FMS-LFS | 2.5Y 4/2 -10YR 6/4 | F-U | S17A | calcareous 50-100cm |
| Eutric | >100 | W-S | CS-LS | 2.5Y 4/2 -10YR 6/4 | F-U | S17c | dunes,beachridges |
| Eutric | >100 | W-S | FS-FMS | 2.5Y 4/2 -10YR 6/4 | U | S17d | dunes,beachridges |
| Eutric,duripan | >100 | W-S | FMS-LFS | 2.5Y 4/2 -10YR 6/4 | F-U | S17b | |
| **REGOSOLS** | | | | | | | |
| Arenic Eutric,petric | 25-100 | S | S-LS | 10YR 6/8 -5YR 4/6 | U-H | S1b | |
| **XEROSOLS** | | | | | | | |
| Arenic Luvic | > 100 | W-S | LFS-LFMS | 7.5YR 5/8-10R 4/6 | F-U | S7a | ferric |
| Arenic Luvic | > 100 | S-E | LFS-LFMS | 5YR 5/6 -10R 4/8 | U-R | S8a | ferric,dunes,hills |
| Arenic Luvic | > 100 | W-S | FSL-FMSL | 5YR 5/8 -10R 4/6 | F-U | S10a | ferric |
| Arenic Luvic | > 150 | W-S | FSL-FMSL | 10YR 5/3 -10R 4/8 | F-U | S11a | |
| Arenic Luvic | > 150 | W-S | FMSL-SCL | 10YR 5/8 -10R 4/8 | U | S14a | dunes |
| Arenic Calcic Luvic | > 100 | W-S | SL | 10YR 5/3 -5YR 4/8 | F-U | S12a | |
| **NITOSOLS** | | | | | | | |
| Arenic Eutric | >150 | W-S | FSL-FMSL | 10YR 5/3-10R 4/8 | F-U | S11 | |
| Arenic Eutric | >150 | W-S | FMSL-SCL | 10YR 5/3 10R 4/8 | U | S14 | dunes |
| **ACRISOLS** | | | | | | | |
| Arenic Ferric | >100 | S | LS | 7.5YR 5/8-10R 4/6 | F-U | S9 | |
| Arenic Ferric | >100 | S | SL | 7.5YR 5/8-10R 4/6 | F-U | S9a | |
| **LUVISOLS** | | | | | | | |
| Arenic Calcic | >100 | W-S | SL | 10YR 5/3-5YR 4/8 | F-U | S12 | |
| Arenic Ferric | >100 | W-S | LFS-LFMS | 7.5YR 5/8-10R 4/6 | F-U | S7 | |
| Arenic Ferric | >100 | W-S | LFS-LFMS | 10YR 5/3-7.5YR 4/8 | F-U | S7b | |
| Arenic Ferric | >100 | S-E | LFS-LFMS | 5YR 5/8 -10R 4/6 | U-R | S8 | dunes,hills |
| Arenic Ferric | >100 | W-S | FSL-FMSL | 5YR 5/8 -10R 4/6 | F-U | S10 | |

Map 1. Agro Climatic Zones of Botswana (Dombe, 1987)




| Length of Season | | Number of Dry Days within the Season | Length of Humid Period | |
|---|---|---|---|---|
| Duration (days) | Frequency (%) | | Duration (days) | Frequency (%) |
| 1 101-120 | 75-100 | A 0-10 | 1 41-60 | 75-100 |
| 2 81-100 | 75-100 | B 11-20 | 2 20-40 | 50-74 |
| 3 61-80 | 75-100 | C 21-30 | 3 20-40 | 25-49 |
| 4 41-60 | 75-100 | D 31-40 | 4 20-40 | <25 |
| 5 41-60 | 50-74 | E 41-50 | | |

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