GUIDELINES FOR SOIL PROFILE DESCRIPTION

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

INTERNATIONAL SOIL REFERENCE INFORMATION CENTRE

ISRIC

GUIDELINES FOR SOIL DESCRIPTION

3rd Edition (Revised)

Soil Resources, Management and Conservation Service
Land and Water Development Division

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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INTRODUCTION

The second edition of the Guidelines for Soil Description (FAO, 1977) is a standard in soil survey agencies in many countries. An updated version has been prepared to take account of recent developments in soil description, computerized data bases and horizon designations.

The guidelines have been developed to assist field staff engaged in survey activities or research programmes. They are intended to enhance the standardization and uniformity of soil profile descriptions so as to facilitate cross-references and comparison between soil descriptions. It is recommended that they be adhered to as much as possible for routine soil profile observations as well as for the description of reference profiles. The present version contains basically the same material as did the 1977 version; part of it, however, has been summarized or restructured with standardized class definitions while new sections have been added. The contents have been organized in three main chapters dealing with (1) general information on the soil and the sampling site, (2) methods and terminology for the description of the soil properties horizon by horizon and (3) the linkage of soil data to computerized information systems.

The use of a coding system for recording soil and site characteristics is strongly recommended. The coding for most of the soil properties and site characteristics are given and are meant to correlate with the FAO-ISRIC Soil Database (SDB) (FAO, 1989) referred to in Chapter 3. Standardized codes (appearing in bold characters in the text) are also useful for non-computerized data banks, and will facilitate the subsequent transfer of the data onto computer.

Complete definitions of soil terminology and characteristics are not given. Substantial sections have been extracted from the USDA Soil Survey Manual (SSM) (Soil Survey Staff, 1981 and later versions) which remains a standard reference book for field soil scientists. Other sources are the Revised Legend of the Soil Map of the World (FAO , 1988), the Keys to Soil Taxonomy (Soil Survey Staff, 1990) and the Australian Soil and Land Survey Field Handbook (McDonald et al., 1984).

The attention of field scientists and surveyors is drawn to the following important aspects of soil description. Firstly, investigation of the three-dimensional variability of soil morphological properties is often neglected and should be encouraged. Secondly, the study of the ecological conditions has become an important and integral part of land inventories. Thirdly, there are other notation systems that have been proposed for designating horizons other than the one that is presented in these guidelines; in particular that of Fitzpatrick (1986, 1988), which merits further field testing. Finally, soil profile descriptions are not an end in themselves but should contribute, through the objective description and recording of soil properties, both to the understanding of the land of which the soil forms an integral part, and to the reliable transfer of technology.

This revision has been prepared by A. Remmelzwaal, with major contributions by J. Van Wambeke, M. F. Purnell and H. Van Baren. Valuable contributions were made by the International Soil Reference and Information Centre, which has been recognized on the title page. The amendments are based on discussions with colleagues and reports prepared by FAO staff, and contributions made by many others.

Suggestions and comments are invited. They should be sent to:

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Rome, October 1990

CHAPTER 1 GENERAL INFORMATION

In this chapter the characteristics of the profile site as well as the information related to the identification is presented. The order in which the description appears in these guidelines is as far as is possible that of the FAO-ISRIC Soil Database (SDB) (FAO, 1989) soil coding sheet.

1.1 Registration and Location

1.1.1 Profile Number

The profile number, or profile identification code should be constructed in such a way that it meets local needs and also allows easy and simple retrieval of profile descriptions from computerized data storage systems. The profile identification code should be constructed from a combination of a location letter code and a profile number code. The letter code should consist of a practical selection of codes referring to a country or local administrative division, a topographic map sheet, or any other defined area or town.

Examples: LTGA0381 - Latina province, Gaeta, number 381
BOSE1278 - Botswana, Serowe sheet, number 1278

Note: The latitude and longitude of the site may also be given here: in a geographical information system (GIS), these coordinates might be considered the primary reference data for any site.

1.1.2 Soil Profile Description Status

The status of the soil profile description refers to the quality of the soil description and the analytical data. The status is allocated after completion of the analyses and should also serve as an indicator of the reliability of existing soil profile information entered into a computerized database.

The following distinctions are made:

1 Reference profile description. No essential elements or details are missing from the description, sampling or analysis. The accuracy and reliability of the description and analytical results permits the full characterization of all soil horizons to a

depth of 125 cm, or more if required for full classification, or down to a shallower cemented C or R horizon or layer.

2 Routine profile description. No essential elements are missing from the description, sampling or analysis. The number of samples collected is sufficient to characterize all major soil horizons, but may not allow precise definition of all sub-horizons, especially in the deeper soil. The profile depth is 80cm or more, or down to a shallower, cemented or gravelly, C or R horizon or layer. Additional augering and sampling may be required for lower level classification.

3 Incomplete description. Certain relevant elements are missing from the description, an insufficient number of samples was collected, or the reliability of the analytical data does not permit a complete characterization of the soil. The description is however useful for specific purposes and provides a satisfactory indication of the nature of the soil at high levels of soil taxonomic classification.

4 Soil augering description. Soil augerings do not permit a comprehensive soil profile description. Augerings are made for routine soil observation and identification in soil mapping, and for that purpose normally provide a satisfactory indication of the soil characteristics. Soil samples may be collected from augerings.

5 Other descriptions. Essential elements are missing from the description, preventing a satisfactory soil characterization and classification.

Note: Descriptions from soil augerings or from other observations made for routine soil mapping are either kept on ordinary field data sheets or included in the database, with an appropriate indication of status.

1.1.3 Date of description

The date of description is given as **yymmdd** (6 digits).

Example: 23 September 1986 would be coded 860923

1.1.4 Author(s)

The name(s) or initial(s) of the author(s) is given.

1.1.5 Soil Unit

The soil unit refers to a local classification system or legend unit of which the profile is representative.

1.1.6 Location

A description, as precise as possible, is given of the distance (in meters or kilometers) and direction to the site from permanent features which are recognizable in the field and on the topographic map. Distances along roads or traverses relate to a marked reference point (0.0 km). The description of the location should be such that readers who are unfamiliar with the area are able to locate the approximate position of the site.

It is advisable to mention the administrative units, such as region, province, district, county or locality. This information could also be given in a coded form in a separate entry, or as part of the profile number.

1.1.7 Elevation

The elevation relative to sea level is given as accurately as possible, preferably from detailed contour maps. If such information is not available, the best possible estimate is made from general maps or by altimeter readings. Elevation is given in metres (1 foot = 0.3048 metre).

1.1.8 Map sheet number and grid reference

The number of the topographic map sheet, preferably at 1:50 000 scale, on which the soil observation occurs is given.

The grid reference number, UTM (Universal Transverse Mercator) or the established local system, can be read directly from the topographic map.

1.1.9 Coordinates

The latitude and longitude of the site are given as accurately as possible; they can be derived directly from topographic maps (see note under 1.1.1).

1.2 Soil Classification

1.2.1 Soil Taxonomic Classification

The surveyor should attempt to classify the soil in the field at the lowest possible taxonomic level, on the basis of the soil morphological features which have been observed and described. The final classification is made after the analytical data have become available. It is recommended that the occurrence and depth of diagnostic horizons and properties identified are listed (see section 2.1.3).

The SDB provides entries for the 1974 Legend of the Soil Map of the World (FAO-Unesco, 1974) and the 1988 Revised Legend (FAO-Unesco-ISRIC, 1988), including provisions for third-level soil subunits, as well as for the USDA Soil Taxonomy. Recommended taxonomic unit codes can be found in the SDB (FAO, 1989).

Phases, as defined in the 1988 Revised Legend, should be identified. Additional phases may be defined as required to meet local conditions, for example sandy and clayey phases indicating contrasting sedimentary surface layers with a thickness of 10-50cm. The following codes for designating the FAO phases are recommended:

AN	Anthraquic	PH	Phreatic
DU	Duripan	PL	Placic
FR	Fragipan	RU	Rudic
GE	Gelundic	SA	Salic
GI	Gilgai	SK	Skeletic
IN	Inundic	SO	Sodic
LI	Lithic	TK	Takyric
PF	Petroferric	YR	Yermic

1.2.2 Soil climate

The soil climate classification should be indicated, if applicable. When using the USDA Soil Taxonomy, the soil moisture and soil temperature regimes may be mentioned (for codes see below). Where such information is not available or cannot confidently be derived from representative climatic data, it is preferable to leave the space blank. Other agro-climatic parameters worth mentioning would be a local climate class, the agro-climatic zone, length of growing period, etc.

Soil Temperature Regime		Soil Moisture Regime	
PG	Pergelic	AQ	Aquic
CR	Cryic	PQ	Peraquic
FR	Frigid	AR	Aridic
ME	Mesic	UD	Udic
TH	Thermic	PU	Perudic
HT	Hyperthermic	US	Ustic
IF	Isofrigid	XE	Xeric
IM	Isomesic	TO	Torric
IT	Isothermic		
IH	Isohyperthermic		

1.3 Landform and Topography

1.3.1 Topography

The topography refers to the differences in elevation of the land surface on a broad scale. It is derived from the most representative or characteristic slope gradient of the area around the site, and defined as follows:

F	Flat	0 - 0.5%
A	Almost flat	0.5 - 2%
G	Gently undulating	2 - 5%
U	Undulating	5 - 10%
R	Rolling	10 - 15%
H	Hilly	15 - 30%
S	Steeply dissected	> 30%, moderate range of elevation
M	Mountainous	> 30%, great range of elevation (>300m)

For measurement of slope see section 1.35.

1.3.2 Landform

The landform refers to the shape of the land surface in the area in which the soil observation is made. It is described in geomorphological terms, distinguishing one of two levels. The higher level corresponds with the SOTER (1990) approach, using only seven major landforms indicating the general physiography of the area. If a more detailed nomenclature is required, other landform names may be applied. Landforms may be further subdivided into constituent land elements.

The major landforms and the recommended codes are:

MO	Mountain	PT	Plateau
HI	Hill	BA	Basin
UP	Upland	VA	Valley
PL	Plain		

Examples of landforms of the second level, with their recommended codes, are given below. Other specific terms may be added to this list.

AP	Alluvial plain	VO	Volcano
CP	Coastal plain	DU	Dunefield
LP	Lacustrine plain	DT	Delta
GP	Glacial plain	TF	Tidal flat
PN	Peneplane	PY	Playa
PE	Pediment		

1.3.3 Land element

The land element describes the geomorphology of the immediate surroundings of the site. In most cases the land elements are subdivisions of the landforms described above. However, depending on the magnitude, the same geomorphological feature may be described as a landform or as a land element, e.g. valley, depression.

The dimensions of a land element are in general comparable with mapping units for semi-detailed map scales (1:50 000 or larger). At reconnaissance map scales (1:250 000 or smaller) the mapping unit usually includes more than one land element. In soil associations, the occurrence of each associated soil is generally related to a single land element.

Some examples of land elements and their suggested codes are:

IF	Interfluve	CO	Coral reef
VA	Valley	CA	Caldera
VF	Valley floor	DE	Depression
CH	Channel	DU	Dune
LE	Levee	LD	Longitudinal dune
TE	Terrace	ID	Interdunal depression
FP	Floodplain	SL	Slope
LA	Lagoon	RI	Ridge
PA	Pan	BR	Beachridge

1.3.4 **Position**

The relative position of the site within the land element is indicated. The position affects the hydrological conditions of the site (external drainage), which may be interpreted as being predominantly water receiving, water shedding or neither of these.

Position in undulating to mountainous terrain		Position in flat or almost flat terrain	
CR	Crest	HI	Higher part
UP	Upper slope	IN	Intermediate part
MS	Middle slope	LO	Lower part
LS	Lower slope	BO	Bottom (drainage line)
BO	Bottom (flat)		

1.3.5 **Slope**

The slope gradient refers to the slope of the land immediately surrounding the site. The gradient is measured using a clinometer aimed in the direction of the steepest slope. If clinometer readings are not possible, field estimates of slope gradient should be matched against calculated gradients from contour maps.

Slope gradients in almost flat terrain are often overestimated. In open plains, slope gradients of 0.2 % are usually clearly visible. The proper recording of minor slope gradient variations is important, especially for irrigation and drainage.

Gradient

The slope gradient is recorded in two ways. The first is by means of the actual, measured value, and the second by entering in one of the following classes; they may need to be modified to fit the local topography:

01	Flat	0	-	0.2	%
02	Level	0.2	-	0.5	%
03	Nearly level	0.5	-	1.0	%
04	Very gently sloping	1.0	-	2	%
05	Gently sloping	2	-	5	%
06	Sloping	5	-	10	%
07	Strongly sloping	10	-	15	%
08	Moderately steep	15	-	30	%
09	Steep	30	-	60	%
10	Very steep		>	60	%

Form

The slope form refers to the general shape of the slope in both the vertical and horizontal directions. The following slope form classes are distinguished:

S	Straight	T	Terraced
C	Concave	X	Complex (Irregular)
V	Convex		

In addition to the above attributes of slope, both the slope length and aspect (orientation) may be recorded. The former is particularly useful, in conjunction with the slope gradient, for the estimation of degree of soil erosion by water; the latter influences, for instance, the type of humus formed in temperate climates.

1.3.6 **Micro-topography**

Micro-topography refers to natural or artificial differences in height over short distances.

LE	No micro-relief	- Surface is (nearly) level
GI	Gilgai (unspecified)	
GI	Low gilgai	- Height difference (within 10m)<20cm

GM	GM Medium gilgai	- Height difference (within 10m) 20-40cm
GH	High gilgai	- Height difference (within 10m) > 40cm
TM	Termite or ant mounds	
AT	Animal tracks	
AB	Animal burrows	
HU	Hummocks (unspecified)	
HL	Low hummocks	- Height difference <20cm
HM	Medium hummocks	- Height difference 20-40cm
HH	High hummocks	- Height difference > 40cm
SS	Shifting sands	
TS	Terracettes	
RI	Ripples	

Gilgai may be more precisely described giving the average interval and amplitude from mound to depression, for example 12m x 30cm, and also indicating the type of gilgai, such as basin, linear, lattice or melonhole (McDonald et al. 1984). Termite and ant mounds may be described in more detail according to their shape and dimensions. Some of the micro-topographical features show gradual transitions to surface characteristics (see section 1.6).

1.3.7 **Soil-Landscape sequential relationships**

This item calls attention to the three-dimensional aspects of the soil unit. Information on spatial relationships or sequential soil transitions may be given. Lateral water movements and lateral variations and transitions in soil horizons may be described. Further guidelines are expected to be formulated as part of the International Reference Base for Soils (IRB), being developed under the auspices of the International Society of Soil Science (ISSS).

1.4 Land Use and Vegetation

1.4.1 **Land Use**

It is recommended that present land use type be described thus:

S Settlement, industry

SR	Residential use	SC	Recreational use
SI	Industrial use	SX	Excavations
ST	Transport		

A Crop Agriculture

AA Annual field cropping
AA1 Shifting cultivation
AA2 Fallow system cultivation
AA3 Ley system cultivation
AA4 Rainfed arable cultivation
AA5 Wet rice cultivation
AA6 Irrigated cultivation

AP Perennial field cropping
AP1 Non-irrigated cultivation
AP2 Irrigated cultivation

AT Tree and shrub cropping
AT1 Non-irrigated tree crop cultivation
AT2 Irrigated tree crop cultivation
AT3 Non-irrigated shrub crop cultivation
AT4 Irrigated shrub crop cultivation

H Animal Husbandry

HE Extensive grazing

HE1 Nomadism
HE2 Semi-nomadism

HI Intensive grazing

HI1 Animal production
HI2 Dairying
HE3 Ranching

F Forestry

FN Natural forest and woodland
FN1 Selective felling
FN2 Clear felling

FP Plantation forestry

M Mixed farming

MF Agro-forestry
MP Agro-pastoralism (cropping and livestock systems)

E Extraction and collection

EV Exploitation of natural vegetation
EH Hunting and fishing

P	Nature Protection		
PN	Nature and game preservation	PD	Degradation control
PN1	Reserves	PD1	Without interference
PN2	Parks	PD2	With interference
PN3	Wildlife management		
U	Not used and not managed		

Additional codes may be used to further specify the land utilization type. For example:

AA4	Rainfed arable cultivation	AA4T	Traditional
		AA4I	Improved traditional
		AA4M	Mechanized traditional
		AA4C	Commercial
		AA4U	Unspecified

For arable land use, the dominant crops which are grown should be mentioned, and as much information as possible given on soil management, use of fertilizers, duration of fallow period, rotation systems and yields.

Crops

Information on crops can be given in a general or detailed way as required. Examples of crops with their recommended codes:

BA	Barley	PO	Potato
BE	Beans	RI	Rice
CH	Cashew	RB	Rice (flooded)
CA	Cassava	RU	Rice (upland)
CO	Cocoa	RR	Rubber
CC	Coconut	SO	Sorghum
CF	Coffee	SB	Soyabean
CT	Cotton	SC	Sugar cane
CP	Cowpea	SF	Sunflower
FR	Fruit trees	SP	Sweet potato
GR	Groundnut	TE	Tea
MA	Maize	TB	Tobacco
MI	Millet	VE	Vegetables
OP	Oilpalm	WH	Wheat
PE	Peas	YA	Yams

1.4.2 Human influence

This item refers to any evidence of human activity which is likely to have affected the landscape or the physical and chemical properties of the soil. Erosion is dealt with separately, in section 1.6.3. For various environments it is useful to indicate the degree of disturbance of the natural vegetation. The existing vegetation is described in section 1.4.4.

Examples of human influence with their recommended codes are:

N	No influence	**BU**	Bunding
NK	Not known	**BR**	Burning
VS	Vegetation slightly disturbed	**TE**	Terracing
VM	Vegetation moderately disturbed	**PL**	Ploughing
VE	Vegetation strongly disturbed	**MP**	Plaggen
VU	Vegetation disturbed (unspec.)	**MR**	Raised beds
IS	Sprinkler irrigation	**MS**	Sand additions
IF	Furrow irrigation	**MU**	Mineral additions (unspecified)
IP	Flood irrigation		
IB	Border irrigation	**PO**	Pollution
IU	Irrigation (unspecified)	**CL**	Clearing
AD	Artificial drainage	**SC**	Surface compaction
FE	Application of fertilizers	**BP**	Borrow pit

1.4.3 Vegetation

There is no uniform acceptance of a system for the description of the natural or semi-natural vegetation. The kind of vegetation can be described using a local, regional or international system.

Two examples are given, the first being a common descriptive terminology:

N	No vegetation	
G	Grassland:	Grasses, subordinate forbs, no woody species.
FO	Forbland:	Herbaceous plants predominant.
F	Forest:	Continuous tree layer, crowns overlapping, large number of tree and shrub species in distinct layers.
W	Woodland:	Continuous tree layer, crowns usually not touching, understorey may be present.
S	Shrubland:	Continuous layer of shrubs, crowns touching.
SA	Savanna:	Grasses with a discontinuous layer of trees or shrubs.

The vegetation may be further subdivided according to the height of the trees, shrubs and grasses, for example savanna into tree, shrub or low shrub savanna, and low, medium and tall grass savanna, and also according to the density and patchiness of tree and ground cover.

The second example is the vegetation classification according to Unesco (1973), with codes added:

F	Closed Forest	D	Dwarf Shrub
FE	Evergreen forest	DE	Evergreen dwarf shrub
FS	Semi-deciduous forest	DS	Semi-deciduous dwarf shrub
FD	Deciduous forest	DD	Deciduous dwarf shrub
FX	Xeromorphic forest	DX	Xeromorphic dwarf shrub
		DT	Tundra
W	Woodland	H	Herbaceous
WE	Evergreen woodland	HT	Tall grassland
WS	Semi-deciduous woodland	HM	Medium grassland
WD	Deciduous woodland	HS	Short grassland
WX	Xeromorphic woodland	HF	Forb
S	Shrub		
SE	Evergreen shrub		
SS	Semi-deciduous shrub		
SD	Deciduous shrub		
SX	Xeromorphic shrub		

In addition, other characteristics of the vegetation, such as height of trees or canopy cover, may be recorded.

Grass cover

It is recommended that the grass cover be estimated according to classes which suit local conditions. The following classification is recommended:

0	No cover	
1	0	- 15%
2	15	- 40%
3	40	- 80%
4		> 80%

Tree, shrub, grass and forb species should be listed if known, and their dominance indicated.

1.5 Parent Material

1.5.1 Parent material

The parent material should be described as accurately as possible, indicating its origin and nature. There are basically two groups of parent material on which the soil has formed, either unconsolidated materials, mostly sediments, or weathering materials overlying the hard rock from which they have been derived. There are also transitional cases, such as partly consolidated materials and weathering materials which have been transported or colluviated.

Two lists of examples of parent material and rock, including suggested codes are given below. The reliability of the geological information and the knowledge of the local lithology will determine whether a general or a specific definition of the parent material can be given. The first list refers to unconsolidated materials, the second to rock types. SDB has different entries for these groups. For weathered rock, the code **WE** is first entered, followed by the rock type code. The code **SA** for Saprolite is recommended if the in situ weathered material is thoroughly decomposed, clay-rich but still showing rock structure. Alluvial deposits and colluvium derived from a single rock type may be further specified by that rock type. If one parent material overlies another, both are indicated.

Unconsolidated material

AU	Aeolian deposits (unspecified)	VA	Volcanic ash
AS	Aeolian sand	LO	Loess
LI	Littoral deposits	PY	Pyroclastic deposits
LG	Lagoonal deposits	GL	Glacial deposits
MA	Marine deposits	OR	Organic deposits
LA	Lacustrine deposits	CO	Colluvial deposits
FL	Fluvial deposits	WE	In situ weathered
AL	Alluvial deposits	SA	Saprolite
UU	Unconsolidated (unspecified)		

Rock type

AC	Acid igneous/metamorphic rock	SE	Sedimentary rock
GR	Granite	LI	Limestone
GN	Gneiss	DM	Dolomite
GG	Granite/Gneiss	SA	Sandstone
QZ	Quartzite	QS	Quartzitic sandstone
SC	Schist	SH	Shale
AN	Andesite	MA	Marl
DI	Diorite	TR	Travertine
BA	Basic igneous/metamorphic rock	CO	Conglomerate
UB	Ultra basic rock	SI	Siltstone
GA	Gabbro	TU	Tuff
BT	Basalt	PY	Pyroclastic rock
DO	Dolerite	EV	Evaporite
VO	Volcanic rock	GY	Gypsum rock
		NK	Not known

1.5.2 Effective soil depth

The effective soil depth may be defined as the depth of the soil at which root growth of grasses or crops is strongly inhibited. Rooting depth being plant specific, it is recommended that representative species of grasses and cereals are used to indicate the effective rooting depth of the soil.

The effective depth of the soil is governed by such factors as the presence of cemented, toxic or compacted layers; hard rock; or indurated gravel layers. A high permanent water table may also control the effective soil depth, but may change after drainage.

Apart from obvious situations such as the presence of a lithic contact, it is realized that the estimation of effective soil depth is subject to individual interpretation. Judgment should be exercised, using the following effective soil depth classes:

1	Very shallow		<	30cm
2	Shallow	30	-	50cm
3	Moderately deep	50	-	100 cm
4	Deep	100	-	150 cm
5	Very deep		>	150 cm

Extremely shallow (<10 cm) and extremely deep may be added where desirable.

1.6 Surface Characteristics

1.6.1 Rock outcrops

Exposures of bedrock may limit the use of modern, mechanized, agricultural equipment. Rock outcrops are described in terms of percentage surface cover, together with additional relevant information on the size, spacing or hardness of the individual outcrops.

The following classes of percentage of surface cover are recommended:

N	None			0 %
V	Very few	0	-	2 %
F	Few	2	-	5 %
C	Common	5	-	15 %
M	Many	15	-	40 %
A	Abundant	40	-	80 %
D	Dominant		>	80 %

The following classes of average distance between rock outcrops (single or clusters) are suggested:

1		>	50 m
2	20	-	50 m
3	5	-	20 m
4	2	-	5 m
5		<	2 m

1.6.2 Surface coarse fragments

The occurrence of surface coarse fragments, which includes those which are partially exposed as well, is described in terms of percentage of surface coverage and in terms of size of the fragment. Classes of occurrence of surface coarse fragments have been correlated with the rock outcrop ones, as follows:

N	None			0 %	**M**	Many	15	-	40 %
V	Very few	0	-	2 %	**A**	Abundant	40	-	80 %
F	Few	2	-	5 %	**D**	Dominant		>	80 %
C	Common	5	-	15 %					

Size classes, indicating the greatest dimensions, are as follows:

F	Fine gravel	0.2	-	0.6	cm
M	Medium gravel	0.6	-	2.0	cm
C	Coarse gravel	2	-	6	cm
S	Stones	6	-	20	cm
B	Boulders	20	-	60	cm
L	Large boulders	60	-	200	cm

1.6.3 Erosion

In the description of erosion, emphasis is given to accelerated or human-induced erosion. It is not always easy to distinguish between natural and accelerated erosion, as they are often closely related. Human-induced erosion is the result of irrational use and poor management, such as incorrect agricultural practices, overgrazing and removal or overexploitation of the natural vegetation.

Main categories

Most of the erosion can be classified as either water or wind erosion, and also deposition; a third major category is mass movements (landslides and related phenomena).

N No evidence of erosion
W Wind erosion or deposition
A Wind (aeolian) erosion or deposition
M Mass movement (landslides and similar phenomena)
NK Not known

Types

If more specific categories are required the following codes are recommended for subdivision of types of erosion and deposition:

WS Sheet erosion
WR Rill erosion
WG Gully erosion
WT Tunnel erosion
WD Deposition by water
WA Water and wind erosion

AD Wind deposition
AM Wind erosion and deposition
AS Shifting sands
AZ Salt deposition

Area affected

The total area affected by erosion and deposition is estimated following the classes defined by GLASOD (UNEP-ISRIC, 1990):

0			0	%
1	0	-	5	%
2	5	-	10	%
3	10	-	25	%
4	25	-	50	%
5		>	50	%

Degree

It is difficult to define classes of the degree of erosion which would be equally appropriate for all soils and environments and which would also fit the various types of water and wind erosion. Four classes are recommended, which may have to be further defined for each type or combination of erosion and deposition and specific environment. For example, in the case of gully and rill erosion the depth and spacing may need to be recorded, for sheet erosion the loss of topsoil, for dunes the height, for deposition the thickness of the layer. The following classes are recommended to describe the degree of erosion in the affected area:

S Slight: Some evidence of damage to surface horizons. Original biotic functions largely intact.

M Moderate: Clear evidence of removal of surface horizons. Original biotic functions partly destroyed.

V Severe: Surface horizons completely removed and subsurface horizons exposed. Original biotic functions largely destroyed.

E Extreme: Substantial removal of deeper subsurface horizons (badlands). Original biotic functions fully destroyed.

Activity

The period of activity of accelerated erosion or deposition is described using the following recommended classes:

A	Active at present
R	Active in recent past (previous 50-100 years)
H	Active in historical times
N	Period of activity not known
X	Accelerated and natural erosion not distinguished

1.6.4 Surface sealing

Surface sealing is used to describe crusts which develop at the soil surface after the topsoil dries out. These crusts may inhibit seed germination, reduce water infiltration and increase run-off. The attributes of surface sealing are the consistency, when dry, and thickness of the crust, as follows:

Thickness

N	None		
F	Thin	< 2	mm
M	Medium	2 - 5	mm
C	Thick	5 - 20	mm
V	Very thick	> 20	mm

Consistency

S	Slightly hard
H	Hard
V	Very hard
E	Extremely hard

1.6.5 Surface cracks

Surface cracks develop in shrink-swell clay-rich soils after they dry out. The width (average, or average width and maximum width) of the cracks at the surface is indicated in centimetres. The average distance between cracks may be indicated as well in centimetres. The following classes are suggested:

Width

F	Fine	< 1	cm
M	Medium	1 - 2	cm
W	Wide	2 - 5	cm
V	Very wide	5 - 10	cm
E	Extremely wide	> 10	cm

Distance between cracks

C	Very closely spaced		<	0.2	m
D	Closely spaced	0.2	-	0.5	m
M	Moderately widely spaced	0.5	-	2.0	m
W	Widely spaced	2	-	5	m
V	Very widely spaced		>	5	m

1.6.6 Other surface characteristics

A number of other surface characteristics, such as the occurrence of salts, bleached sand, litter, manure, worm casts, ant paths, cloddiness, puddling, etc., may be recorded.

Salt

The occurrence of salt at the surface may be described in terms of cover, appearance and type of salt. Classes for the percentage of surface cover and thickness are:

Cover

O	None			0	
1	Low	0		15	
2	Moderate	15	-	40	%
3	High	40	-	80	%
4	Dominant		>	80	%

Thickness

N	None				
F	Thin		>	2	mm
M	Medium	2	-	5	mm
C	Thick	5	-	20	mm
V	Very Thick		>	20	mm

Bleached Sand

The presence of bleached, loose sand grains on the surface is typical for certain soils and influences the reflection characteristics of the area and hence the image obtained through remote sensing. Classes, based on percentage of surface covered, are:

0	None			0%
1	Low	0	-	15%
2	Moderate	15	-	40%
3	High	40	-	80%
4	Dominant		>	80%

1.7 Soil-Water Relationships

This section deals with the present drainage conditions in the soil, water movement through and over the soil, flooding, groundwater, and the moisture conditions at the time of sampling.

1.7.1 Drainage Classes

The concept of soil drainage used in the FAO Guidelines for Soil Description (1977) based on the SSM relates to the frequency and duration of periods when the soil is free of saturation or partial saturation. The soil drainage classes defined therefore reflect the combined effects of climate, landscape and soil. Rainfall, seepage, soil permeability, surface infiltration rate, internal vertical and lateral movement of water, and external surface run-off and run-on, may all affect the drainage class.

Soil drainage is usually reflected by the colours of soil materials but relict features may persist after natural or artificial improvements in drainage. The depth of occurrence and intensity of gley features usually indicate the drainage status of the soil but not always: some soil materials will not develop strong features of gleying because of their specific chemical composition, texture, structure or porosity.

The original (SSM) drainage classes are useful for a rapid appraisal of drainage conditions, although the definitions need to be modified for different climates and cropping conditions. Seven classes are distinguished and intermediate classes, such as well to moderately well drained (WM) and imperfectly to poorly drained (IP) may be described as well.

E Excessively drained: Water is removed from the soil very rapidly. The soils are commonly very coarse textured or rocky, shallow or on steep slopes.

S Somewhat excessively drained: The water is removed from soil rapidly. The soils are commonly sandy and very pervious.

W Well drained: Water is removed from the soil readily but not rapidly. The soils commonly retain optimal amounts of moisture, but wetness does not inhibit growth of roots for significant periods.

M Moderately well drained: Water is removed from the soil somewhat slowly during some periods of the year. The soils are wet for short periods within the rooting depth. They commonly have an almost impervious layer, or periodically receive heavy rainfall.

I Somewhat poorly(imperfectly) drained: Water is removed slowly so that the soil is wet at a shallow depth for significant periods. The soils commonly have an almost impervious layer, a high water table, additions of water by seepage, or very frequent rainfall.

P Poorly drained: Water is removed so slowly that the soils are commonly wet at a shallow depth for considerable periods. The soils commonly have a shallow water table which is usually the result of an almost impervious layer, seepage, or very frequent rainfall.

V Very poorly drained: Water is removed so slowly that the soils are wet at shallow depths for long periods. The soils have a very shallow water table and are commonly in level or depressed sites or have very high rainfall falling almost every day.

1.7.2 Internal Drainage

In the description of drainage the combination of two features (the period when the soil is saturated or very wet, and the rate of movement of water through the soil) is not satisfactory, conceptually, nor in practice, especially where the rainfall is strongly seasonal or irregular. Very permeable sands may be permanently or seasonally waterlogged and impermeable clays may never be saturated or only for a few days a year. A more specific description of drainage conditions should therefore distinguish between the existing (or recent) conditions of wetness, and the rate at which water can move through the soil (vertically or laterally) expressed as permeability or hydraulic conductivity (if it is measured). The following descriptions are proposed.

Saturation The period during which the soil near the surface is saturated by groundwater or a perched water table should be indicated, based on local information or judgment supplemented by gleying features in the profile:

W	Never saturated (well drained)
R	Rarely saturated (a few days in some years)
S	Saturated for short periods in most years (up to 30 days)
L	Saturated for long periods every year
V	Always saturated (very poorly drained)
NK	Not known

Permeability or Hydraulic Conductivity Hydraulic conductivity is a measure of the ability of the soil to transmit water, defined as a volume of water flowing through a unit cross section per unit time at unit hydraulic gradient. Permeability is a general term for the same ability to transmit water. The hydraulic conductivity, when measured by the pumped-out auger hole method, indicates the ability of the whole soil below the water table to transmit water to a drain. It can also be measured for individual horizons or can be estimated from other soil physical features. It should not be confused with the infiltration rate vertically into the soil surface.

The classes, in m/day or cm/h, recommended to indicate hydraulic conductivity are:

ES	Extremely slow		<	0.06	cm/h
VS	Very slow	0.06	-	0.2	cm/h
S	Slow	0.2	-	0.6	cm/h
MS	Moderately slow	0.6	-	2.0	cm/h
MR	Moderately rapid	2.0	-	6.0	cm/h
R	Rapid	6	-	20	cm/h
VR	Very rapid		>	20	cm/h

For further information about measurement and estimation of hydraulic conductivity see FAO Soil Bulletin No. 42 (1986) and Irrigation and Drainage Paper No. 38 (1982).

1.7.3 External drainage

The external drainage of a site refers to its relative position in the landscape and consequent movement of surface water, in which the site is in a receiving or shedding position. The following classes are suggested for the description of external drainage, but should be further elaborated to accommodate local needs:

P	Ponded (run-on site)
N	Neither receiving nor shedding water
S	Slow run-off
M	Moderately rapid run-off
R	Rapid run-off

1.7.4 Flooding

Flooding, or temporary inundation, is described according to its estimated frequency, duration and depth. At most sites it is difficult to assess flooding accurately. Information may be obtained from records of past flooding or from local enquiry. The frequency and duration classes as suggested below should give an indication of the average occurrence of inundation.

Frequency

N	None	**F**	Once every 2-4 years
D	Daily	**T**	Once every 5-10 years
W	Weekly	**R**	Rare (less than once in 10 years)
M	Monthly	**NK**	Not known
A	Annually		
B	Biennially		

Duration

1	Less than 1 day
2	1 - 15 days
3	15 - 30 days
4	30 - 90 days
5	90 - 180 days
6	180 - 360 days
7	Continuous

Depth

1	Very shallow	0 - 25 cm
2	Shallow	25 - 50 cm
3	Moderately deep	50 - 100 cm
4	Deep	100 - 150 cm
5	Very deep	>150 cm

It may also be useful to separate slow inundation from floods and to indicate their speed and the damage likely to be caused by them.

1.7.5 Groundwater

The depth to the groundwater table, if present, as well as an estimate of the approximate annual fluctuation, should be given. The maximum rise of the groundwater table can be inferred approximately from changes in profile colour in many, but not all, soils.

Depth

The following depth classes for groundwater in the soil for present, minimum and maximum depth levels are suggested:

N	Not observed				
V	Very shallow	0	-	25	cm
S	Shallow	25	-	50	cm
M	Moderately deep	50	-	100	cm
D	Deep	100	-	150	cm
E	Very deep		>	150	cm

The presence of deeper groundwater tables, phreatic water, can also be recorded when it is known. Suggested depths are:

S	Shallow phreatic water	2	-	3 m
M	Moderately deep phreatic water	3	-	5 m
D	Deep phreatic water	5	-	8 m
E	Extremely deep phreatic water		>	8 m
NK	Not known			

Quality

An indication should also be given of the quality of the groundwater.

SA	Saline	**PO**	Polluted
BR	Brackish	**OX**	Oxygenated
FR	Fresh	**SG**	Stagnating

Salinity may also be indicated by a field measurement of the elctrical conductivity of the water.

1.7.6 Moisture conditions

The moisture conditions prevailing in the soil at the time of the description should be given together with the depth (for example: moist throughout, or: dry to 50cm moist below). Attention should be paid to unusual moisture conditions caused by unseasonal weather, prolonged exposure of the profile, flooding, etc.

D Dry
S Slightly moist
M Moist
W Wet

Such a general description can be supplemented by descriptions of moisture conditions in the horizons.

CHAPTER 2 SOIL HORIZON DESCRIPTION

In this chapter the soil morphological and other characteristics are presented as they are described by horizon. The order in which they appear corresponds with the SDB soil profile coding sheet, as far as possible.

2.1 Horizon Designation and Dimensions

2.1.1 Horizon symbol

Horizon symbols consist of one or two capital letters for the master horizon and lower case letter suffixes for subordinate distinctions, with or without a figure suffix. For the presentation and understanding of the soil profile description, it is essential that correct horizon symbols are given.

(i) Master horizons and layers

The capital letters **H, O, A, E, B, C** and **R** represent the master horizons and layers of soils. The capital letters are the base symbols to which other characters are added to complete the designation. Most horizons and layers are given a single capital letter symbol, but some require two.

Currently seven master horizons and layers and seven transitional horizons are recognized. The master horizons correspond to the SSM master horizons except for the H horizon, which is part of the O horizon in SSM.

The master horizons and their subdivisions represent layers which show evidence of change and some layers which have not been changed. Most are genetic soil horizons, reflecting a qualitative judgement about the kind of changes which have taken place. Genetic horizons are not equivalent to diagnostic horizons (see section 2.1.3), although they may be identical in soil profiles. Diagnostic horizons are quantitatively defined features used in classification.

H horizons or layers: Layers dominated by organic material, formed from accumulations of undecomposed or partially decomposed organic material at the soil surface which may be underwater. All H horizons are saturated with water for prolonged periods or were once saturated but are now artificially drained. An H horizon may be on top of mineral soils or at any depth beneath the surface if it is buried.

O horizons or layers: Layers dominated by organic material, consisting of undecomposed or partially decomposed litter, such as leaves, needles, twigs, moss, and lichens, which has accumulated on the surface; they may be on top of either mineral or organic soils. O horizons are not saturated with water for prolonged periods. The mineral fraction of such material is only a small percentage of the volume of the material and generally is much less than half of the weight.

An O layer may be at the surface of a mineral soil or at any depth beneath the surface if it is buried. An horizon formed by illuviation of organic material into a mineral subsoil is not an O horizon, though some horizons formed in this manner contain much organic matter.

A horizons: Mineral horizons which formed at the surface or below an O horizon, in which all or much of the original rock structure has been obliterated and which are characterized by one or more of the following:

- an accumulation of humified organic matter intimately mixed with the mineral fraction and not displaying properties characteristic of E or B horizons (see below);

- properties resulting from cultivation, pasturing, or similar kinds of disturbance; or

- a morphology which is different from the underlying B or C horizon, resulting from processes related to the surface.

If a surface horizon (or epipedon) has properties of both A and E horizons but the dominant feature is an accumulation of humified organic matter, it is designated an A horizon. In some places such as warm arid climates, the undisturbed surface horizon is less dark than the adjacent underlying horizon and contains only small amounts of organic matter. It has a morphology distinct from the C layer, though the mineral fraction may be unaltered or only slightly altered by weathering. Such an horizon is designated A because it is at the surface. Examples of epipedons which may have a different structure or morphology due to surface processes are Vertisols, soils in pans or playas with little vegetation, and soils in deserts.

However, recent alluvial or æolian deposits that retain fine stratification are not considered to be an A horizon unless cultivated.

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, and in which all or much of the original rock structure has been obliterated.

An E horizon is usually, but not necessarily, lighter in colour than an underlying B horizon. In some soils the colour is that of the sand and silt particles, but in many soils coatings of iron oxides or other compounds mask the colour of the primary particles. An E horizon is most commonly differentiated from an underlying B horizon in the same soil profile by colour of higher value or lower chroma, or both; by coarser texture; or by a combination of these properties. An E horizon is commonly near the surface, below an O or A horizon and above a B horizon, but the symbol E may be used without regard to position in the profile for any horizon that meets the requirements and that has resulted from soil genesis.

B horizons: Horizons that formed below an A, E, O or H horizon, and in which the dominant features are the obliteration of all or much of the original rock structure, together with one or a combination of the following:

- illuvial concentration, alone or in combination, of silicate clay, iron, aluminum, humus, carbonates, gypsum or silica;
- evidence of removal of carbonates;
- residual concentration of sesquioxides;
- 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;
- alteration that forms silicate clay or liberates oxides or both and that forms a granular, blocky, or prismatic structure if volume changes accompany changes in moisture content; or
- brittleness.

All kinds of B horizons are, or were originally, subsurface horizons. Included as B horizons are layers of illuvial concentration of carbonates, gypsum, or silica that are the result of pedogenetic processes (these layers may or may not be cemented) and brittle layers that have other evidence of alteration, such as prismatic structure or illuvial accumulation of clay.

Examples of layers that are not B horizons are layers in which clay films either coat rock fragments or are on finely stratified unconsolidated sediments, whether the films were formed in place or by illuviation; layers into which carbonates have been illuviated but that are not contiguous to an overlying genetic horizon; and layers with gleying but no other pedogenetic changes.

C horizons or layers: Horizons or layers, excluding hard bedrock, that are little affected by pedogenetic processes and lack properties of H, O, A, E, or B horizons. Most are mineral layers, but some siliceous and calcareous layers such as shells, coral and diatomaceous earth, are included. The material of C layers 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. Plant roots can penetrate C horizons, which provide an important growing medium.

Included as C layers are sediments, saprolite, and unconsolidated bedrock and other geologic materials that commonly slake within 24 hours when air dry or drier chunks are placed in water and when moist can be dug with a spade. Some soils form in material that is already highly weathered, and such material that does not meet the requirements of A, E or B horizons is designated C. Changes not considered pedogenetic are those not related to overlying horizons. Layers having accumulations of silica, carbonates, or gypsum, even if indurated, may be included in C horizons, unless the layer is obviously affected by pedogenetic processes; then it is a B horizon.

R layers: Hard bedrock underlying the soil.

Granite, basalt, quartzite and indurated limestone or sandstone are examples of bedrock that are designated R. Air dry or drier chunks of an R layer when placed in water will not slake within 24 hours. The R layer is sufficiently coherent when moist to make hand digging with a spade impractical, although it may be chipped or scraped. Some R layers can be ripped with heavy power equipment. The bedrock may contain cracks, but these are so few and so small that few roots can penetrate. The cracks may be coated or filled with clay or other material.

(ii) Transitional horizons

There are two kinds of transitional horizons: those with properties of two horizons superimposed and those with the two properties separate.

For horizons dominated by properties of one master horizon but having subordinate properties of another, two capital letter symbols are used, such as **AB**, **EB**, **BE** and **BC**. The master horizon symbol that is given first designates the kind of horizon whose properties dominate the transitional horizon. An **AB** horizon, for example, has characteristics of both an overlying **A** horizon and an underlying **B** horizon, but is more like the **A** than like the **B**.

In some cases, a horizon can be designated as transitional even if one of the master horizons to which it is apparently transitional is not present. A **BE** horizon may be recognized in a truncated soil if its properties are similar to those of a **BE** horizon in a soil in which the overlying **E** horizon has not been removed by erosion. An **AB** or a **BA** horizon may be recognized where bedrock underlies the transitional horizon. A **BC** horizon may be recognized even if no underlying **C** horizon is present; it is transitional to assumed parent material. A **CR** horizon can be used for weathered bedrock which can be dug with a spade though roots cannot penetrate except along fracture planes.

Horizons in which distinct parts have recognizable properties of two kinds of master horizons are indicated as above, but the two capital letters are separated by a virgule (/), as **E/B**, **B/E**, **B/C** or **C/R**. Commonly most of the individual parts of one of the components are surrounded by the other.

(iii) Subordinate Characteristics within Master Horizons and Layers

Designations of subordinate distinctions and features within the master horizons and layers are based on profile characteristics observable in the field and are applied during the description of the soil at the site. Lower case letters are used as suffixes to designate specific kinds of master horizons and layers, and other features. The list of symbols and terms is shown on page 32 and explanations are given below:

b Buried genetic horizon: Used in mineral soils to indicate identifiable buried horizons with major genetic features that were formed before burial. Genetic horizons may or may not

Subordinate Characteristics within Master Horizons

The symbols used are given here for easy reference, with a full explanation in the text.

a (not used)
b Buried genetic horizon
c Concretions or nodules
d (not used)
e (not used)
f Frozen soil
g Strong gleying
d Accumulation of organic matter
i (not used)
j Jarosite mottles
k Accumulation of carbonates
l (not used)
m Cementation or induration
n Accumulation of sodium
o Residual accumulation of sesquioxides
p Ploughing or other disturbance
q Accumulation of silica
r Strong reduction
s Illuvial accumulation of sesquioxides
t Accumulation of silicate clay
u (not used)
v Occurrence of plinthite
w Development of colour or structure
x Fragipan character
y Accumulation of gypsum
z Accumulation of salts more soluble than gypsum

have formed in the overlying material, which may be either like or unlike the assumed parent materials of the buried soil. The symbol is not used in organic soils or to separate an organic layer from a mineral layer.

c Concretions or nodules: Indicates a significant accumulation of concretions or of nodules. The nature and consistence of the nodules is specified by other suffixes and in the horizon description.

f Frozen soil: Designates horizons or layers that contain permanent ice or are perennially colder than 0°C. It is not used for seasonally frozen layers nor for bedrock layers (R).

g Gleying: Designates horizons in which a distinct pattern of mottling occurs which reflects alternating conditions of oxidation and reduction of sesquioxides (caused by seasonal waterlogging).

h Accumulation of organic matter: Designates the accumulation of organic matter in mineral horizons. The accumulation may occur in surface horizons, or in subsurface horizons through illuviation.

j Jarosite mottles: Indicates the presence of jarosite mottles.

k Accumulation of carbonates: Indicates an accumulation of alkaline earth carbonates, commonly calcium carbonate.

m Cementation or induration: Indicates continuous or nearly continuous cementation, and is used only for horizons that are more than 90% cemented, though they may be fractured. The layer is root restrictive and roots do not enter except along fracture planes. The single predominant or codominant cementing agent may be indicated using defined letter suffices singly or in pairs. If the horizon is cemented by carbonates **km** is used; by silica, qm; by iron, sm; by gypsum, ym; by both lime and silica, **kqm**; by salts more soluble than gypsum, zm.

n Accumulation of sodium: Indicates an accumulation of exchangeable sodium.

o Residual accumulation of sesquioxides: Indicates residual accumulation of sesquioxides and differs from the use of symbol **s**, which indicates illuvial accumulation of organic matter and sesquioxide complexes.

p Ploughing or other disturbance: Indicates disturbance of the surface layer by ploughing or any other tillage practice. A disturbed organic horizon is designated **Op** or **Hp**. A disturbed mineral horizon, even though clearly once an **E**, **B** or **C**, is designated **Ap**.

q Accumulation of silica: Indicates an accumulation of secondary silica. If silica cements the layer and cementation is continuous or nearly continuous, **qm** is used.

r Strong reduction: Indicates that iron has been reduced during soil formation, or that continuous saturation with stagnant water has preserved a reduced state. If **r** is used with **B**, pedogenetic change in addition to reduction is implied; if no other change has taken place, the horizon is designated **Cr**.

s Illuvial accumulation of sesquioxides: Used with **B** to indicate the accumulation of illuvial, amorphous, dispersible organic matter-sesquioxide complexes if the value and chroma of the horizon are more than 3. The symbol is also used in combination with **h** as **Bhs** if both the organic matter and sesquioxides components are significant and both value and chroma are approximately 3 or less.

t Accumulation of silicate clay: Used with **B** or **C** to indicate an accumulation of silicate clay that either has formed in the horizon or has been moved into it by illuviation, or both. At least some part should show evidence of clay accumulation in the form of coatings on ped surfaces or in pores, as lamellae, or as bridges between mineral grains.

v Occurrence of plinthite: Indicates the presence of iron-rich, humus-poor material that is firm or very firm when moist and that hardens irreversibly when exposed to the atmosphere. When hardened, it is no longer called plinthite but a hardpan, ironstone, a petroferric or a skeletic phase.

w Development of colour or structure: Used with **B** to indicate development of colour or structure, or both. It should not be used to indicate a transitional horizon.

x Fragipan character: Used to indicate genetically developed firmness, brittleness or high bulk density. These features are characteristic of fragipans, but some horizons designated **x** do not have all the properties of a fragipan.

y Accumulation of gypsum: Indicates an accumulation of gypsum.

z Accumulation of salts more soluble than gypsum: Indicates an accumulation of salts more soluble than gypsum.

(iv) Conventions for using letter suffixes

Many master horizons and layers that are symbolized by a single capital letter will have one or more lowercase letter suffixes. More than three suffixes are rarely used. The following rules apply:

Letter suffixes should immediately follow the capital letter.

When more than one suffix is needed, the following letters, if used, are written first: **r**, **s**, **t**, and **w**. Except for the **Bhs** or **Crt** horizons, these letters are rarely used in combination in a single horizon.

If more than one suffix is needed and the horizon is not buried, these symbols, if used, are written last: **c**, **f**, **g**, **m**, **u**, **v**, and **x**. Some examples: **Btc**, **Bkm**, and **Bsv**.

If a horizon is buried, the suffix **b** is written last.

A **B** horizon that has significant accumulation of clay and also shows evidence of development of colour or structure, or both, is designated **Bt** (**t** has precedence over **w**, **s**, and **h**). A **B** horizon that is gleyed or that has accumulations of carbonates, sodium, silica, gypsum, salts more soluble than gypsum, or residual accumulation or sesquioxides carries the appropriate symbol **g**, **k**, **n**, **q**, **y**, **z**, or **o**. If illuvial clay is also present, **t** precedes the other symbol: **Bto**.

Suffixes **h**, **s**, and **w** are normally not used with **g**, **k**, **n**, **q**, **y**, **z**, or **o** unless needed for explanatory purposes.

Unless otherwise indicated, suffixes are listed alphabetically.

(v) Vertical subdivisions

Horizons or layer designated by a single combination of letter symbols can be subdivided using arabic numerals which follow all the letters. Within a **C**, for example, successive layers could be **C1**, **C2**, **C3**, etc.; or if the lower part is gleyed and the upper part is not, the designations could be **C1-C2-Cg1-Cg2** or **C-Cg1-Cg2-R**.

These conventions apply whatever the purpose of subdivision. A horizon identified by a single set of letter symbols may be subdivided on the basis of evident morphological features, such as structure, colour, or texture. These subdivisions are numbered consecutively. The numbering starts with 1 at whatever level in the profile. Thus **Bt1-Bt2-Btk1-Btk2** is used, not **Bt1-Bt2-Btk3-Btk4**. The numbering of vertical subdivisions within a horizon is not interrupted at a discontinuity (indicated by a numerical prefix) if the same letter combination is used in both materials: **Bs1-Bs2-2Bs3-2Bs4** is used, not **Bs1-Bs2-2Bs1-2Bs2**. **A** and **E** horizons can be subdivided similarly, for example **Ap, A1, A2; Ap1, Ap2; A1, A2, A3;** and **E1, E2, Eg1, Eg2.**

(vi) Discontinuities

In mineral soils, arabic numerals are used as prefixes to indicate discontinuities. Wherever needed, they are used preceding **A**, **E**, **B**, **C** and **R**. These prefixes are distinct from arabic numerals used as suffixes to denote vertical subdivisions.

A discontinuity is a significant change in particle size distribution or mineralogy that indicates a difference in the material from which the horizons formed or a significant difference in age or both, unless that difference in age is indicated by the suffix **b**. Symbols to identify discontinuities are used only when they will contribute substantially to the reader's understanding of relationships among horizons. The stratification common in soils formed in alluvium is not designated as discontinuities unless particle size distribution differs markedly from layer to layer even though genetic horizons have formed in the contrasting layers.

Where a soil has formed entirely in one kind of material, a prefix is omitted from the symbol; the whole profile is material 1. Similarly, the uppermost material in a profile having two or more contrasting materials is understood to be material 1, but the number is omitted. Numbering starts with the second layer of contrasting material, which is designated 2. Underlying contrasting layers are numbered consecutively. Even though a layer below material 2 is similar to material 1, it is designated 3 in the sequence. The numbers indicate a change in the material, not the type of material. Where two or more consecutive horizons formed in one kind of material, the same prefix number applied to all of the horizon designations in that material: **Ap-E-Bt1-2Bt2-2Bt3-2bC.** The number suffixes designating subdivisions of the Bt horizon continue in consecutive order across the discontinuity.

If an **R** layer is below a soil that formed in residuum and the material of the **R** layer is judged to be like that from which the material of the soil weathered, the arabic number prefix is not used. If the **R** layer would not produce material like that in the solum, the number prefix is used, as in **A-Bt-C-2R** or **A-Bt-2R.** If part of the solum formed in residuum, **R** is given the appropriate prefix: **Ap-Bt1-2Bt2-2Bt3-2C1-2C2-2R.**

Buried horizons (designated b) are special problems. A buried horizon is obviously not the same deposit as horizons in the overlying deposit. Some buried horizons, however, formed in material lithologically like that of the overlying deposit. A prefix is not used to distinguish material of such buried horizons. If the material in which a horizon of a buried soil formed is lithologically unlike that of the overlying material, the discontinuity is designated by number prefixes and the symbol for a buried horizon is used as well: **Ap-Bt1-Bt2-BC-C-2ABb-2Btb1-2Btb2-2C.**

In organic soils, discontinuities between different kinds of layers are not identified. In most cases the differences are shown by the letter suffix designations, if the different layers are organic, or by the master symbol if the different layers are mineral.

(vii) Use of the prime

Identical designations may be appropriate for two or more horizons or layers separated by at least one horizon or layer of a more different kind in the same pedon. The sequence **A-E-Bt-E-Btx-C** is an example: the soil has two **E** horizons. To make communication easier, a prime is used with the master horizon symbol of the lower of two horizons having identical letter designations: **A-E-Bt-E'-Btx-C**. The prime is applied to the capital letter designation, and any lower case symbol follows it: **B't**. The prime is not used unless all letters of the designations of two different layers are identical. Rarely, three layers have identical letter symbols; a double prime can be used: E''.

The same principle applies in designating layers of organic soils. The prime is used only to distinguish two or more horizons that have identical symbols: **O-C-C'-C''**. The prime is added to the lower **C** layer to differentiate it from the upper.

2.1.2 Horizon boundary

Horizon boundaries are described in terms of depth, distinctness and topography.

Depth

Most soil boundaries are zones of transition rather than sharp lines of division. The average depth of the upper and lower boundaries of each horizon is given in centimetres, measured from the surface of the soil downwards. The zero depth is placed at the very surface of the soil profile, at the air-soil interface, also above H, O and C horizons, including litter layers and shifting aeolian sands or other unstable covering layers which are changing in depth.

Precise notations in centimetres are used when boundaries are abrupt or clear. Rounded off figures (to the nearest 5 cm) are entered when the boundaries are gradual or diffuse, avoiding the suggestion of spurious levels of accuracy.

Most horizons do not have a constant depth. The variation or irregularity of the surface of the boundary is described by the topography, in terms of smooth, wavy, irregular and broken. If required, ranges in depth may be given in addition to the average depth, for instance 28 (25-31) cm to 45 (39-51) cm.

Distinctness

The distinctness of the boundary refers to the thickness of the zone within which the horizon boundary can be located without being within one or the other adjoining horizons.

A	Abrupt	0 - 2	cm
C	Clear	2 - 5	cm
G	Gradual	5 - 15	cm
D	Diffuse	> 15	cm

Topography

The topography of the boundary indicates the smoothness of depth variation of the boundary.

S	Smooth	Nearly plane surface
W	Wavy	Pockets less deep than wide
I	Irregular	Pockets more deep than wide
B	Broken	Discontinuous

2.1.3 Checklist of diagnostic horizons and properties

Whilst still in the field, it is advisable to determine or estimate, for each horizon, the diagnostic characteristics which apply to the classification system used. A checklist of diagnostic horizons and properties are given below in the order as they appear in the Revised Legend of the Soil Map of the World.

Diagnostic horizons

Histic H horizon
Mollic A horizon
Fimic A horizon
Umbric A horizon
Ochric A horizon
Argic B horizon
Natric B horizon
Cambic B horizon
Spodic B horizon
Ferralic B horizon
Calcic horizon
Petrocalcic horizon
Gypsic horizon
Petrogypsic horizon
Sulfuric horizon
Albic E horizon

Diagnostic properties

Abrupt textural changes
Andic properties
Calcareous
Calcaric
Continuous hard rock
Ferralic properties
Ferric properties
Fluvic properties
Geric properties
Gleyic and stagnic properties
Gypsiferous
Interfingering
Nitic properties
Organic soil materials
Permafrost
Plinthite
Salic properties
Slickensides
Smeary consistence
Sodic properties
Soft powdery lime
Stagnic properties
Strongly humic
Sulfidic materials
Tonguing
Vertic properties
Weatherable minerals

2.2. Soil Colour

2.2.1 Matrix colour

The colour of the soil matrix material of each horizon is recorded in the moist condition (or both dry and moist condition, if possible) using the notations for hue, value and chroma as given in the Munsell Soil Color Charts (Munsell, 1975). If there is no dominant soil matrix colour, the horizon is described as mottled and two or more colours are given. In addition to the colour notations, the standard Munsell colour names may be given.

For routine descriptions, soil colours should be determined out of direct sunlight and by matching a broken ped with the colour chip of the Munsell Color Chart. For special purposes, such as for soil classification, additional colours from crushed or rubbed material may be required. The occurrence of contrasting colours related to the structural organization of the soil, such as ped surfaces, may be noted.

Soil colour should be measured, if possible, under uniform conditions. Early morning and late evening readings are not accurate. Moreover, the determination of colour by the same or different individuals has proven to be often inconsistent. Since soil colour is significant with respect to various soil properties, including organic matter contents, coatings and state of oxidation or reduction, and for soil classification, cross-checks are recommended and should be established on a routine basis.

Intermediate colours may be recorded, when desirable for the distinction between two soil horizons and for purposes of classification and interpretation of the soil profile. Intermediate hues (important for Chromic, Rhodic, Cambic B horizon, etc.) which may be used are: 3.5YR, 4YR, 6YR, 6.5YR, 8.5YR and 9YR. When for instance 3.5YR is noted, it means that the intermediate hue is closer to 2.5YR than 5YR; 4YR means closer to 5YR, and so on.

If values and chromas are near diagnostic limits, rounded-off figures should not be used, but accurate recordings should be made by using intermediate values, or by adding a + or -.

Some important diagnostic values and chromas are:

Value 4 and 5	Albic horizons and hydromorphic properties
Value 3.5 and 5.5	Mollic and umbric horizons
Chroma 1 and 2	Hydromorphic properties
Chroma 2	Chernozems
Chroma 1.5	Vertisols
Chroma 3.5	Mollic and umbric horizons
Chroma 4	Chromic

2.2.2 Mottling

Mottling of the soil matrix is described in terms of abundance, size, contrast, boundary and colour. In addition, the shape, position or any other feature may be recorded. Rusty colours along root channels are not usually considered as mottles.

Abundance

The abundance of mottles is described in terms of classes indicating the percentage the mottles occupy of the exposed surface. The class limits correspond with those of mineral nodules.

N	None	0 %
V	Very few	0 - 2 %
F	Few	2 - 5 %
C	Common	5 - 15 %
M	Many	15 - 40 %
A	Abundant	> 40 %

When the abundance of mottles does not allow the distinction of a single predominant matrix colour, the predominant colours should be determined and entered as soil matrix colours.

Size

The following classes are used to indicate the approximate diameters of individual mottles. They correspond with the size classes of mineral nodules.

V	Very fine	< 2 mm
F	Fine	2 - 6 mm
M	Medium	6 - 20 mm
C	Coarse	> 20 mm

Contrast

The colour contrast between mottles and soil matrix can be described as follows:

F	Faint	The mottles are evident only on close examination. Soil colours in both the matrix and mottles have closely related hues, chromas and values.
D	Distinct	Although not striking, the mottles are readily seen. The hue, chroma or value of the matrix are easily distinguished from those of the mottles. They may vary by as much as 2.5 units of hue or several units in chroma or value.
P	Prominent	The mottles are conspicuous and mottling is one of the outstanding features of the horizon. Hue, chroma and value alone or in combination are at least several units apart.

Boundary

The boundary between mottle and matrix is described as the thickness of the zone within which the colour transition can be located without being in either the mottle or matrix.

S	Sharp	0	- 0.5 mm
C	Clear	0.5	- 2 mm
D	Diffuse		> 2 mm

Colour

It is usually sufficient to describe the colour of the mottles in general terms, corresponding with the Munsell Soil Color Charts. If required, full Munsell notations can be given. The following colour names and codes are suggested (similar to colours of mineral nodules):

WH	White	YE	Yellow
RE	Red	RY	Reddish yellow
RS	Reddish	GE	Greenish, green
YR	Yellowish red	GR	Grey
BR	Brown	GS	Greyish
BS	Brownish	BU	Blue
RB	Reddish brown	BB	Bluish-black
YB	Yellowish brown	BL	Black

2.3 Primary Constituents

In this section the particle size distribution and nature of the primary rock and mineral fragments are described, subdivided into (1) the fine earth fraction and (2) the coarse fragments fraction.

2.3.1 Texture of the fine earth

Particle size classes

The particle size classes of the fine earth fraction (<2mm) are defined below. The class names correspond as closely as possible with commonly used standard terminology, incuding the USDA System.

Diagram 1: TEXTURAL CLASSES

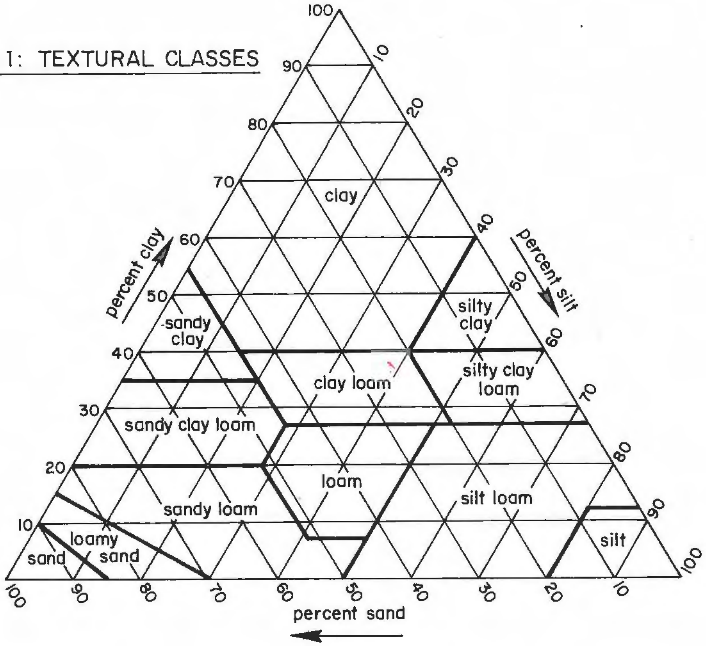
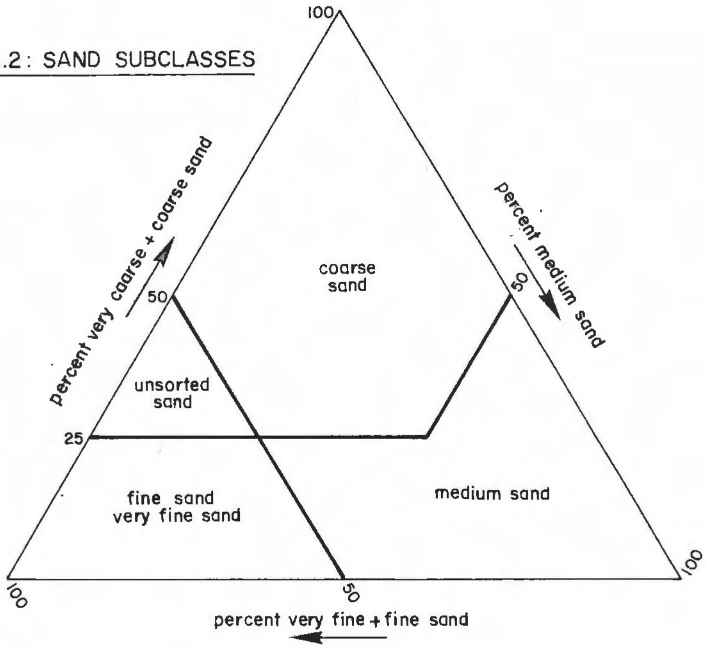


Diagram.2: SAND SUBCLASSES



Clay		<	2	µm
Fine silt	2	-	20	µm
Coarse silt	20	-	63	µm
Very fine sand	63	-	125	µm
Fine sand	125	-	200	µm
Medium sand	200	-	630	µm
Coarse sand	630	-	1250	µm
Very coarse sand	1250	-	2000	µm

Soil texture classes

The names of the textural classes of the described soil material (combined size classes) are similar to the SSM class names, coded as follows:

C	Clay	CSL	Coarse sandy loam
L	Loam	LS	Loamy sand
CL	Clay loam	LVFS	Loamy very fine sand
Si	Silt	LFS	Loamy fine sand
SiC	Silty clay	LCS	Loamy coarse sand
SiCL	Silty clay loam	VFS	Very fine sand
SiL	Silt loam	FS	Fine sand
SC	Sandy clay	MS	Medium sand
SCL	Sandy clay loam	CS	Coarse sand
SL	Sandy loam	US	Sand, unsorted
FSL	Fine sandy loam	S	Sand, unspecified

In addition to the textural class, a field estimate of the percentage of clay is given. This estimate is useful to indicate increases or decreases in clay content within textural classes, and to compare field estimates with analytical results. The relationship between the basic textural classes and the percentages of clay, silt and sand are indicated in triangular diagram 1.

Subdivision of the sand fraction

Sands, loamy sands and sandy loams are subdivided according to the proportions of very coarse to coarse, medium, fine and very fine sands in the sand fraction. The proportions are calculated from the particle size distribution, taking the total of the sand fraction as being 100 % (see diagram 2). The definitions of the sand subclasses have been modified from the previous edition of the Guidelines.

Definitions are as follows (reading as a key):

Very fine sand: 50 % or more very fine sand (and less than 25 % coarse and very coarse sand).

Fine sand: 50 % or more fine and very fine sand (and less than 25 % coarse and very coarse sand).

Coarse sand: 25 % or more very coarse and coarse sand, and less than 50 % medium sand and less than 50% fine and very fine sand.

Medium sand: either 50% or more medium sand, or 25% or more medium sand with less than 25% coarse and very coarse sand and less than 50% fine and very fine sand

Unsorted sand: other proportions

2.3.2 Rock fragments

Large rock and mineral fragments (>2mm) are described according to abundance, size, shape, state of weathering and nature of the fragments. The abundance class limits correspond with the ones for surface coarse fragments and mineral nodules, and the 40% boundary coincides with the requirement for the skeletic phase.

Abundance (by soil volume)

N	None			0	%
V	Very few	0	-	2	%
F	Few	2	-	5	%
C	Common	5	-	15	%
M	Many	15	-	40	%
A	Abundant	40	-	80	%
D	Dominant		>	80	%

Size

F	Fine gravel	0.2 - 0.6	cm
M	Medium gravel	0.6 - 2	cm
C	Coarse gravel	2 - 6	cm
S	Stones	6 - 20	cm
B	Boulders	20 - 60	cm
L	Large boulders	> 60	cm

Combined size classes and codes can be constructed as follows:

FM	Fine and medium gravel
MC	Medium and coarse gravel
SB	Stones and boulders

Shape

The general shape or roundness may be described using the following terms:

F	Flat
A	Angular
S	Subrounded
R	Rounded

Weathering

The state of weathering of the coarse fragments is described as follows:

F Fresh or 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 while the centres remain relatively fresh and the fragments have lost little of their original strength.

S Strongly weathered: All but the most resistant minerals are weathered, strongly discoloured and altered throughout the fragments, which tend to disintegrate under only moderate pressure.

Nature

The nature of rock and primary mineral fragments is described by using the same terminology as for the rock type description (see section 1.5.1). Some examples are:

QU	Quartz	MI	Mica
QZ	Quartzite	FE	Feldspar
CH	Chert	GR	Granite

Fragments of individual weatherable minerals (e.g., feldspar or micas) may be smaller than 2 mm in diameter. Nevertheless, if present in appreciable quantity, such fragments should receive a separate mention in the description.

2.4 Organization of Soil Constituents

In this section, the primary physical organization or arrangement of the soil constituents is described. Primary organization is considered as being the overall arrangement of the soil mass without concentrations, reorientations and biological additions. It will not always be possible to make clear distinctions between primary and secondary elements of the organization. Voids (pores), which relate to the structural organization of the soil, are described in section 2.5.

2.4.1 Structure

Soil structure refers to the natural organization of soil particles into discrete soil units (peds) which are separated from each other by persistent surfaces of weakness. It is preferable to describe the structure when the soil is dry or slightly moist. In moist or wet conditions, it is often advisable to leave the description of structure to a later time when the soil will have dried out.

For the description of soil structure, a large lump of the soil should be taken from the profile, from various parts of the horizon if necessary, rather that observing the soil structure from the profile face alone.

Soil structure is described in terms of grade, class and type of aggregates. When a soil horizon contains aggregates of more than one grade, class or type, the different kinds of aggregates should be described separately and their relationship indicated.

Grade

In describing the grade or development of the structure the first division is into apedal soils, lacking soil structure, and pedal soils, showing soil structure.

In apedal or structureless soil, no peds or units are observable in place and there is no definite arrangement of natural surfaces of weakness. Structureless soils are subdivided into single grain and massive. Single grain soil material **(SG)** has a loose, soft or very friable consistence and consists on rupture of more than 50% discrete mineral particles. Massive soil material **(MA)** has normally a stronger consistence and is more coherent on rupture. Massive soil material may be further defined by consistence (section 2.4.2) and porosity (section 2.5).

Grades of structure of pedal soil materials are defined as follows:

Weak: Peds are barely observable in place and there is only a weak arrangement of natural surfaces of weakness. When gently disturbed, the soil material breaks into a mixture of few entire peds, many broken peds, and much material without ped faces. Ped surfaces will differ in some way from the ped interior.

Moderate: Peds are observable in place and there is a distinct arrangement of natural surfaces of weakness. When disturbed, the soil material breaks into a mixture of many entire peds, some broken peds, and little material without ped faces. Ped surfaces generally show distinct differences with the ped interiors.

Strong: Peds are clearly observable in place and there is a prominent arrangement of natural surfaces of weakness. When disturbed, the soil material separates mainly into entire peds. Ped surfaces generally differ markedly from ped interiors.

The following classes may be used for description of the structure:

VW	Very weak	**ST**	Strong
WE	Weak	**VS**	Very strong
MO	Moderate		

Combined classes may be constructed as follows:

WM Weak to moderate
MS Moderate to strong

Size

It should be noted 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.

Symbol	Class	Platy	Prismatic	Blocky	Granular
VF	Very fine	<1	<10	<5	<1
FI	Fine	1 - 2	10 - 20	5 - 10	1 - 2
ME	Medium	2 - 5	20 - 50	10 - 20	2 - 5
CO	Coarse	5 - 10	50 - 100	20 - 50	5 - 10
VC	Very coarse	>10	>100	>50	>10

Combined classes may be constructed as follows:

FF	Fine and very fine	**CV**	Coarse and very coarse
FM	Fine and medium	**FC**	Fine to coarse
MV	Medium to very coarse	**MC**	Medium and coarse

Type of structure

The basic types of structure are defined as follows:

Granular: Spheroids or polyhedrons, having curved or irregular surfaces which are not casts of the faces of surrounding peds.

Blocky: Blocks or polyhedrons, nearly equidimensional, having flat or slightly rounded surfaces which are casts of the faces of the surrounding peds. Subdivision is recommended into angular, with faces intersecting at relatively sharp angles, and subangular blocky faces with intersecting at rounded angles.

Prismatic: The dimensions are limited in the horizontal and extended along the vertical plane; vertical faces well defined; having flat or slightly rounded surfaces which are casts of the faces of the surrounding peds. Faces normally intersect at relatively sharp angles. Prismatic structures with rounded caps are distinguished as **Columnar**.

Platy: Flat with vertical dimensions limited; generally oriented on a horizontal plane and usually overlapping.

Rock structure: Rock structure includes fine stratification in unconsolidated sediment, and pseudomorphs of weathered minerals retaining their positions relative to each other and to unweathered minerals in saprolite from consolidated rocks.

If required, special cases or combinations of structures may be distinguished, which are subdivisions of the basic structures. The following codes are recommended:

SG	Single grain	**AS**	Angular and subangular blocky
MA	Massive	**SA**	Subangular and angular blocky
GR	Granular	**SN**	Nutty subangular blocky
PR	Prismatic	**AW**	Angular blocky wedge-shaped
PS	Subangular prismatic	**AP**	Angular blocky parallelepiped
CO	Columnar	**PL**	Platy
AB	Angular blocky	**RS**	Rock structure
SB	Subangular blocky	**SS**	Stratified structure

Compound structure relationship

If a second structure is present, its relation to the first structure is described. The first and second structures may both be present (for example columnar and prismatic structures). The primary structure may break down into a secondary structure (for example prismatic breaking to angular blocky). The first structure may merge into the second structure (for example platy merging into prismatic). These can be indicated thus:

CO	+	PR	Both structures present
PR	→	AB	Primary breaking to secondary structure
PL	/	PR	One structure merging into the other

2.4.2 Consistence

For reference descriptions (Status 1) a recording of consistence is required for the dry, moist and wet (stickiness and plasticity) states. If applicable, also the smeariness (thixotropy) and fluidity may be recorded. For routine descriptions, the soil consistence in the natural moisture condition of the profile may be described. Wet consistence can always be described, and moist conditions if the soil is dry, by wetting the soil.

Consistence when dry

Determined by breaking an air-dried mass of soil between thumb and forefinger or in the hand.

LO	Loose: Non-coherent
SO	Soft: Soil mass is very weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.
SHA	Slightly hard: Weakly resistant to pressure; easily broken between thumb and forefinger.
HA	Hard: Moderately resistant to pressure; can be broken in the hands; not breakable between thumb and forefinger.
VHA	Very hard: Very resistant to pressure; can be broken in the hands only with difficulty.
EHA	Extremely hard: Extremely resistant to pressure; cannot be broken in the hands.

Additional codes, needed occasionally to distinguish between two horizons or layers, are:

SSH Soft to slightly hard
SHH Slightly hard to hard
HVH Hard to very hard

Consistence when moist

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

LO Loose: Non-coherent

VFR Very friable: Soil material crushes under very gentle pressure, but coheres when pressed together.

FR Friable: Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together.

FI Firm: Soil material crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

VFI Very firm: Soil material crushes under strong pressures; barely crushable between thumb and forefinger.

EFI Extremely firm: Soil material crushes only under very strong pressure; can not be crushed between thumb and forefinger.

Additional codes are:

VFF Very friable to friable
FRF Friable to firm
FVF Firm to very firm

Consistence when wet: maximum stickiness and maximum plasticity

Soil stickiness depends on the extent to which soil structure is destroyed and on the amount of water present. The determination of stickiness should be performed under standard conditions on a soil sample in which structure is completely destroyed and which contains enough water for its maximum stickiness to be expressed. In such a way, the soil's maximum stickiness will be determined and comparison between degrees of stickiness of various soils will be feasible. The same principles apply to soil plasticity.

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.

NST Non sticky: after release of pressure, practically no soil material adheres to thumb and finger.

SST Slightly sticky: after pressure, soil material adheres to both thumb and finger but comes off one or the other rather cleanly. It is not appreciably stretched when the digits are separated.

ST 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.

VST Very sticky: after pressure, soil material adheres strongly to both thumb and finger and is decidedly stretched when they are separated.

Additional codes are:

SSS Slightly sticky to sticky
SVS Sticky to very sticky

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 in the hands until a wire about 3 mm in diameter has been formed.

NPL Non plastic: No wire is formable

SPL Slightly plastic: Wire formable but immediately breaks if bent into a ring; soil mass deformed by very slight force.

PL Plastic: Wire formable but breaks if bent into a ring; slight to moderate force required for deformation of the soil mass.

VPL Very plastic: Wire formable and can be bent into a ring; moderately strong to very strong force required for deformation of the soil mass.

Additional codes are:

SPP Slightly plastic to plastic
PVP Plastic to very plastic

2.5 Voids (Porosity)

Voids include all space in the soil. The voids are related to the arrangement of the primary constituents, rooting patterns, burrowing of animals or any other soil forming process such as cracking, translocation, leaching, etc. The term void is about equivalent to the term pore, but the latter is often used in a more restrictive way and does not, for instance, include fissures or planes.

Voids are described in terms of type, size and abundance. In addition, continuity, orientation or any other feature may also be recorded.

Type

There is a large variety in the shape and origin of voids. It is impractical and usually not necessary to describe all different kinds of voids comprehensively. Emphasis should be given to estimating the continuous and elongate voids. The major types of voids may be classified in a simplified way as follows:

I Interstitial: Controlled by the fabric, or arrangement, of the soil particles. Also called textural voids. Subdivision possible into simple packing voids, which relate to the packing of sand particles, and compound packing voids, which result from the packing of non accommodating peds. Predominantly irregular and interconnected, and cannot be quantified in the field.

B Vesicles: Discontinuous spherical or elliptical voids (chambers) of sedimentary origin or formed by compressed air, for instance gas bubbles in slaking crusts after heavy rainfall. Relatively unimportant in connection with plant growth.

V Vughs: Mostly irregular, equidimensional voids of faunal origin or resulting from tillage or disturbance of other voids. Discontinuous or interconnected. May be quantified in specific cases.

C Channels: Elongate voids of faunal or floral origin. Mostly of tubular shape and continuous, strongly varying in diameter. When wider than a few centimetres (burrow holes) they are more adequately described under biological activity (section 2.7).

P Planes: Most planes are extra-pedal voids, related to accommodating ped surfaces or cracking patterns. They are often not persistent and vary in size, shape and quantity depending on the moisture condition of the soil. Planar voids may be recorded, describing width and frequency. Cracks at the surface are described in section 1.6.5.

In most cases it is recommended that only the size and abundance of the channels, which are mostly continuous tubular pores, be described. For the other types of voids the following size and abundance classes should serve as a guide for the construction of suitable classes for each category.

Size

The diameter of the elongate or tubular voids is described using the following classes:

V	Very fine	< 0.5	mm
F	Fine	0.5 - 2	mm
M	Medium	2 - 5	mm
C	Coarse	5 - 20	mm
VC	Very coarse	20 - 50	mm

Additional codes are:

FM Fine and medium
FF Fine and very fine
MC Medium and coarse

Abundance

The abundance of fine and very fine elongate pores as one group and of medium and coarse pores as another is recorded as the number per unit area of a square decimeter.

		Very fine/fine	Medium/coarse
N	None	0	0
V	Very few	1 - 20	1 - 2
F	Few	20 - 50	2 - 5
C	Common	50 - 200	5 - 20
M	Many	> 200	> 20

Porosity

The porosity is an indication of the total volume of voids of all sizes, measured by area, recorded as the percentage of the surface occupied by pores.

1	Very low	< 2 %
2	Low	2 - 5 %
3	Medium	5 - 15 %
4	High	15 - 40 %
5	Very high	> 40 %

2.6 Concentrations

In this section the most commonly occurring concentrations of soil materials are described, including secondary enrichments, cementations and reorientations.

2.6.1 Cutanic features

Described in this section are clay or mixed-clay illuviation features and surface-related reorientations such as slickensides and pressure faces, according to abundance, contrast, nature, and location.

Abundance

For surface-related cutanic features, the estimate is made according to how much of the best developed ped faces is covered. Corresponding criteria should be applied when the cutanic feature is related to other surfaces (voids, coarse fragments) or occurs as lamellae.

N	None	0 %
V	Very few	0 - 2 %
F	Few	2 - 5 %
C	Common	5 - 15 %
M	Many	15 - 40 %
A	Abundant	40 - 80 %
D	Dominant	> 80 %

Contrast

F Faint: Surface of cutan shows only little contrast in colour, smoothness or any other property to the adjacent surface. Fine sand grains are readily apparent in the cutan. Lamellae are less than 2 mm thick.

D Distinct: Surface of cutan is distinctly smoother or different in colour than the adjacent surface. Fine sand grains are enveloped in the cutan but their outlines are still visible. Lamellae are between 2 and 5 mm thick.

P Prominent: Surface of cutan contrasts strongly in smoothness or colour with the adjacent surface. Outlines of fine sand grains are not visible. Lamellae are more than 5 mm thick.

Nature

The nature of cutans may be described as follows:

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
SF	Shiny faces (as in nitic properties)

Location

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

P	Pedfaces	LA	Lamellae (clay bands)
PV	Vertical pedfaces	VO	Voids
PH	Horizontal pedfaces	NS	No specific location
CF	Coarse fragments		

2.6.2 Cementation and Compaction

The occurrence of cementation or compaction, in pans or otherwise, is described according to its continuity, structure, nature of agent and degree.

Compacted material has a firm or stronger consistence when moist and a close packing of particles. Cemented material does not slake after one hour of immersion in water.

Continuity

B   Broken: The layer is less than 50% cemented or compacted, and shows a rather irregular appearance.

D   Discontinuous: The layer is 50-90% cemented or compacted, and in general shows a regular appearance.

C Continuous: The layer is more than 90% cemented or compacted, and is only in places interrupted by cracks or fissures.

Structure

The fabric, or structure, of the cemented or compacted layer may be described as follows:

N None: The structure is massive without recognizable orientation.

P Platy: The compacted or cemented parts are plate-like and have a (sub)horizontal orientation.

V Vesicular: The layer has large, equidimensional voids which may be filled with uncemented material.

P Pisolithic: The layer is largely constructed from cemented spherical nodules.

D Nodular: The layer is largely constructed from cemented nodules or concretions of irregular shape.

Nature

The nature of cementation or compaction is described according to the cementing agent or compacting activity, such as:

K	Carbonates	GY	Gypsum
Q	Silica	C	Clay
KQ	Carbonates-silica	CS	Clay-sesquioxides
F	Iron	M	Mechanical
FM	Iron-manganese (sesquioxides)	P	Ploughing
FO	Iron-organic matter	NK	Not known

Degree

N Non-cemented and non-compacted: Neither cementation nor compaction observed (slakes in water).

Y Compacted but non-cemented: Compacted mass is appreciably harder or more brittle than other comparable soil mass (slakes in water).

W Weakly cemented: Cemented mass is brittle and hard, but can be broken in the hands.

M Moderately cemented: Cemented mass cannot be broken in the hands but is discontinuous (less than 90% of soil mass).

C Cemented: Cemented mass cannot be broken in the hands and is continuous (more than 90% of soil mass).

2.6.3 Mineral Nodules

Mineral nodules cover a large variety of secondary crystalline, microcrystalline and amorphous concentrations of non-organic substances. Gradual transitions exist with mottles, some of which may be considered as weak expressions of nodules. The mineral nodules are described according to their abundance, kind, size, shape, hardness, nature and colour.

Abundance (by volume)

N	None	0 %
V	Very few	0 - 2 %
F	Few	2 - 5 %
C	Common	5 - 15 %
M	Many	15 - 40 %
A	Abundant	40 - 80 %
D	Dominant	>80 %

Kind

T Crystal

C Concretion: A discrete body with a concentric internal structure, generally cemented.

S Soft segregation (or soft accumulation): Differs from the surrounding soil mass in colour and composition but is not easily separated as a discrete body.

N Nodule: Discrete body without an internal organization.

R Residual rock fragment: Discrete impregnated body still showing rock structure

Size

V	Very fine	< 2 mm
F	Fine	2 - 6 mm
M	Medium	6 - 20 mm
C	Coarse	> 20 mm

Shape

R	Rounded (spherical)
E	Elongate
F	Flat
I	Irregular
A	Angular

Hardness

H Hard: Nodule cannot be broken in the fingers.
S Soft: Nodule can be broken between forefinger and thumb nail.
B Both hard and soft.

Nature

The mineral nodules are described according to their composition or impregnating substance. Some examples are:

K	Carbonates (calcareous)	S	Sulphur (sulphurous)
KQ	Carbonates-silica	Q	Silica (siliceous)
C	Clay (argillaceous)	F	Iron (ferruginous)
CS	Clay-sesquioxides	FM	Iron-manganese (sesquioxides)
GY	Gypsum (gypsiferous)	M	Manganese (manganiferous)
SA	Salt (saline)	NK	Not known

Colour

The following general colour names are usually sufficient to describe the colour of the nodules (similar to mottles):

WH	White	YE	Yellow
RE	Red	RY	Reddish yellow
RS	Reddish	GE	Greenish
YR	Yellowish red	GR	Grey
BR	Brown	GS	Greyish
BS	Brownish	BU	Blue
RB	Reddish brown	BB	Bluish-black
YB	Yellowish brown	BL	Black

2.7 Biological Activity

In this section evidence of past or present biological activity, including activity of man, is recorded.

2.7.1 Roots

The recording of both the size and the abundance of the roots is in general sufficient to characterize the distribution of roots in the profile. In specific cases, additional information can be noted, such as a sudden change in root orientation.

Abundance

The abundance of roots can only be compared within the same size class. The abundance of fine and very fine roots may be recorded similarly as for voids, expressed in the number of roots per square decimetre.

N	No roots	0
V	Very few	1 - 20
F	Few	20 - 50
C	Common	50 - 200
M	Many	> 200

Size (diameter)

VF	Very fine		<	0.5	mm
F	Fine	0.5	-	2	mm
M	Medium	2	-	5	mm
C	Coarse		>	5	mm

Additional codes are:

FF	Very fine and fine
FM	Fine and medium
MC	Medium and coarse

2.7.2 Biological features

Biological features (e.g. krotovinas, termite burrows, insect nests, worm casts or burrows of larger animals) are described in terms of abundance and kind. In addition, specific locations, patterns, size, composition or any other characteristic may be recorded.

Abundance

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

N	None	C	Common
F	Few	M	Many

Kind

Examples of biological features are the following:

A	Artefacts	E	Earthworm channels
B	Burrows (unspecified)	P	Pedotubules
BO	Open large burrows	T	Termite or ant channels and nests
BI	Infilled large burrows	I	Other insect activity
C	Charcoal		

2.8 Soil Reaction

2.8.1 Carbonates

The calcium carbonate content of the matrix material is tested with 10% HCl. In many soils it is difficult to distinguish in the field between primary and secondary carbonates. Care should be taken not to include carbonate nodules with the test. Classes for the reaction are defined as follows:

- **N** Non-calcareous: No detectable visible or audible effervescence
- **SL** Slightly calcareous: Audible effervescence but not visible
- **MO** Moderately calcareous: Visible effervescence
- **ST** Strongly calcareous: Strong visible effervescence. Bubbles form a low foam
- **EX** Extremely calcareous: Extremely strong reaction. Thick foam forms quickly.

Note that the reaction to acid depends upon soil texture and is usually more vigorous in sandy material than in fine-textured material with the same carbonate content. Other materials, such as roots, may also give an audible reaction.

2.8.2 Field pH

When the pH is measured in the field, the method used should be indicated under Remarks on the field data sheet. The field pH should not be a substitute for a laboratory determination. Field pH measurements should be correlated with laboratory determinations whenever possible.

2.9 Samples

The sample code and sampling depth are given.

It is recommended that the number given to the sample is the profile number followed by an additional capital letter (A,B,C,D, etc.) and depth range at which each sample has been collected from top to bottom, regardless of the horizon they are taken from (some may not be sampled while others may be sampled twice). Samples are never taken across horizon boundaries. The weight of material taken for each sample is usually one kilogram.

Horizon symbols should not be used as sample codes, as the horizon classifications may be changed later.

There are basically two methods of collecting samples:

1. To collect the sample in equal proportions over the whole horizon. This is the recommended method and should be used for reference (status 1) descriptions where a dense sampling is required.

2. To take the sample in equal proportions within a depth of 20cm, either from the centre (area of maximum expression) of the horizon, or, if more than one sample is to be taken from the same horizon, at balanced intervals.

In both methods the boundary area itself should not be sampled. In detailed descriptions of soils with horizons no more than 30 or 40cm thick, there will be little difference between the two methods in practice.

It is recommended that the topsoil is sampled within the first 20cm from the surface, or shallower if the horizon depth is less. This will facilitate comparison of topsoil characteristics in soil inventories and land evaluation. If the presence of a mollic horizon is assumed, the sampling depth for a soil with a solum of more than 60cm thick may be more than 20cm, but not exceeding 30cm.

Depth criteria of diagnostic horizons and properties should be taken into account when determining the depth of sampling. To indicate the occurrence of an argic (or argillic) horizon, which is defined as having a specified clay increase over a vertical distance of 15 or 30 cm, the samples are preferably taken at that depth interval (for example, A 0-20cm, B 20-30cm or 30-50cm). Another example is for the classification of Nitisols; a sample should be taken at a depth of 140-160cm, in addition to the one taken from that part of the B horizon where the clay content is assumed to be the highest.

CHAPTER 3. LINKAGE TO COMPUTERIZED INFORMATION SYSTEMS

The large amount of soil data generated by soil surveys are seldom exploited beyond their traditional function, which is to characterize individual soil or mapping units. The potential to generate all kinds of useful information for a variety of users is often hampered by the data handling limitations of manual methods of data analysis, as well as the labour involved in condensation of voluminous data recorded, in written documents.

Computerized data storage and processing facilities, that are now available, offer an entirely new perspective in the handling of huge amounts of data. Full use should be made of these information processing techniques in soil surveys and related activities if soil data is to retain its interpretative value for land evaluation and land use planning.

It is recommended that the computerized soil database package (SDB) developed by FAO in collaboration with ISRIC (FAO-ISRIC, 1989), should be used in conjunction with these Guidelines. This is a user-friendly tool for the organization, storage and retrieval of soil data on a micro-computer. Site and soil characteristics are coded on a specially designed data sheet. The coding can be performed directly in the field by the surveyor, which is the recommended way of working.

The SDB is a menu-driven system with on-screen instructions and help screens. Data screens facilitate the easy input and updating of data. The system has extensive retrieval possibilities by which soil and site data can be retrieved according to one or two characteristics. Communication with other databases is done through the built-in read/write facility. The coding system is flexible and allows the user to add new variables and codes or modify the existing ones. The databases are protected against operational errors and power failures.

The SDB is a stand-alone program (it does not need a supporting database management system) but the files are 100 percent dBASE III/IV compatible. The write-to-disk options, in combination with the dBASE compatibility, makes the data available to other systems, such as a geographical information system (GIS) and, for interpretation and analysis, an automated land evaluation package or statistical programs.

The following data sets can be stored in the SDB:

- Field descriptions; information on site and profile characteristics. These data are stored in a coded format.

- Standard soil analytical results; chemical analyses, soluble salts.

- Soil physical analytical results; infiltration and water retention data.

This third edition of the Guidelines for Soil Description has been written for the conventional methods of describing soils in the field that are still common in many parts of the world. However it may also serve as the basis for computer-assisted field description, as well as for entry into soil databases such as that briefly described above.

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Land characteristics used in STRESS-evaluations:

Code	Land Characteristics	Unit
ASP1	Aluminium saturation % (0-30cm)	%
ASP2	Aluminium saturation % (30-60cm)	%
ASP3	Aluminium saturation % (> 60cm)	%
AWC	Available Water Capacity	m.m.
Alu	Critical alum. level in profile	cmol(+)/kg
BAS	Exchangeable Bases	cmol(+)/dm
CECpH7	Cation Exchange Capacity - pH7	cmol(+)/dm
ECEC	Effective Cation Exchange Capa	cmol(+)/dm
ECEC/kg	Effective Cation Exchange Capa	cmol(+)/dm
ECe-1	Electrical conductivity(0-25cm)	dS/m
ECe-2	Electrical conductivity(25-50cm)	dS/m
ECe-3	Electrical conductivity(50-100cm)	dS/m
ECe-4	Electrical conductivity(100-150cm)	dS/m
ECe-5	Electrical conductivity (> 150)	dS/m
ESP1	ESP between 0 - 25 cm	%
ESP-2	ESP between 25 - 50 cm	%
ESP-3	ESP between 50 - 100 cm	%
ESP-4	ESP between 100 - 150 cm	%
ESP-5	ESP > 150 cm	%
GROWP	Growing period (days)	days
GWT	Depth to groundwater table	cm
LPG	Length of Growing Period	months
Slo	dominant slope	%
clay%	Clay percentage	%
consd	consitence dry	
consw	consistence wet	
drai	soil drainage class	
ecs	evidence of capping/sealing	
flf	flooding frequency	
grav	gravel content/stoniness of pr	%
inf	basic infiltration rate (cm/h)	cm/h
orgC%	organic carbon percentage	%
r/ET0	r/ET0 - ratio	r/ET0
roo	rootable (effective) soil dept	cm
sa	soil acidity	pH
sb	soil basicity	pH
silt%	silt percentage	%
sst	surface stoniness	%
struct	topsoil structure type	
strucz	topsoil structure element size	