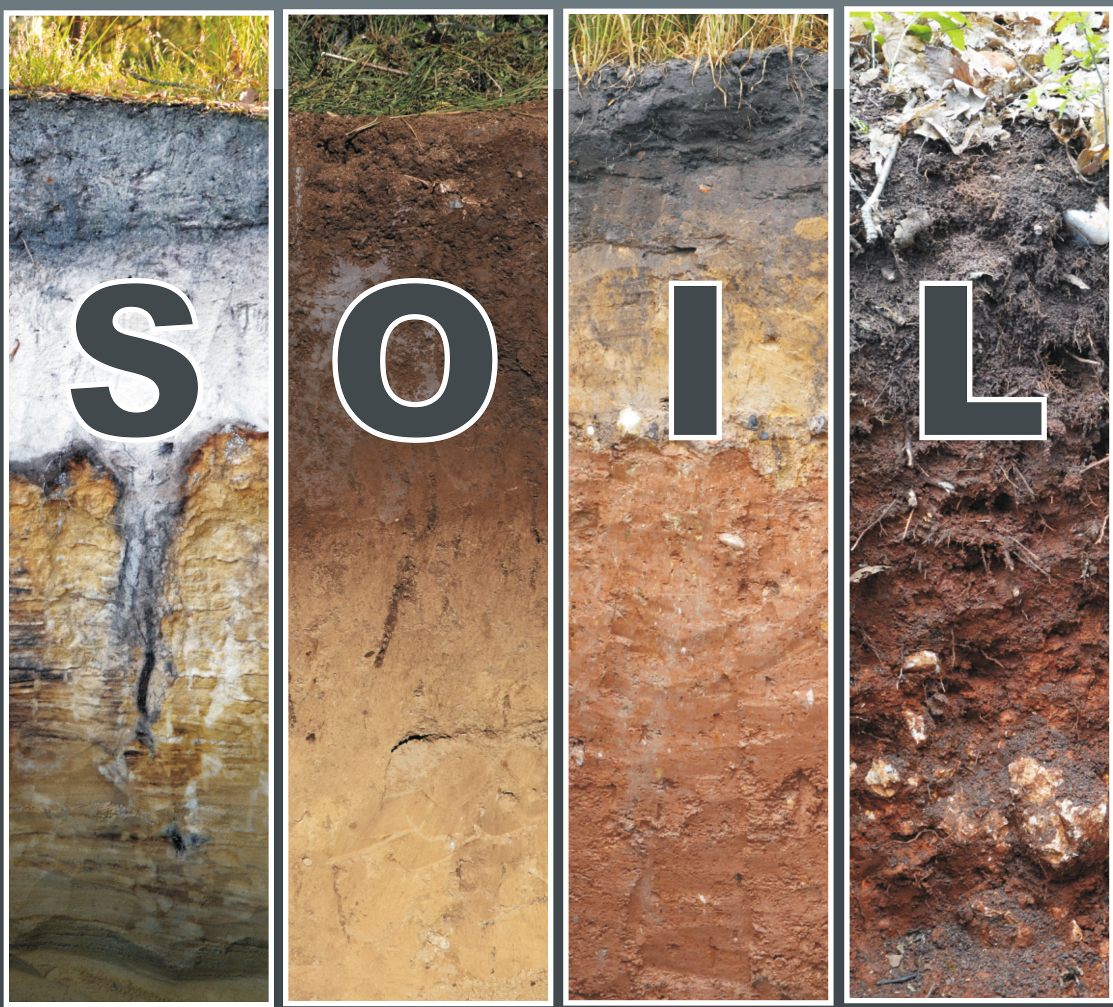

GUIDELINES FOR SOIL DESCRIPTION AND CLASSIFICATION

CENTRAL AND EASTERN EUROPEAN STUDENTS' VERSION

P.T.G

Guidelines for
Soil Description and Classification
Central and Eastern European
Students' Version

Editors:
Marcin Świtoniak, Cezary Kabała,
Aldis Karklins, Przemysław Charzyński

Toruń, 2018

based on

FAO Guidelines for soil description (FAO, Rome, 2006)

and

WORLD REFERENCE BASE FOR SOIL RESOURCES 2014

International soil classification system for naming soils and creating legends for soil maps
Update 2015

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Contents

List of acronyms and abbreviations

Al_{dith}	Aluminium extracted by a dithionite-citrate bicarbonate solution
Al_{ox}	Aluminium extracted by an acid ammonium oxalate solution
Al_{py}	Aluminium extracted by a pyrophosphate solution
$CaCO_3$	Calcium carbonate
CEC	Cation exchange capacity
COLE	Coefficient of linear extensibility
EC	Electrical conductivity
EC_{se}	Electrical conductivity of saturation extract
ESP	Exchangeable sodium percentage
FAO	Food and Agriculture Organization of the United Nations
Fe_{dith}	Iron extracted by a dithionite-citrate-bicarbonate solution
Fe_{ox}	Iron extracted by an acid ammonium oxalate solution
Fe_{py}	Iron extracted by a pyrophosphate solution
GPS	Global Positioning System
HCl	Hydrochloric acid
HDPE	High-density polyethylene
HTM	Human-transported material
ISO	International Organization for Standardization
ISRIC	International Soil Reference and Information Centre
IUSS	International Union of Soil Sciences
KCl	Potassium chloride
KOH	Potassium hydroxide
Mn_{dith}	Manganese extracted by a dithionite-citrate-bicarbonate solution
M/V	Mass in volume
NaOH	Sodium hydroxide
NH_4OAc	Ammonium acetate
ODOE	Optical density of the oxalate extract
PVC	Polyvinyl chloride
RSG	Reference Soil Group
SAR	Sodium adsorption ratio
Si_{ox}	Silicon extracted by an acid ammonium oxalate solution
SiO_2	Silica
SUITMA	Soils in Urban, Industrial, Traffic, Mining and Military Areas

TRB	Total reserve of bases
USDA	United States Department of Agriculture
UTM	Universal Transverse Mercator
WRB	World Reference Base for Soil Resources
UNESCO	United Nations Educational, Scientific, and Cultural Organization
V/V	Volume in volume

Introduction

Soil investigation may be carried out on various levels of knowledge, research capacity and proficiency. Scientists commonly apply advanced methodology for soil resources inventory, including the professional terminology for landscape and soil description, data acquisition and processing, soil classification and mapping, soil and land evaluation. By default, an internationally accepted system should be recommended. An implementation of such methodology is also recommended in more advanced courses of soil science studies on bachelor and master study levels. However, the long-term teaching experience reveals difficulties connected mainly with complicated terminology and excessive number of characteristics obligatory to know, and justifies some simplification of the language, rules and structure at the introductory stage of teaching. This was the base and rationale for the preparation of simplified **Guidelines for Soil Description and Classification: Central and Eastern European Students' Version**.

This book is divided into three parts. The first one – **Site and soil description** - follows the layout and content of professional edition of Guidelines for Soil Description, 4th ed., published by FAO (2006), simplified for educational purposes. The order of description has been modified to correspond to the layout of an original **Soil description sheet**. The second part - **Soil classification** - is a simplified WRB classification (based on a 2014/2015 edition) limited to reference soil groups known from Central Europe. The third part is an **Illustrated explanatory guide** that includes: i) examples of typical soil profiles for all Central European Reference Soil Groups; ii) morphological features important for soil description and identification in the field; iii) soil-landscape relationships. The photos have been enriched with graphical tips helpful at the recognizing of important soil features.

The textbook was developed in the framework of EU Erasmus+ FACES project (Freely Accessible Central European Soil) aiming to facilitate the knowledge and implementation of an international rules of soil characterization adopted by the FAO. It will be used to unify the presentation of soil data collected in the partner countries. The interpretation of soil data fully based on the international soil classification WRB (World Reference Base for Soil Resources 2015) as WRB was endorsed by the International Union of Soil Sciences (IUSS) and accepted by the European Commission as an official system for the

European Union. Therefore, this guideline might be a starting point for preparation of basic teaching materials to spread the knowledge on an internationally recommended rules and terminology for soil description and classification. However, this guideline is designed as teaching tool for students in Central and Eastern European countries and therefore it may not be applicable worldwide. Moreover, it is suited for the "first step" training, and it is not substituting any professional original classification.

Authors of this guidebook assume that the users are familiar with the basic knowledge in soil science. Therefore, the guidelines do not contain explanations related to basic soil forming factors, soil forming processes and basic physico-chemical features.

1. Site and soil description

1.1. General site information, registration and location

Before any actual soil description should be done, it is necessary to take note of some relevant information related to the registration and identification of the soil to be described, such as profile number, description status, and date of description, author, location, elevation. This information is necessary for easy referencing and retrieval of the soil description from data storage systems.

PROFILE NUMBER

The profile number or 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 codes referring to a country accepted by International Organization for Standardization (ISO) code. Example: LV010 = Latvia, profile No. 10 or PL005 = Poland, profile No. 5 etc.

DATE OF DESCRIPTION

The date of soil description given as: yymmdd (six digits). For example, 8 May 2018 would be coded as 180508.

AUTHORS

The persons who perform the description: the surnames and initials of the authors are given.

LOCATION

A description of the soil location should be given as precise as possible. 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.

ELEVATION

The elevation of the site in meters relative to sea level should be obtained as accurately as possible, preferably from detailed contour or topographic maps or GPS devices.

GRID REFERENCE (COORDINATES)

The grid reference number, Universal Transverse Mercator (UTM) or the

established local system, can be read directly from the topographic map or a GPS unit. The latitude and longitude of the site are given as accurately as possible (in degrees, minutes, seconds and decimal seconds). Example: 56° 23' 30.84" N; 24° 52' 40.16" E.

1.2. Soil formation factors and site characteristics

This chapter provides the guidelines for the description of factors that define the kind and intensity of soil formation processes. These factors are also part of the important site qualities. The information may be derived from a combination of field measurements and observations, climate records, topographical, geological and geomorphological maps and documents. For land use and vegetation, the present conditions are reported.

1.2.1. CLIMATE CONDITIONS

The minimum climate data: the monthly mean temperature and the monthly mean precipitation (in millimeters) can be taken from the nearest meteorological station. Where available, the length of the growing period (days with average temperature > 5°C) should be specified.

1.2.2. LANDFORM AND TOPOGRAPHY (RELIEF)

Landform refers to any physical feature on the earth's surface that has been formed by natural and/or human-induced processes and has a distinct shape. Topography refers to the configuration of the land surface described in four categories:

1) the major landform, which refers to the morphology of the whole landscape;
2) the position of the site within the landscape;
3) the slope form;
4) the slope gradient and orientation.

1.2.2.1. Major landform

Landforms are described foremost by their morphology and not by their genetic origin or processes responsible for their shape. The dominant slope is the most important differentiating criterion, followed by the relief intensity (Table 1). The relief intensity is the median difference between the highest and lowest point within the terrain per specified distance and is normally given in meters per kilometer.

Table 1. Hierarchy of major landforms

1st level	2nd level	Gradient, [%]	Relief intensity [$m \cdot km^{-1}$]
L level land	**LP** plain	< 10	< 50
	LL plateau	< 10	< 50
	LD depression	< 10	< 50
	LV valley floor	< 10	< 50
S sloping land	**SE** medium-gradient escarpment zone	10–30	50–100
	SH medium-gradient hill	10–30	100–150
	SM medium-gradient mountain	15–30	150–300
	SP dissected plain	10–30	50–100
	SV medium-gradient valley	10–30	100–150
T steep land	**TE** high-gradient escarpment zone	> 30	150–300
	TH high-gradient hill	> 30	150–300
	TM high-gradient mountain	> 30	> 300
	TV high-gradient valley	> 30	> 150

With complex landforms, the protruding landform should be at least 25 m high (if not it is to be considered mesorelief) except for terraced land, where the main terraces should have elevation differences of at least 10 m. In areas, the major terraces may be very close to each other – particularly towards the lower part of the plain. Finally, the older levels may become buried by down wash.

1.2.2.2. Position

The relative position of the site within the land should be indicated. The position affects the hydrological conditions of the site (e.g. external and internal drainage).

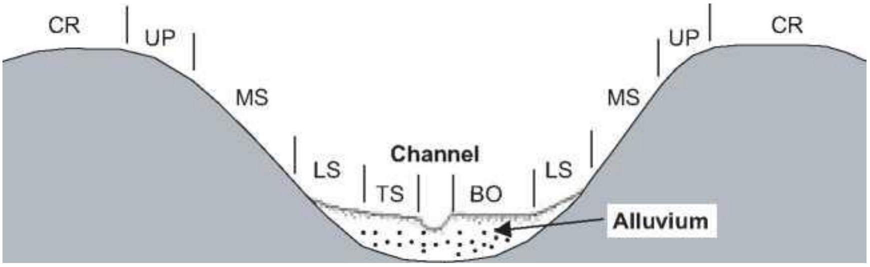


Fig. 1. Slope positions in undulating and mountainous terrain

Position in undulating to mountainous terrain	
CR	Crest (summit)
UP	Upper slope (shoulder)
MS	Middle slope (back slope)
LS	Lower slope (foot slope)
TS	Toe slope
BO	Bottom (flat)

Position in flat or almost flat terrain	
HI	Higher part (rise)
IN	Intermediate part (talf)
LO	Lower part (and dip)
BO	Bottom (drainage line)

1.2.2.3. Slope form

The slope form refers to the general shape of the slope in both the vertical and horizontal directions (Figure 2).

Classification of slope forms	
S	straight
C	concave
V	convex
T	terraced
X	complex (irregular)

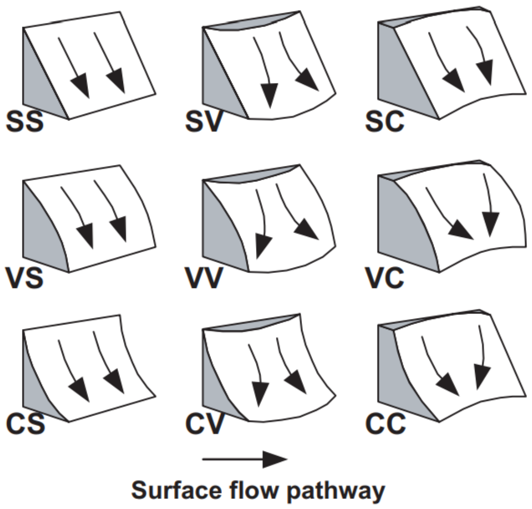


Fig. 2. Slope forms and surface pathways
Source: Redrawn from Schoeneberger et al., 2002.

1.2.2.4. Slope gradient and orientation

The slope gradient refers to the slope of the land immediately surrounding the site. It is measured using a clinometer aimed in the direction of the steepest slope. In addition to the attributes of slope, both the slope length (particularly above the site) and aspect (orientation) should be recorded.

Slope gradient or inclination classes, %		
01	Flat	0 – 0.2
02	Level	0.2 – 0.5
03	Nearly level	0.5 – 1.0
04	Very gently sloping	1.0 – 2.0
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

The orientation (exposition) that a slope is facing is coded **N** for north, **E** for east, **S** for south and **W** for west; for example, **SSW** means south-southwest (Figure 3).

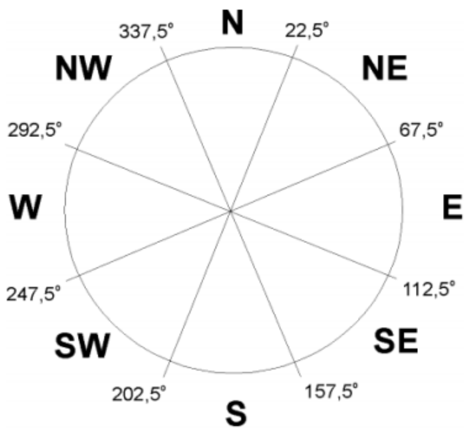


Fig. 3. Slope orientation (exposition)

Microtopography

Small, relative differences in elevation (cm) between adjacent areas on the earth's surface at the place of profile excavation.

Microtopography (microrelief) classes		
LE	Level – surface almost flat	0 cm
HL	Low hummocks	< 20 cm
HM	Medium hummocks	20 – 40 cm
HH	High hummocks	> 40 cm
DE	Depression	
SS	Shifting sands	
RI	Ripples	
TS	Terraced slope	

1.2.3. LAND USE AND VEGETATION

Land use applies to the current use of the land, whether agricultural or nonagricultural, in which the soil is located. For arable land use, the dominant crops 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.

Land use classification			
A	Agriculture		
		AA	Arable farming – crop rotations
		AG	Permanent grasslands, pastures
		AP	Orchards, plantations
		AO	Others (must be specified)
F	Forestry		
		FN	Natural forest and woodland
		FR	Plantation forestry
		FN	Forest nursery
P	Nature protection		
S	Settlement, industry		
		SR	Residential use
		SI	Industrial use
		ST	Transport
		SC	Recreational use
		SX	Excavations
		SD	Disposal sites
Y	Military area		
O	Other land uses (must be specified)		
U	Not used and not managed		

Crops grown			
CE	Cereals	VE	Vegetables
OI	Oil crops	PU	Pulses
RO	Roots and tubers	FO	Fodder plants
FI	Fibre crops	FR	Fruits
OT	Other crops (must be specified)		

Forest and natural vegetation. Description of the natural, semi-natural vegetation or plantation forests. The kind of vegetation can be described using a local, regional or international system. In addition, other characteristics of the vegetation, such as height of trees or canopy cover, may be recorded.

Forest and natural vegetation classes		
F	Closed forest. Continuous tree layer, crowns overlapping, large number of tree and shrub species in distinct layers.	
	FC	Coniferous forest
	FS	Semi-deciduous forest
	FD	Deciduous forest
W	Woodland. Continuous tree layer, crowns usually not touching, understorey may be present.	
	WE	Evergreen woodland
	WS	Semi-deciduous woodland
	WD	Deciduous woodland
S	Shrub	
	SS	Semi-deciduous shrub
	SD	Deciduous shrub
D	Dwarf shrub	
H	Herbaceous – natural grasslands	
M	Rainwater-fed moor peat	
B	Groundwater-fed bog peat	
O	Other vegetation (must be specified)	

Human influence. This item refers to any evidence of human activity that is likely to have affected the landscape or the physical and chemical properties of the soil. Registration is descriptive.

1.2.4. PARENT MATERIAL

The parent material is the material from which the soil has presumably been derived. There are basically two groups of parent material on which the soil has formed: unconsolidated materials (mostly sediments) – **UN**; and weathering materials – **WE** overlying

the hard rock from which they originate. Type of parent material is recorded descriptive, e.g., **UN** – sedimentary, glacial till.

1.2.5. SURFACE CHARACTERISTICS

Rock outcrops and coarse surface fragments. Should be described in terms of percentage surface cover and size. Additional relevant information on the spacing and hardness of the individual outcrops and/or coarse surface fragments is optional.

Surface cover of rock outcrops and coarse fragments, %		
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 classes, indicating the greatest dimension of surface coarse fragments.

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

Erosion. Emphasis should be given to accelerated or human-induced erosion. Erosion can be classified as water or wind erosion, and include off-site effects such as deposition; a third major category is mass movements (landslides and related phenomena).

Classification of erosion, by category

N	No evidence of erosion	
W	Water erosion or deposition	
	WS	Sheet erosion
	WR	Rill erosion
	WG	Gully erosion
	WT	Tunnel erosion
	WD	Deposition by water
WA	Water and wind erosion	
M	Mass movement (landslides and similar phenomena)	
A	Wind (aeolian) erosion or deposition	
	AD	Wind deposition
	AM	Wind erosion and deposition
	AS	Shifting sands
	AZ	Salt deposition
NK	Not known	

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

Activity of erosion classes

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.

Surface sealing. Surface sealing is used to describe crusts that develop at the soil surface after the topsoil dries out as well as soil coverage by artificial materials, e.g., asphalt, concrete etc. Thickness and

consistency of crust should be described.

Sealing classes		
Thickness, mm		
N	None	
F	Thin	< 2
M	Medium	2 – 5
C	Thick	5 – 20
V	Very thick	> 20
Consistence		
S	Slightly hard	
H	Hard	
V	Very hard	
E	Extremely hard	

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 and average distance between cracks is indicated.

Surface cracks classes		
Width, cm		
F	Fine	< 1
M	Medium	1 – 2
W	Wide	2 – 5
V	Very wide	5 – 10
E	Extremely wide	> 10
Distance between cracks, m		
C	Very closely spaced	< 0.2
D	Closely spaced	0.2 – 0.5
M	Moderately widely spaced	0.5 – 2
W	Widely spaced	2 – 5
V	Very widely spaced	> 5
Depth, cm		
S	Surface	< 2
M	Medium	2 – 10
D	Deep	10 – 20
V	Very deep	> 20

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

1.2.6. MOISTURE CONDITIONS

This section deals with the present drainage conditions in the soil, water movement through and over the soil, possible flooding, groundwater depth, and the moisture conditions at the time of profile description. Registration is descriptive.

Water saturation (stagnation). The period during which the soil feasibly near surface is saturated by groundwater or a perched water table, e.g., ponding.

Flooding. Temporary inundation probability assuming estimated frequency, duration and depth.

Artificial drainage, irrigation. Man-made water management installations, their possible efficiency.

Groundwater. The depth to the groundwater, if present, as well as estimate of the approximate annual fluctuation.

1.3. Soil description

1.3.1. SOIL HORIZON DESIGNATION

Master horizons and layers

H horizon or layer. 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 drained artificially.

O horizon or layer. Dominated by organic material consisting of undecomposed or partially decomposed litter, such as leaves, needles, twigs, moss and lichens, that has accumulated on the surface and are not saturated with water for prolonged periods. A horizon formed by illuviation of organic material into a mineral subsoil is not an O horizon.

A horizon. Mineral horizon that 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;
- a morphology that is different from the underlying B or C horizon, resulting from processes related to the surface.

E horizon. Mineral horizon in which the main feature is loss of silicate clay, iron, aluminium, 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.

B horizon. Horizons that formed below an A, E, H or O 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, aluminium, 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;
- brittleness.

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 horizon or layer. 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. The C horizon may have been modified even where 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 geological 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 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 layer. Hard bedrock underlying the soil. The R layer is sufficiently coherent when moist to make hand digging with a spade impractical, although it may be chipped or scraped. 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.

L layer. Sediments deposited in a body of water (subaqueous) composed of both organic and inorganic materials, also known as limnic material. The L symbol is not used in transitional horizon designations.

W layer. Water layers in soils or water submerging soils, either permanently or cyclic within the time frame of 24 hours. Some organic soils float on water. In such cases, the W symbol may be used at the end of the soil description to indicate the floating character. In other cases, shallow water (i.e. water not deeper than 1 m) may cover the soil permanently, as in the case of shallow lakes, or cyclic, as in tidal flats. The symbol W is then used to indicate the depth of submergence at the start of the horizon or layer sequence. The occurrence of tidal water can be indicated by (W).

Transitional horizons

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.

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 (/), such as E/B, B/E, B/C and C/R. Commonly, most of the individual parts of one of the components are surrounded by the other. The I, L and W symbols are not used in transitional horizon designations.

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.

a Highly decomposed organic material: Used with **H** and **O** horizons only, to indicate the state of decomposition of the organic material. Highly decomposed organic material has less than one-sixth (by volume) visible plant remains.

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 have formed in the overlying materials, 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, in cryoturbated soils, or with **C** horizons.

c Concretions or nodules: In mineral soil, it indicates a significant accumulation of concretions or nodules. The nature and consistence of the nodules is specified by other suffixes and in the horizon description. Coprogenous earth: With limnic material **L** it denotes coprogenous earth, i.e. organic materials deposited under water and dominated by faecal material from aquatic animals.

d Dense layer: Used in mineral soils to indicate a layer of relatively unaltered, mostly earthy material that is non-cemented, but that has such bulk density or internal organization that roots cannot enter except in cracks; the symbol is not used in combination with the symbols m (cementation) and **x** (fragipan). Diatomaceous earth: In combination with limnic material **L**, it is used to indicate diatomaceous earth, i.e. materials deposited under water and dominated by the siliceous remains of diatoms.

e Moderately decomposed organic materials: Used with **H** and **O** horizons only, to indicate the state of decomposition of the

organic material. Moderately decomposed organic material has between one-sixth and two-thirds (by volume) visible plant remains.

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 or for bedrock layers (**R**). If needed, "dry frozen soil" layers may be labelled (**f**).

g Stagnic conditions: Designates horizons in which a distinct pattern of mottling occurs that reflects alternating conditions of oxidation and reduction of sesquioxides, caused by seasonal surface waterlogging. If aggregates are present, the interiors of the aggregates show oxidizing colours and the surface parts reducing colours.

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.

i Slickensides: Denotes in mineral soils the occurrence of slickensides, i.e. oblique shear faces 20 – 60° of horizontal owing to the shrink-swell action of clay; wedge-shaped peds and seasonal surface cracks are commonly present. Slightly decomposed organic material: In organic soils and used in combination with **H** or **O** horizons, it indicates the state of decomposition of the organic material; slightly decomposed organic material has in more than two-thirds (by volume) visible plant remains.

j Jarosite: Indicates the presence of jarosite mottles, coatings or hypodermic coatings.

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

l Capillary fringe mottling: Indicates mottling caused by ascending groundwater. If aggregates are present, the interiors of the aggregates show reducing colours and the surface parts oxidizing colours.

m Strong cementation or induration: Indicates in mineral soils continuous or nearly continuous cementation, and is used only for horizons that are more than 90% cemented, although 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 single 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**; and by salts more soluble than gypsum, **zm**.

m Marl: In combination with limnic material it is used to indicate marl, i.e. materials deposited under water and dominated by a mixture of clay and calcium carbonate; typically grey in colour.

n Sodium: Indicates pedogenetic accumulation of exchangeable sodium.

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

p Ploughing or other human disturbance: Indicates disturbance of the surface layer by ploughing or other tillage practices. 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 pedogenetic 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 presence of iron in 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 about 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.

u Urban and other human-made materials: Used to indicate the dominant presence of human-made materials, including technogenic ones. The symbol can be used in combination with **H, O, A, E, B** and **C**.

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. In that case, **v** is used in combination with **m**.

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

x Fragipan characteristics: 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 Gypsum: Indicates an pedogenetic accumulation of gypsum.

z Indicates pedogenetic accumulation of salts more soluble than gypsum.

@ Evidence of cryoturbation: irregular or broken boundaries, sorted rock fragments (patterned ground), or organic matter in the lower boundary between the active layer and permafrost layer. The suffix is always used last, e.g. **Hi@**.

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 follow the capital letter immediately.
- When more than one suffix is needed, the following letters, if used, are written first: **r**, **s**, **t**, **u** and **w**. The symbol **t** has precedence over all other symbols, e.g. **Btr, Btu**. In all other combinations, the symbols are listed alphabetically, e.g. **Cru**.
- If more than one suffix is needed and the horizon is not buried, these symbols, if used, are written last: **c**, **f**, **g**, **m**, **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 symbols, e.g. **Bto**.
- Suffixes **h**, **s** and **w** are normally not used with **g**, **k**, **n**, **q**, **y**, z or **o** unless needed for explanatory purposes.
- Suffixes **a** and **e** are used only in combination with **H** or **O**.
- Suffixes **c**, **d**, **i** and **m** each have two different meanings, depending on the master horizon designation they are coupled to. The different combinations are mutually exclusive, e.g. **Bi** indicates presence of slickensides in the **B** horizon, whereas **Hi** indicates a slightly decomposed **H** horizon. Similarly, **Bd** indicates a dense **B** horizon, and **Ld** diatomaceous earth in a limnic layer.
- Suffix @ is always used last, and cannot be combined with **b**.
- Unless otherwise indicated, suffixes are listed alphabetically.

Table 2. Subordinate characteristics used with master horizons

Suffix	Short description	Used for
a	Highly decomposed organic material	H and O horizons
b	Buried genetic horizon	mineral horizons, not cryoturbated
c	Concretions or nodules	mineral horizons
c	Coprogenous earth	L horizon
d	Dense layer (physically root restrictive)	mineral horizons, not with m
d	Diatomaceous earth	L horizon
e	Moderately decomposed organic material	H and O horizons
f	Frozen soil	not in I and R horizons
g	Stagnic conditions	no restriction
h	Accumulation of organic matter	mineral horizons
i	Slickensides	mineral horizons
i	Slightly decomposed organic material	H and O horizons
j	Jarosite accumulation	no restriction
k	Accumulation of pedogenetic carbonates	no restriction
l	Capillary fringe mottling (gleying)	no restriction
m	Strong cementation or induration (pedogenetic, massive)	mineral horizons
m	Marl	L horizon
n	Pedogenetic accumulation of exchangeable sodium	no restriction
o	Residual accumulation of sesquioxides (pedogenetic)	no restriction
p	Ploughing or other human disturbance	no restriction, E, B or C as Ap
q	Accumulation of pedogenetic silica	no restriction
r	Strong reduction	no restriction
s	Illuvial accumulation of sesquioxides	B horizons
t	Illuvial accumulation of silicate clay	B and C horizons
u	Urban and other human-made materials	H, O, A, E, B and C horizons
v	Occurrence of plinthite	no restriction
w	Development of colour or structure	B horizons
x	Fragipan characteristics	no restriction
y	Pedogenetic accumulation of gypsum	no restriction
z	Pedogenetic accumulation of salts more soluble than gypsum	no restriction
@	Evidence of cryoturbation	no restriction

Vertical subdivisions

Horizons or layers designated by a single combination of letter symbols can be subdivided using Arabic numerals, which follow all the master

horizon designation. For example, within a C, 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 symbol 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, e.g. Ap, A1, A2 or Ap1, Ap2 or A1, A2, A3 or E1, E2, Eg1, Eg2.

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. They are not used with I and W, because these symbols clearly indicate a discontinuity. These prefixes are different 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 where 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 applies 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 not the same deposit as horizons in the overlying deposit. However, some buried horizons formed in material lithological 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 lithological 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.

1.3.2. HORIZON BOUNDARY

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

Depth. The depth of the upper and lower boundaries of each horizon is given in centimeters, measured from the surface (including organic and mineral covers) of the soil downwards.

The distinctness of the boundary refers to the thickness of the zone in which the horizon boundary can be located without being in one of the adjacent horizons. **The topography** of the boundary indicates the smoothness of depth variation of the boundary.

Boundaries classes		
Distinctness, cm		
A	Abrupt	0 – 2
C	Clear	2 – 5
G	Gradual	5 – 15
D	Diffuse	> 15
Topography		
S	Smooth	Nearly plane surface
W	Wavy	Pockets less deep than wide
I	Irregular	Pockets more deep than wide
B	Broken	Discontinuous

1.3.3. SOIL TEXTURE AND COARSE FRAGMENTS

Soil texture refers to the proportion of the **various particle-size classes** (or soil separates, or fractions) in a given soil volume and is described as **soil textural class** (Figure 4). Classifications are typically named for the primary constituent particle size or a combination of the most abundant particles sizes, e.g. "sandy clay" or "silty clay". A fourth term, loam, is used to describe a roughly equal concentration of sand, silt, and clay, and lends to the naming of even more classifications, e.g. "clay loam" or "silt loam".

Fine earth (< 2 cm) particle size classes / fractions, mm

Clay	< 0.002
Fine silt	0.002 – 0.020
Coarse silt	0.02 –0.063
Very fine sand	0.063 – 0.125
Fine sand	0.125 – 0.200
Medium sand	0.20 – 0.63
Coarse sand	0.63 – 1.25
Very coarse sand	1.25 – 2.00

Soil textural classes

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

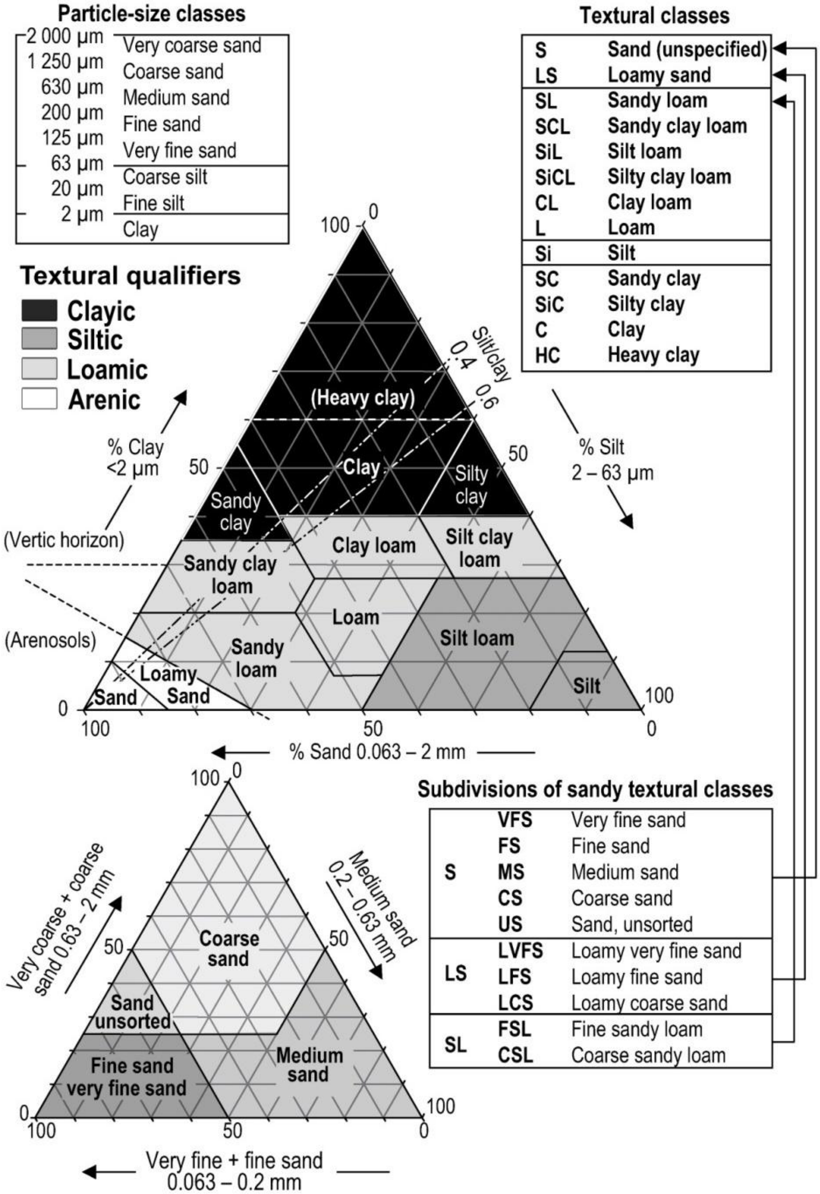


Fig. 4. Relation of constituents of fine earth by size, defining textural classes and subclasses

Subdivision of the sand fraction

Sands, loamy sands and sandy loams are subdivided according to the proportions of sand fractions. The proportions are calculated from the particle-size distribution, taking the total of the sand fraction as being 100% (Figure 4).

Field estimation of textural classes

The textural class can be estimated in the field by simple field tests and feeling the constituents of the soil (Table 3). For this, the soil sample must be in a moist to weak wet state. Gravel and other constituents > 2 mm must be removed.

The constituents have the following feel:

- Clay: soils fingers, is cohesive (sticky), is formable, has a high plasticity and has a shiny surface after squeezing between fingers.
- Silt: soils fingers, is non-sticky, only weakly formable, has a rough and ripped surface after squeezing between fingers and feels very floury (like talcum powder).
- Sand: cannot be formed, does not soil fingers and feels very grainy.

Table 3. Key to the field test of soil textural classes

Nr	Actions, observations	Textural class		Clay, %
1	**Not possible to roll a wire of about 7 mm in diameter (about the diameter of a pencil)**			
1.1	not dirty, not floury, no fine material in the finger rills:	sand	S	< 5
	if grain sizes are mixed:	unsorted sand	US	< 5
	if most grains are very coarse (> 0.6 mm):	very coarse and coarse sand	CS	< 5
	if most grains are of medium size (0.2–0.6 mm):	medium sand	MS	< 5
	if most grains are of fine size (< 0.2 mm) but still grainy:	fine sand	FS	< 5
	if most grains are of very fine size (< 0.12 mm), tending to be floury:	very fine sand	VFS	< 5

Nr	Actions, observations	Textural class		Clay, %
1.2	not floury, grainy, scarcely fine material in the finger rills, weakly shapeable, adheres slightly to the fingers:	loamy sand	LS	< 12
1.3	similar to 1.2 but moderately floury:	sandy loam (clay-poor)	SL	< 10
2	**Possible to roll a wire of about 3–7 mm in diameter (about half the diameter of a pencil) but breaks when trying to form the wire to a ring of about 2–3 cm in diameter, moderately cohesive, adheres to the fingers**			
2.1	very floury and not cohesive:			
	some grains to feel:	silt loam (clay-poor)	SiL	< 10
	no grains to feel:	silt	Si	< 12
2.2	moderately cohesive, adheres to the fingers, has a rough and ripped surface after squeezing between fingers and			
	very grainy and not sticky:	sandy loam (clay-rich)	SL	10–25
	moderate sand grains:	loam	L	8–27
	not grainy but distinctly floury and somewhat sticky:	silt loam (clay-rich)	SiL	10–27
2.3	rough and moderate shiny surface after squeezing between fingers and is sticky and grainy to very grainy:	sandy clay loam	SCL	20–35
3	**Possible to roll a wire of about 3 mm in diameter (less than half the diameter of a pencil) and to form the wire to a ring of about 2–3 cm in diameter, cohesive, sticky, gnashes between teeth, has a moderately shiny to shiny surface after squeezing between fingers**			
3.1	very grainy:	sandy clay	SC	35–55
3.2	some grains to see and to feel, gnashes between teeth:			
	moderate plasticity, moderately shiny surfaces:	clay loam	CL	25–40
	high plasticity, shiny surfaces:	clay	C	40–60
3.3	no grains to see and to feel, does not gnash between teeth:			
	low plasticity:	silty clay loam	SiCL	25–40
	high plasticity, moderately shiny surfaces:	silty clay	SiC	40–60
	high plasticity, shiny surfaces:	heavy clay	HC	> 60

Note: Field texture determination may depend on clay mineralogical composition. The above key works mainly for soils having illite, chlorite and/or vermiculite composition. Smectite clays are more plastic, and kaolinitic clays are stickier. Thus, clay content can be overestimated for the former, and underestimated for the latter.

Rock fragments and artefacts

The presence of rock and mineral fragments (> 2 mm) and artefacts are described according to **abundance** (Fig. 5), **size** (Fig. 6), **shape, state of weathering,** and **nature of the fragments**. Where rock fragments are not distributed regularly within a horizon but form a "stone line", this should be indicated clearly.

Abundance of rock fragments and artefacts, 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
S	Stone line – any content, but concentrated at a distinct depth of a horizon.	

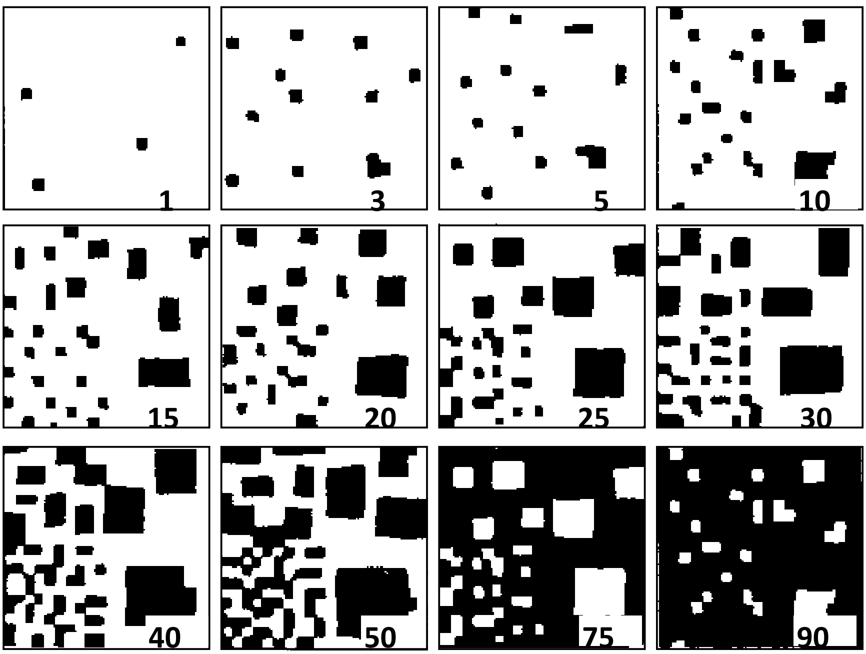


Fig. 5. Charts for estimating proportions of coarse fragments and mottles

Classification of rock fragments and artefacts by size, mm

F	Fine gravel	2 – 6
M	Medium gravel	6 – 20
C	Coarse gravel	20 – 60
S	Stones	60 – 200
B	Boulders	200 – 600
L	Large boulders	> 600
V	Very fine artefacts	< 2
F	Fine artefacts	2 – 6
M	Medium artefacts	6 – 20
C	Coarse artefacts	> 20

Combination of classes

FM	Fine and medium gravel/artefacts
MC	Medium and coarse gravel/artefacts
CS	Coarse gravel and stones
SB	Stones and boulders
BL	Boulders and large boulders

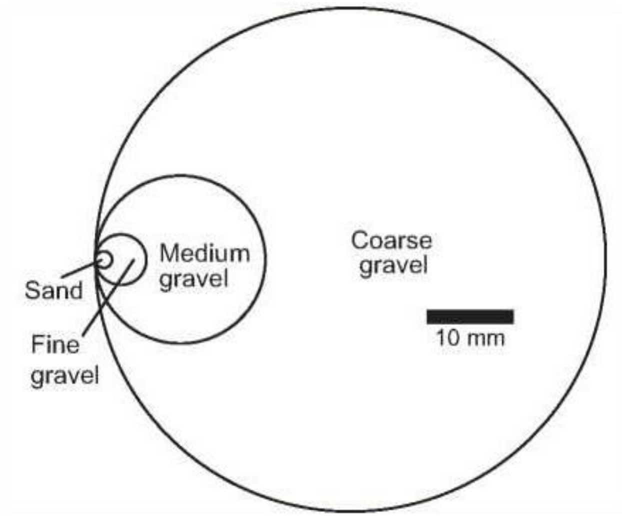


Fig. 6. Chart for estimating coarse fragments size

Shape of rock fragments	
F	Flat
A	Angular
S	Subrounded
R	Rounded

Weathering of coarse fragments	
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.

Examples of codes for nature of the fragments desription	
QU	Quartz
MI	Mica
FE	Feldspar

1.3.4. ORGANIC LAYERS CHARACTERISTICS

Degree of decomposition and humification of peat

In most organic layers, the determination of the texture class is not possible. More valuable is an estimate of the **degree of decomposition and humification of the organic material**. Colour and percentage of recognizable plant tissue of dry as well as of wet organic material can be used to estimate the degree of decomposition (Table 4).

Table 4. Field estimation and coding of the degree of decomposition and humification of peat

<table>
<tr><th rowspan="2">Type</th><th rowspan="2">Co-de</th><th rowspan="2">Degree of decompo-sition/ humifi-cation</th><th colspan="2">Attributes of dry peat</th><th colspan="3">Attributes of wet peat</th></tr>
<tr><th>Colour</th><th>visible plant tis-sues</th><th colspan="2">goes between the fingers by squeezing in the hand</th><th>remnant</th></tr>
<tr><td rowspan="3">Fibric</td><td>**D1**</td><td>Very low</td><td>White to light brown</td><td>Only</td><td>± clear</td><td rowspan="2">Wa-ter</td><td rowspan="2">Not muddy</td></tr>
<tr><td>**D2**</td><td>Low</td><td>Dark brown</td><td>Most</td><td>Brown to muddy</td></tr>
<tr><td>**D3**</td><td>Moderate</td><td rowspan="4">Dark brown to black</td><td>> $^{2}/_{3}$</td><td>Muddy</td><td rowspan="4">Mud</td><td>Muddy</td></tr>
<tr><td rowspan="2">Hemic</td><td>**D4**</td><td>Strong</td><td>$^{1}/_{3}$ – $^{2}/_{3}$</td><td>$^{1}/_{2}$ to $^{2}/_{3}$</td><td>Plant structure more visible than before</td></tr>
<tr><td>**D5.1**</td><td>Moderately strong</td><td>$^{1}/_{6}$ – $^{1}/_{3}$</td><td rowspan="2">More or less all</td><td>Only heavy decom-postable remnants</td></tr>
<tr><td>Sapric</td><td>**D5.2**</td><td>Very strong</td><td>< $^{1}/_{6}$</td><td>No remnant</td></tr>
</table>

Aeromorphic organic layers on forest floors

Raw humus (mor): usually thick (5 – 30 cm) organic matter accumulation that is largely unaltered owing to lack of decomposers.

Moder: more decomposed than raw humus but characterized by an organic matter layer on top of the mineral soil with a diffuse boundary between the organic matter layer and A horizon.

Mull: characterized by the periodic absence of organic matter accumulation on the surface owing to the rapid decomposition process and mixing of organic matter and the mineral soil material by bioturbation.

1.3.5. SOIL COLOUR (MATRIX)

The colour of the soil matrix of each horizon should be recorded in the moist condition (or both dry and moist conditions where possible) using the notations for **hue, value** and **chroma** as given in the Munsell Soil Color Charts (Fig. 7). Where there is no dominant soil matrix colour, the horizon is described as mottled and two or more colours are given.

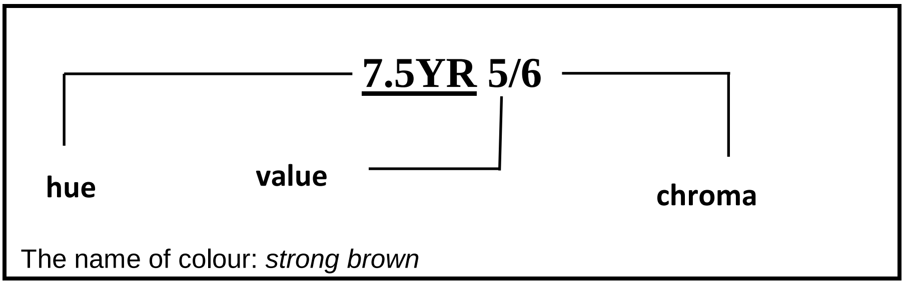


Figure 7. Example how to register soil colour

For routine descriptions, soil colours should be determined out of direct sunlight and by matching a broken ped, 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.

1.3.6. MOTTLING

Mottles are spots or blotches of different colours or shades of colour interspersed with the dominant colour of the soil. They indicate that the soil has been subject to alternate wetting (reducing) and dry (oxidizing) conditions. For soil classification purposes, the most important is to distinguish between two types of mottles caused by water status in soil: oximorphic and reductomorphic. **Abundance** and **colour of these types of mottles** should be described. Supplementary parameters, e.g., size, contrast and boundary as well as other types of mottles are alternatives and are given in descriptive notes.

Abundance of mottles, % of surface area		
N	None	0
V	Very few	0 – 2
F	Few	2 – 5
C	Common	5 – 15
M	Many	15 – 40
A	Abundant	> 40

Colour of mottles – using Munsell Soil Color Charts.

1.3.7. SOIL REDOX POTENTIAL AND REDUCING CONDITIONS

Reducing conditions. Reductimorphic properties of the soil matrix reflect permanently wet or at least reduced conditions. They are expressed by neutral (white to black: Munsell N1 to N) or bluish to greenish colours (Munsell 2.5Y, 5Y, 5G, 5B). The colour pattern will often change by aeration in minutes to days owing to oxidation processes.

Reductimorphic patterns classes	
N	No sign of redox properties
GL	Gleyic colour pattern
ST	Stagnic colour pattern
RO	Oximorphic colours
RD	Reductimorphic colours.

The presence of Fe^{2+} ions can be tested by spraying the freshly exposed soil surface with a 0.2% (M/V) α,α dipyridyl solution in 10% (V/V) acetic acid solution. The test yields a striking reddish-orange colour in the presence of Fe^{2+} ions but may not give the strong red colour in soil materials with a neutral or alkaline soil reaction. Care is necessary as the chemical is slightly toxic.

1.3.8. CARBONATES

The presence of calcium carbonate ($CaCO_3$) is established by adding a few drops of 10% HCl to the soil. The degree of effervescence of carbon dioxide gas is indicative for the amount of calcium carbonate present.

Classification of HCl reaction and rough $CaCO_3$ content in the soil matrix

N	**Non-calcareous.** No detectable visible or audible effervescence, 0%.
SL	**Slightly calcareous.** Audible effervescence but not visible, 0 – 2%.
MO	**Moderately calcareous.** Visible effervescence, 2 – 15%.
ST	**Strongly calcareous.** Strong visible effervescence. Bubbles form a low foam, 15 – 25%.
VS	**Very strongly calcareous.** Very strong visible effervescence. Bubbles form a low to high foam, 25 – 40%.
EX	**Extremely calcareous.** Extremely strong reaction. Thick foam forms quickly, > 40%.

Forms of carbonates. Carbonates in soils are either residues of the **parent material (primary or geological carbonates)** or the result of **neo-formation (secondary carbonates)**. The latter are concentrated mainly in the form of soft powdery lime, coatings on peds, concretions, surface or subsoil crusts, or hard banks.

Primary carbonates:

LS	Limestone fragments
DM	Dolomite fragments
MR	Marl fragments
ML	Lake/meadow marl fragments
LC	Lime clods
O	Others (must be specified)

Secondary carbonates	
SC	Soft concretions
HC	Hard concretions
HHC	Hard hollow concretions
D	Disperse powdery lime
PM	Pseudomycelia[1] (carbonate infillings in pores, resembling mycelia)
HL	Hard cemented layer or layers of carbonates (less than 10 cm thick)

1.3.9. READILY SOLUBLE SALTS

The **salt content** of the soil can be estimated roughly from EC (in dS m^{-1} = mS cm^{-1}), measured in a saturated soil paste or a more diluted suspension of soil in water. Conventionally, EC is measured in the laboratory in the saturation extract (EC_{se}). Most classification values and data about salt sensitivity of crops refer to EC_{se}.

Classification of salt content of soil, ECse = dS m^{-1} (25°C)		
N	Not salty	< 0.75
SL	Slightly salty	0.75 – 2
MO	Moderately salty	2 – 4
ST	Strongly salty	4 – 8
VST	Very strongly salty	8 – 15
EX	Extremely salty > 15	

1.3.10. FIELD SOIL pH

Measured with a portable pH meter in a soil suspension (1 part soil and 2.5 parts 1 *M* KCl or 0.1 *M* $CaCl_2$ solution). pH field measurements might be used for rough estimation of base saturation (taking into consideration organic matter content). Soil base saturation will be lower than 50%, if:

[1] Pseudomycelia carbonates are not regarded as "secondary carbonates" if they migrate seasonally and have no permanent depth.

- pH KCl < 5.1 if OM > 15%;
- pH KCl < 4.6 if OM 4 – 15%;
- pH KCl < 4.2 if OM < 4%.

1.3.11. ORGANIC MATTER CONTENT

The content of organic matter of mineral horizons can be estimated from the Munsell colour of a dry and/or moist soil, taking the textural class into account.

Table 5. Estimation of organic matter content (%) based on Munsell soil colour

Colour	Munsell value	Moist soil			Dry soil		
		S	LS, SL, L	SiL, Si, SiCL, CL, SCL, SC, SiC, C	S	LS, SL, L	SiL, Si, SiCL, CL, SCL, SC, SiC, C
Light grey	7				< 0.3	< 0.5	< 0.6
Light grey	6.5				0.3 – 0.6	0.5 – 0.8	0.6 – 1.2
Grey	6				0.6 – 1	0.8 – 1.2	1.2 – 2
Grey	5.5			< 0.3	1 – 1.5	1.2 – 2	2 – 3
Grey	5	< 0.3	< 0.4	0.3 – 0.6	1.5 – 2	2 – 4	3 – 4
Dark grey	4.5	0.3 – 0.6	0.4 – 0.6	0.6 – 0.9	2 – 3	4 – 6	4 – 6
Dark grey	4	0.6 – 0.9	0.6 – 1	0.9 – 1.5	3 – 5	6 – 9	6 – 9
Black grey	3.5	0.9 – 1.5	1 – 2	1.5 – 3	5 – 8	9 – 15	9 – 15
Black grey	3	1.5 – 3	2 – 4	3 – 5	8 – 12	> 15	> 15
Black	2.5	3 – 6	> 4	> 5	> 12		
Black	2	> 6					

1.3.12. SOIL STRUCTURE

Grade. In describing the grade or development of the structure, the first division is into:

- apedal soils (lacking soil structure); or
- pedal soils (showing soil structure).

Apedal (structureless) soils are subdivided into single grain and massive.

<u>Grades of structure of pedal soil materials</u>

WE	**Weak.** Aggregates 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 aggregates, many broken aggregates, and much material without aggregate faces. Aggregate surfaces differ in some way from the aggregate interior.
MO	**Moderate.** Aggregates 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 complete aggregates, some broken aggregates, and little material without aggregates faces. Aggregates surfaces generally show distinct differences with the aggregates interiors.
ST	**Strong.** Aggregates are clearly observable in place and there is a prominent arrangement of natural surfaces of weakness. When disturbed, the soil material separates mainly into complete aggregates. Aggregate surfaces generally differ markedly from aggregate interiors.

Combined classes may be constructed as follows:

WM Weak to moderate
MS Moderate to strong

Type of soil structure is defined according to main shape of soil aggregates (Fig. 8).

Classification of types of soil structure:

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

Granular. Spheroids or polyhedrons, having curved or irregular surfaces that are not casts of the faces of surrounding aggregates.

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

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

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.

Wedge-shaped. Elliptical, interlocking lenses that terminate in sharp angles, bounded by slickensides; not limited to vertic materials.

Crumbs, lumps and clods. Mainly created by artificial disturbance, e.g. tillage.

Codes for types of soil structure

RS		Rock structure
	SS	Stratified structure
SG		Single grain
MA		Massive
PM		Porous massive
BL		Blocky
	AB	Angular blocky
	AP	Angular blocky (parallelepiped)
	AS	Angular and subangular blocky
	AW	Angular blocky (wedge-shaped)
	SA	Subangular and angular blocky
	SB	Subangular blocky
	SN	Nutty subangular blocky
PR		Prismatic
	PS	Subangular prismatic
WE		Wedge-shaped
CO		Columnar
GR		Granular
WC		Worm casts
PL		Platy
CL		Cloddy
CR		Crumbly
LU		Lumpy

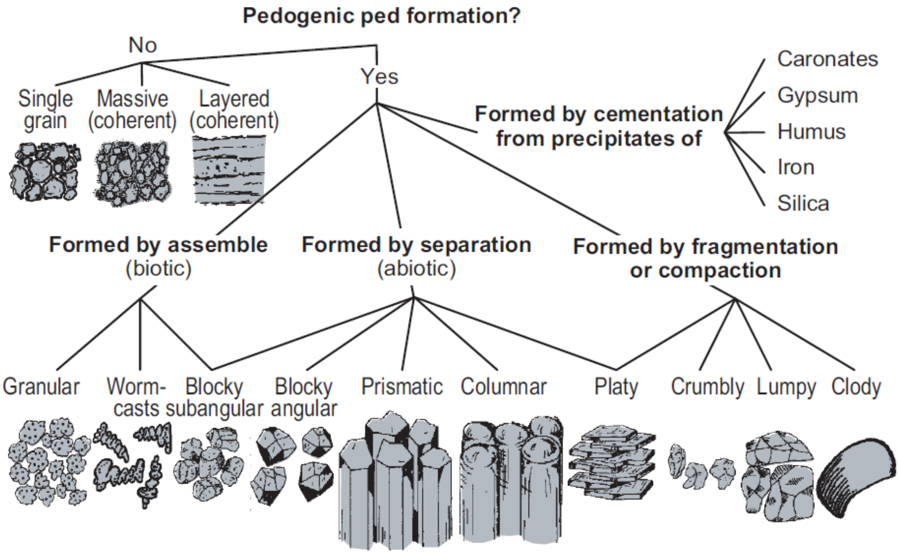


Figure 8. Soil structure types and their formation

Combinations of soil structures types. The primary and secondary structures may both be present (e.g. columnar and prismatic structures). The primary structure may break down into a secondary structure (e.g. prismatic breaking into angular blocky). The first structure may merge into the second structure (e.g. platy merging into prismatic).

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

Size. For prismatic, columnar and platy structures, the size classes refer to the measurements of the smallest dimension of the aggregate (Table 6). Where a second structure is present, its relation to the first structure is described.

Table 6. Size classes for soil structure types, mm

Code	Size class	Granular /platy	Prismatic/ columnar/ wedge-shaped	Blocky/ crumbly/ lumpy/cloddy
VF	Very fine/thin	< 1	< 10	< 5
FI	Fine/thin	1 – 2	10 – 20	5 – 10
ME	Medium	2 – 5	20 – 50	10 – 20
CO	Coarse/thick	5 – 10	50 – 100	20 – 50
VC	Very coarse/thick	> 10	100 – 500	> 50
EC	Extremely coarse	–	> 500	–

<u>Combined size classes for soil structure types</u>

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

1.3.13. CONSISTENCE

Consistence refers to the degree of cohesion or adhesion of the soil mass. It includes soil properties such as friability, plasticity, stickiness and resistance to compression. It depends greatly on the amount and type of clay, organic matterand moisture content of the soil. For reference descriptions, a recording of consistence is required for the **dry** and **moist** (stickiness and plasticity) **states**.

Consistence when dry (by breaking an air-dried soil mass 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.
SSH	**Soft to slightly hard.**
SHH	**Slightly hard to hard.**
HVH	**Hard to very hard.**

Consistence when moist (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; cannot be crushed between thumb and forefinger.
VFF	**Very friable to friable.**
FRF	**Friable to firm.**
FVF	**Firm to very firm.**

SOIL-WATER STATUS

Soil-water status is the term used for the moisture condition of a horizon at the time the profile is described. The moisture status can be estimated in the field as per Table 7.

Table 7. Classification of moisture status of soil

pF (code)	Moisture	Crushing	Forming (to a ball)	Moistening	Rubbing (in the hand)
5	Very dry	Dusty or hard	Not possible, seems to be warm	Going very dark	Not lighter
4	Dry	Makes no dust		Going dark	Hardly lighter
3	Slightly moist	Makes no dust	Possible (not sand)	Going slightly dark	Obvio-usly lighter
2	Moist	Is sticky	Finger moist and cool, weakly shiny	No changes of colour	
1	Wet	Free water	Drops of water	No changes of colour	–
0	Very wet	Free water	Drops of water without crushing	No changes of colour	–

1.3.15. CONCENTRATIONS

This section deals with the most common concentrations of soil materials, including secondary enrichments, cementations and reorientations.

Coatings

Clay or mixed-clay illuviation features, coatings of other composition (such as calcium carbonate, manganese, organic or silt), reorientations (such as slickensides and pressure faces), and concentrations associated with surfaces but occurring as stains in the matrix

("hypodermic coatings"). For coatings, an estimate is made of how much (**abundance**) of the ped or aggregate (also voids, and coarse fragments) faces is covered, in percent of area.

Nature (coatings)	
C	Clay
S	Sesquioxides
H	Humus
CS	Clay and sesquioxides
CH	Clay and humus (organic matter)
CC	Calcium carbonate
GB	Gibbsite
HC	Hypodermic coatings (Hypodermic coatings, as used here, are field-scale features, commonly only expressed as hydromorphic features.
MN	Manganese
SL	Silica (opal)
PF	Pressure faces
SI	Slickensides, predominantly intersecting.
SP	Slickensides, partly intersecting
SN	Slickensides, non intersecting

Abundance (coatings)		
N	None	0
F	Few	0 – 5
C	Common	5 – 40
M	Many	> 40

Location (coatings)	
P	Pedfaces
PV	Vertical pedfaces
PH	Horizontal pedfaces
CF	Coarse fragments
LA	Lamellae (clay bands)
VO	Voids
BR	Bridges between sand grains
NS	No specific location

Cementation and compaction.
Compacted material has a firm or stronger consistence when moist and a close packing of particles. Cemented material does not slake after 1 hour of immersion in water.

Continuity (cementation/compaction)	
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 interrupted in places by cracks or fissures.

Nature (cementation/compaction)	
K	Carbonates
KQ	Carbonates-silica
F	Iron
FM	Iron-manganese (sesquioxides)
FO	Iron-organic matter
C	Clay
CS	Clay-sesquioxides
M	Mechanical
P	Ploughing
NK	Not known

Other (mineral concentrations). Mineral concentrations cover a large variety of secondary crystalline, microcrystalline and amorphous concentrations of nonorganic substances as infillings, soft concretions, irregular concentrations (mottles), nodules of mainly pedogenetically formed materials.

Type (other concentrations)

T	**Crystal.**
C	**Concretion.** A discrete body with a concentric internal structure, generally cemented.
SC	**Soft concretion.**
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.
IP	**Pore infillings.** Including pseudomycelium of carbonates or opal.
IC	**Crack infillings.**
R	**Residual rock fragment.** Discrete impregnated body still showing rock structure.
O	**Other.**

Nature (other concentrations)

K	Carbonates (calcareous)
C	Clay (argillaceous)
CS	Clay-sesquioxides
SA	Salt (saline)
JA	Jarosite
F	Iron (ferruginous)
FM	Iron-manganese (sesquioxides)
M	Manganese (manganiferous)
NK	Not known

Abundance (other concentrations, by volume, %)

N	None	0
F	Few	0 – 5
C	Common	5 – 15
M	Many	15 – 40
A	Abundant	> 40

1.3.16. BIOLOGICAL ACTIVITY (FEATURES)

Abundance of roots. The abundance of roots can only be compared within the same size class (Table 8). The abundance of fine and very fine roots may be recorded expressed in the number of roots per decimetre square (10x10 cm).

Table 8. Classification of the abundance of roots

Code	Class	Root size	
		< 2 mm	> 2 mm
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

Kind of other biological activity

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

1.3.17. HUMAN-MADE MATERIALS

Artefacts – are solid or liquid substances that are: (i) created or modified substantially by humans as part of an industrial or artisanal manufacturing process; or (ii) brought to the surface by human activity from a depth where they were not influenced by surface processes. They have properties substantially different from the environment where they are placed, and they have substantially the same properties as when first manufactured, modified or excavated.

Human-transported material (HTM) – any solid or liquid material moved into the soil from a source area outside of its immediate vicinity by intentional human activity, usually with the aid of machinery, without substantial reworking or displacement by natural forces.

Geomembranes and technic hard rock – synthetic membrane laid on the surface or into the soil or any other substrate. Technic hard rock is consolidated material resulting from an industrial process, with properties substantially different from those of natural materials.

Description of artefacts

Artefacts are described according to their **abundance, kind** and **weathering/transformation stage**. If applicable, other features, e.g., size, hardness, colour etc. are optional.

Abundance. Abundance is described with the same rules as for rock fragments (page 43).

Kind of artefacts is defined by the main type of it.

Kind (artefacts)	
AN	Artesanal natural material
ID	Industrial dust
SL	Slag
CN	Concreate fragments
PS	Pavements and paving stones
BR	Bricks, pottery fragments, tiles
ME	Metal fragments
MM	Mixed material
OG	Organic garbage
SL	Synthetic liquid
SS	Synthetic solid
WL	Waste liquid
CH	Charcoal
O	Other (must be specified)

Weathering/Transformation. State of weathering (transformation) of the material is described with the same rules as for rock fragments (page 45).

1.3.18. FIELD EQUIPMENT CHECKLIST

Digging tools

- Auger
- Standard shovel
- Pickaxe (stone or clay-rich soils)
- Push probe
- Pulaski
- Saw, pruning-shears

Soil description

- Knife
- Hand lens (10× or stronger)
- Acid bottle (1 M HCl)
- Water bottle
- Water spryer
- α,α dipyridyl solution
- Munsell Soil Color Charts
- Picture tape ("pit tape")
- Tape measure
- Horizon markers
- Pocket pH kit
- Camera
- Sample bags
- Soil description sheet
- Stationery (pencils, eraser, permanent marker pens)

Site description

- Field note book and Soil description sheet
- GPS unit
- Clinometer
- Compass (unless combined with GPS)

Field references

- Guidelines for Soil Description

Topographic map, geological map

Aerial photographs, orthophotomaps, etc.

Personal protective gear

Small First Aid kit

Gloves

Sunglasses

Insect repellent

Hat

Drinking water

1.3.19. SOIL DESCRIPTION SHEET

All data should be put into soil description sheet (Fig. 9). Printable version is attached as Annex on the end of quidelines. Proposed codes should be use in particular cells of table.

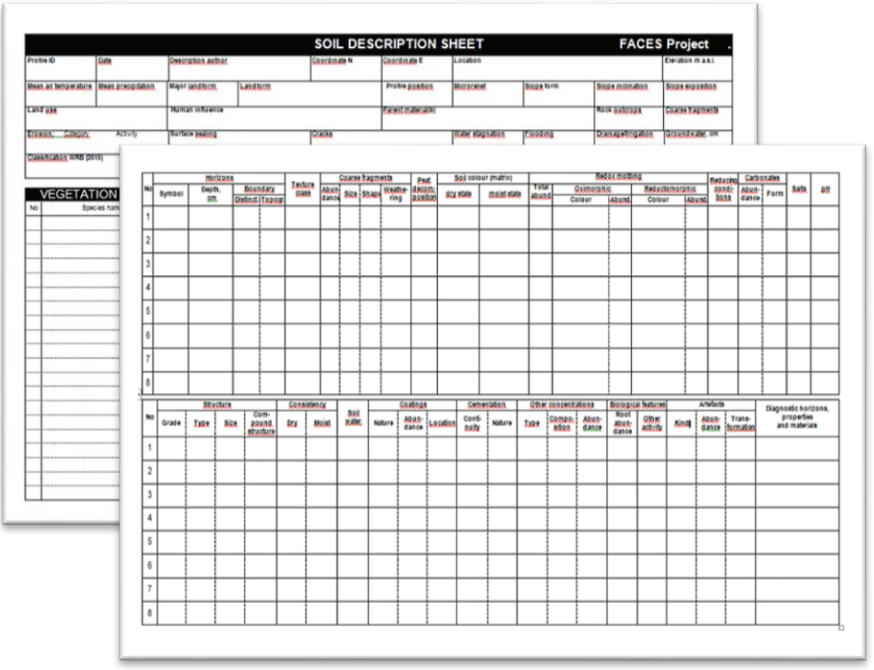


Figure 9. Soil description sheet

2. Soil Classification

2.1. The object classified in the WRB

Regardless of many definitions, soil as an object of classification in WRB has been defined as:

"... a continuous natural body which has three spatial and one temporal dimension. The three main features governing soil are:

- *It is formed by **mineral and organic constituents** and includes solid, liquid and gaseous phases.*
- *The constituents are organized in **structures**, specific for the pedological medium.*
- *These structures form the morphological aspect of the soil cover, equivalent to the anatomy of a living being. They result from the history of the soil cover and from its actual dynamics and properties. Study of the structures of the soil cover facilitates perception of the physical, chemical and biological properties; it permits understanding the past and present of the soil, and predicting its future.*

*The soil is in **constant evolution**, thus giving the soil its fourth dimension, time."*

The object classified in the WRB is: *any material within 2 m of the Earth's surface that is in contact with the atmosphere, excluding living organisms, areas with continuous ice not covered by other material, and water bodies deeper than 2* m. If explicitly stated, the object classified in the WRB includes layers deeper than 2 m.

The definition used by WRB includes continuous rock, paved urban soils, soils of industrial areas, cave soils as well as subaqueous soils. Soils under continuous rock, except those that occur in caves, are generally not considered for classification. In special cases, the WRB may be used to classify soils under rock, for example for palaeopedological reconstruction of the environment.

2.2. General rules of classification

2.2.1. Steps procedure

Classification of soil consists of three steps.

Step one – detecting diagnostic horizons, properties and materials

Step two – allocating the soil to a Reference Soil Group

The described combination of diagnostic horizons, properties and materials is compared to the WRB Key in order to allocate the soil to the appropriate **Reference Soil Group (RSG)**. The user should go through the Key systematically, starting at the beginning and excluding one by one all RSGs for which the specified requirements are not met. The soil belongs to the first RSG for which it fulfils the criteria.

Step three – allocating the qualifiers

The qualifiers available for use with a particular RSG are listed in the Key, along with the RSG. They are divided into principal and supplementary qualifiers. The **principal qualifiers** are ranked and given in an order of importance. The **supplementary qualifiers** are not ranked, but are, as a convention, used in alphabetical order.

The principal qualifiers are added before the name of the RSG without brackets and without commas. The sequence is from right to left, i.e. the uppermost qualifier in the list is placed closest to the name of the RSG.

The supplementary qualifiers are added in brackets after the name of the RSG and are separated from each other by commas. The sequence is from left to right, i.e. the first qualifier according to the alphabet is placed closest to the name of the RSG.

Qualifiers conveying redundant information are not added. For example, Eutric is not added if the Calcaric qualifier applies.

If qualifiers apply but are not in the list for the particular RSG, they should be added last as supplementary qualifiers.

2.2.2. Subqualifiers

Qualifiers may be combined with specifiers (e.g. Epi-) to form subqualifiers (e.g. Epiarenic).

Depending on the specifier, the subqualifier fulfils all the criteria of the respective qualifier, or it deviates in a defined way from its set of criteria.

The use of subqualifiers that deviate form the set of criteria of the respective qualifer is compulsory. The use of subqualifiers that fulfil all the criteria of the respective qualifier is optional. They are recommended especially for soil classification. The use of subqualifiers is not recommended in map units or wherever generalization is important.

The alphabetical sequence of the supplementary qualifiers is according to the qualifier, not the specifier (subqualifier). The use of specifiers does not change the position of the qualifier in the soil name with the exception of the Bathy-, Thapto-, and Proto- specifier (see below).

Some subqualifiers can be constructed by the user (see below). Other subqualifiers have a fixed definition given in the following chapters.

Subqualifiers constructed by the user

1. If a qualifier refers to a characteristic that occurs at a **specific point of depth** (e.g. Raptic), optional subqualifiers can be constructed with the following specifiers:

> **Epi**- (from Greek epi, over): the characteristic is present somewhere ≤ 50 cm from the (mineral) soil surface and is absent > 50 and ≤ 100 cm from the (mineral) soil surface.

Endo- (from Greek endon, inside): the characteristic is present somewhere > 50 and ≤ 100 cm from the (mineral) soil surface and is absent ≤ 50 cm from the (mineral) soil surface.

Amphi- (from Greek amphi, around): the characteristic is present two or more times, once or more times somewhere ≤ 50 cm from the (mineral) soil surface and once or more times somewhere > 50 and ≤ 100 cm from the (mineral) soil surface.

2. If a qualifier refers to a **horizon** or **layer** (e.g. Calcic, Arenic, Fluvic), optional subqualifiers can be constructed with the following specifiers as shown in Figure 10.

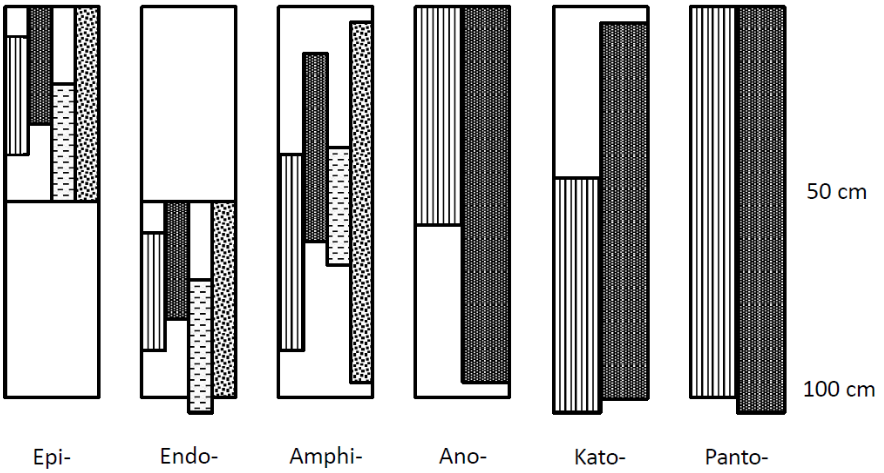


Figure 10. Subqualifiers related to depth requirements and referring to a particular horizon or layer

3. If a qualifier refers to a **specific feature** or to a **layer**, but its **criteria are only fulfilled at a depth of > 100 cm** from the (mineral) soil surface, the **Bathy**- specifier can be used. If used with a principal qualifier, the Bathy- subqualifier must shift to the supplementary qualifiers. If it comprises buried layers, Bathy- is only allowed in combination with the Thapto- specifier, e.g. Bathythaptovertic.

4. If a diagnostic horizon or property belongs to a buried soil, the **Thapto**- specifier can be used. If used with a principal qualifier, the Thapto- subqualifier must shift to the supplementary qualifiers. The Thapto- subqualifiers are placed after the supplementary qualifiers and after any Bathy- subqualifier.

5. For soils with technic hard material, a geomembrane, a continuous layer of artefacts, contiunuous rock or a cemented or indurated layer, subqualifiers with the **Supra**- specifier can be constructed to describe the soil material above, if the thickness or depth requirements of a qualifier or of its respective diagnostics are not fulfilled, but all other criteria are fulfilled throughout in the soil material above (e.g. Ekranic Technosol (Suprafolic)). If the Supra- specifier is used, the Epi- specifier is not used.

Subqualifiers with a given definition

For some qualifiers, subqualifiers are strictly defined (Chapter: Definitions of Qualifiers), e.g. **Hyper**salic and **Proto**salic for the Salic qualifier. These subqualifiers may belong to the optional (e.g. Hypercalcic, **Hypo**calcic) or the mandatory (e.g. Protocalcic) subqualifiers. If the Proto- specifier is used with a principal qualifier, the Proto- subqualifier must shift to the supplementary qualifiers and be placed within the list of the supplementary qualifiers according to the alphabetical position of the qualifier, not the subqualifier.

2.2.3. EXAMPLE OF SOIL NAME FORMATION

Field description

A soil developed from loess has a marked clay increase at 60 cm depth, clay coatings in the clay-rich horizon and a field pH value around 6 in the depth from 50 to 100 cm. The clay-poor upper soil is subdivided into a darker upper and a light-coloured lower horizon. The clay-rich horizon has a limited amount of mottling with intensive colours inside

the soil aggregates and reducing conditions in some parts during spring time. The following conclusions can be drawn:

a. clay increase and/or clay coatings > argic horizon

b. argic horizon with high CEC (loess) and base saturation (inferred by pH 6) is high > Luvisol

c. light colour > Albic qualifier

d. some mottles > stagnic properties

e. stagnic properties and reducing conditions starting at 60 cm > Endostagnic qualifier

f. clay coatings > Cutanic qualifier

g. clay increase > Differentic qualifier

The field classification now is: **Albic Endostagnic Luvisol (Cutanic, Differentic)**

+ Laboratory analyses

The laboratory analyses confirm a high CEC per kg of clay in the argic horizon and a high base saturation in the depth 50–100 cm. They further detect the texture class of silty clay loam with 30% clay (Siltic qualifier) in the topsoil and of silty clay with 45% clay (Clayic Qualifier) in the subsoil.

The final classification is: **Albic Endostagnic Luvisol (Endoclayic, Cutanic, Differentic, Episiltic)**

2.2.4. BURIED SOILS

A buried soil is a soil covered by younger deposits. Where a soil is buried, the following rules apply:

1. The overlying material and the buried soil are classified as one soil if both together qualify as a Histosol, Anthrosol, Technosol, Leptosol, Vertisol, Gleysol, Planosol, Stagnosol, Arenosol, Fluvisol or Regosol.

2. Otherwise, the overlying material is classified with preference if it is ≥ 50 cm thick or if the overlying material, if it stood alone, satisfies the requirements of a Folic Regosol or of a RSG other than a Regosol. For depth requirements in the overlying material, the lower limit of the overlying material is regarded as if it were the upper limit of *continuous rock*.
3. In all other cases, the buried soil is classified with preference. For depth requirements in the buried soil, the upper limit of the buried soil is regarded as its soil surface.
4. If the overlying soil is classified with preference, the name of the buried soil is placed after the name of the overlying soil adding the word 'over' in between, e.g. Skeletic Umbrisol (Siltic) over Albic Podzol (Arenic). As many buried soils are polygenetic, qualifiers that are not in the list for the particular RSG may be applicable. If so, these qualifiers must be used as supplementary qualifiers. Alternatively, instead of the buried soil, a buried diagnostic horizon or a buried layer with a diagnostic property can be added with the Thapto- subqualifier to the name of the overlying soil.
5. If the buried soil is classified with preference, the overlying material is indicated with the Novic qualifier, and if applicable, with the qualifiers Aeolic, Colluvic or Transportic.

2.3. Diagnostic horizons, properties and materials

2.3.1. DIAGNOSTIC HORIZONS

Argic horizon

An argic horizon consists of *mineral* material and:

1. has a texture class of loamy sand or finer and ≥ 8% clay; ***and***
2. one or both of the following:
   a. has an overlying coarser textured horizon with all of the following:
      i. the coarser textured horizon is not separated from the argic horizon by a *lithic discontinuity*; ***and***
      ii. if the coarser textured horizon directly overlies the argic horizon, its lowermost subhorizon does not form part of a plough layer; ***and***
      iii. if the coarser textured horizon does not directly overlie the argic horizon, the transitional horizon between the coarser textured horizon and the argic horizon has a thickness of ≤ 15 cm; ***and***
      iv. if the coarser textured horizon has < 10% clay in the fine earth fraction, the argic horizon has ≥ 4% (absolute) more clay; ***and***
      v. if the coarser textured horizon has ≥ 10 and < 50% clay in the fine earth fraction, the ratio of clay in the argic horizon to that of the coarser textured horizon is ≥1.4; ***and***
      vi. if the coarser textured horizon has ≥ 50% clay in the fine earth fraction, the argic horizon has ≥ 20% (absolute) more clay; ***or***

   b. has evidence of illuvial clay in one or more of the following forms:

      i. oriented clay bridging between ≥ 5% of the sand grains; ***or***

      ii. clay coatings lining ≥ 5% of the surfaces in pores; ***or***

      iii. clay coatings covering ≥ 5% of the vertical and ≥ 5% of the horizontal surfaces of soil aggregates; ***or***

      iv. in thin sections, oriented clay bodies that constitute ≥ 1% of the section; ***or***

      v. a COLE of ≥ 0.04, and a ratio of fine clay to total clay in the argic horizon greater by ≥ 1.2 times than the ratio in the overlying coarser textured horizon; ***and***

3. both of the following

   a. does not form part of a *natric* horizon; ***and***

   b. does not form part of a *spodic* horizon, unless illuvial clay is evidenced by one or more of the diagnostic criteria listed under 2.b.; ***and***

4. has a thickness of one-tenth or more of the thickness of the overlying *mineral* material, if present, and one of the following:

   a. ≥ 7.5 cm (combined thickness if composed of lamellae) if the argic horizon has a texture class of sandy loam or finer ; ***or***

   b. ≥ 15 cm (combined thickness if composed of lamellae).

Calcic horizon

A calcic horizon:

1. has a calcium carbonate equivalent in the fine earth fraction of ≥ 15%; ***and***

2. has one or both of the following:

   a. ≥ 5% (by volume) secondary carbonates; ***or***

b. a calcium carbonate equivalent in the fine earth fraction of ≥ 5% higher (absolute, by mass) than that of an underlying layer and no *lithic discontinuity* between the two layers; ***and***

3. does not form part of a *petrocalcic* horizon; ***and***

4. has a thickness of ≥ 15 cm.

Cambic horizon

A cambic horizon consists of *mineral* material and:

1. has a texture class of

a. sandy loam or finer; ***or***

b. very fine sand or loamy very fine sand; ***and***

2. has absence of rock structure in ≥ 50% of the volume of the fine earth fraction; ***and***

3. shows evidence of pedogenetic alteration in one or more of the following:

a. when compared to the directly underlying layer, if it is not separated from the cambic horizon by a *lithic discontinuity,* one or more of the following:

i. a Munsell colour hue ≥ 2.5 units redder, moist; ***or***

ii. a Munsell colour chroma ≥ 1 unit higher, moist; ***or***

iii. a clay content ≥ 4% (absolute) higher; ***or***

b. soil aggregate structure in ≥ 50% of the volume of the fine earth fraction ***and*** when compared to an overlying mineral layer, if it is not separated from the cambic horizon by a *lithic discontinuity,* one or more of the following:

i. a Munsell colour hue ≥ 2.5 units redder, moist; ***or***

ii. a Munsell colour value ≥ 1 unit higher, moist; ***or***

iii. a Munsell colour chroma ≥ 1 unit higher, moist; ***or***

c. compared to the directly underlying layer, if it is not separated from the cambic horizon by a *lithic discontinuity,* evidence of removal of carbonates or gypsum by one or more of the following:

i. ≥ 5% (by mass, absolute, fine earth fraction) less carbonates or gypsum; ***or***

ii. if all coarse fragments in the underlying layer are completely coated with carbonates, some of these fragments in the cambic horizon are partly free of coatings; ***or***

iii. if the coarse fragments in the underlying layer are coated with carbonates only on their underside, those in the cambic horizon are free of coatings; ***and***

4. does not form part of a plough layer and does not form part of an *argic, calcic, fragic, gypsic, hortic, mollic, natric, plaggic, pretic, salic, spodic, umbric, terric* or *vertic* horizon; ***and***

5. has a thickness of ≥ 15 cm.

Chernic horizon

A chernic horizon is a surface horizon consisting of *mineral* material and has:

1. ≥ 20% (by volume, weighted average) of fine earth; ***and***

2. granular or fine subangular blocky soil structure; ***and***

3. ≥ 1% *soil organic carbon*; ***and***

4. one or both of the following:

a. in slightly crushed samples a Munsell colour value of ≤ 3 moist, and ≤ 5 dry, and a chroma of ≤ 2 moist; ***or***

b. all of the following:

i. ≥ 40% (by mass) calcium carbonate equivalent in the fine earth fraction and/or a texture class of loamy sand or coarser; ***and***

    ii. in slightly crushed samples a Munsell colour value of ≤ 5 and a chroma of ≤ 2, both moist; ***and***

    iii. ≥ 2.5% *soil organic carbon*; ***and***

5. ≥ 1% (absolute) more *soil organic carbon* than the parent material, if parent material is present, that has a Munsell colour value of ≤ 4, moist; ***and***

6. a base saturation of ≥ 50% on a weighted average, throughout the entire thickness of the horizon; ***and***

7. a thickness of ≥ 25 cm.

Ferric horizon

A ferric horizon consists of *mineral* material and:

1. has one or both of the following:

    a. ≥ 15% of the exposed area occupied by coarse mottles (≥ 20 mm in diameter) that are black or have a Munsell colour hue redder than 7.5YR and a chroma of ≥ 5, both moist; ***or***

    b. ≥ 5% of the volume consisting of discrete reddish to blackish concretions and/or nodules with a diameter of ≥ 2 mm, with at least the exteriors of the concretions or nodules being at least weakly cemented or indurated, andif not black, the exteriors having redder hue or stronger chroma than the interiors; ***and***

2. has a thickness of ≥ 15 cm.

Folic horizon

A folic horizon consists of *organic* material and:

1. is saturated with water for < 30 consecutive days in most years and is not drained; ***and***

2. has a thickness of ≥ 10 cm.

Fragic horizon

A fragic horizon consists of *mineral* material and:

1. shows structural units that do not allow roots to enter; separations between these units have an average horizontal spacing of ≥ 10 cm; ***and***

2. shows evidence of alteration as defined in the cambic horizon, at least on the faces of structural units; ***and***

3. contains < 0.5% (by mass) *soil organic carbon*; ***and***

4. shows in ≥ 50% of the volume slaking or fracturing of air-dry clods, 5–10 cm in diameter, within ≤ 10 minutes when placed in water; ***and***

5. does not cement upon repeated wetting and drying; ***and***

6. has a penetration resistance at field capacity of ≥ 4 MPa in ≥ 90% of the volume; ***and***

7. does not show effervescence after adding a 1 *M* HCl solution; ***and***

8. has a thickness of ≥ 15 cm.

Fulvic horizon

A fulvic horizon has:

1. *andic* properties; and

2. one or both of the following:

   a. a Munsell colour value or chroma of > 2, moist; or

   b. a melanic index of ≥ 1.7; and

3. a weighted average of ≥ 6% soil organic carbon, and ≥ 4% soil organic carbon in all parts; and

4. a combined thickness of ≥ 30 cm with ≤ 10 cm non-fulvic material in between.

Gypsic horizon

A gypsic horizon consists of *mineral* material and:

1. has ≥ 5% (by mass) gypsum in the fine earth fraction; ***and***

2. has one or both of the following:

    a. ≥ 1% (by volume) of visible secondary gypsum; ***or***

    b. a gypsum content in the fine earth fraction of ≥ 5% higher (absolute, by mass) than that of an underlying layer and no *lithic discontinuity* between the two layers; ***and***

3. has a product of thickness (in centimetres) times gypsum content (percentage, by mass) of ≥ 150; ***and***

4. does not form part of a *petrogypsic* horizon; ***and***

5. has a thickness of ≥ 15 cm.

Histic horizon

A histic horizon consists of *organic* material and:

1. is saturated with water for ≥ 30 consecutive days in most years or is drained; ***and***

2. has a thickness of ≥ 10 cm

Hortic horizon

A hortic horizon is a surface horizon consisting of *mineral* material and has:

1. a Munsell colour value and chroma of ≤ 3, moist; ***and***

2. a weighted average of ≥ 1% *soil organic carbon*; ***and***

3. a 0.5 *M* $NaHCO_3$ extractable P_2O_5 content7 of ≥ 100 mg kg^{-1} fine earth in the upper 25 cm; ***and***

4. a base saturation of ≥ 50%; ***and***

5. ≥ 25% (by volume, by weighted average) of animal pores, coprolites or other traces of soil animal activity; ***and***

6. a thickness of ≥ 20 cm.

Melanic horizon

A melanic horizon has:

1. *andic* properties; and

2. a Munsell colour value and chroma of ≤ 2, moist; and

3. a melanic index of < 1.7; and

4. a weighted average of ≥ 6% soil organic carbon, and ≥ 4% soil organic carbon in all parts; and

5. a combined thickness of ≥ 30 cm with ≤ 10 cm non-melanic material in between.

Mollic horizon

A mollic horizon is a surface horizon consisting of *mineral* material. For diagnostic criteria 2 to 4, the weighted average of each value is calculated and then checked against the diagnostic criteria, either for the upper 20 cm, or for the entire mineral soil above *continuous rock* or *technic hard* material if starting < 20 cm from the mineral soil surface. If the mollic horizon has subhorizons that start ≥ 20 cm from the mineral soil surface, a weighted average for those subhorizons is not calculated; each value is checked separately against the diagnostic criteria.

A mollic horizon has:

1. a soil structure sufficiently strong that it is not both massive and hard or very hard when dry (prisms larger than 30 cm in diameter are included in the meaning of massive if there is no structure further subdividing the prisms); ***and***

2. ≥ 0.6% *soil organic carbon*; ***and***

3. one or both of the following:

   a. in slightly crushed samples a Munsell colour value of ≤ 3 moist, and ≤ 5 dry, and a chroma of ≤ 3 moist; ***or***

   b. all of the following:

      i. ≥ 40% (by mass) calcium carbonate equivalent in the fine earth fraction and/or a texture class of loamy sand or coarser; ***and***

      ii. in slightly crushed samples a Munsell colour a value of ≤ 5 and a chroma of ≤ 3, both moist; ***and***

      iii. ≥ 2.5% *soil organic carbon*; ***and***

4. ≥ 0.6% (absolute) more *soil organic carbon* than the parent material, if parent material is present, that has a Munsell colour value of ≤ 4, moist; ***and***

5. a base saturation of ≥ 50% on a weighted average, throughout the entire thickness of the horizon; ***and***

6. a thickness of one of the following:

   a. ≥ 10 cm if directly overlying *continuous rock* or *technic hard* material; ***or***

   b. ≥ 20 cm.

Natric horizon

A natric horizon consists of *mineral* material and:

1. has a texture class of loamy sand or finer and ≥ 8% clay; ***and***

2. one or both of the following:

   a. has an overlying coarser textured horizon with all of the following:

      i. the coarser textured horizon is not separated from the natric horizon by a *lithic discontinuity*; ***and***

ii. if the coarser textured horizon directly overlies the natric horizon, its lowermost subhorizon does not form part of a plough layer; ***and***

iii. if the coarser textured horizon does not directly overlie the natric horizon, the transitional horizon between the coarser textured horizon and the natric horizon has a thickness of ≤ 15 cm; ***and***

iv. if the coarser textured horizon has < 10% clay in the fine earth fraction, the natric horizon has ≥ 4% (absolute) more clay; ***and***

v. if the coarser textured horizon has ≥ 10 and < 50% clay in the fine earth fraction, the ratio of clay in the natric horizon to that of the coarser textured horizon is ≥ 1.4; ***and***

vi. if the coarser textured horizon has ≥ 50% clay in the fine earth fraction, the natric horizon has ≥ 20% (absolute) more clay; ***or***

b. has evidence of illuvial clay in one or more of the following forms:

i. oriented clay bridging ≥ 5% of the sand grains; ***or***

ii. clay coatings lining ≥ 5% of the surfaces in pores; ***or***

iii. clay coatings covering ≥ 5% of the vertical and ≥ 5% of the horizontal surfaces of soil aggregates; ***or***

iv. in thin sections, oriented clay bodies that constitute ≥ 1% of the section; ***or***

v. a COLE of ≥ 0.04 and a ratio of fine clay9 to total clay in the natric horizon greater by ≥ 1.2 times than the ratio in the overlying coarser textured horizon; ***and***

3. has one or more of the following:

a. a columnar or prismatic structure in some part of the horizon; ***or***

b. both of the following:

i. a blocky structure; ***and***

   ii. penetrations of an overlying coarser textured horizon in which there are uncoated silt or sand grains, extending ≥ 2.5 cm into the natric horizon; ***and***

4. has one of the following:
   a. an exchangeable Na percentage (ESP) of ≥ 15 throughout the entire natric horizon or its upper 40 cm, whichever is thinner; ***or***
   b. both of the following,
      i. more exchangeable Mg plus Na than Ca plus exchange acidity (at pH 8.2) throughout the entire natric horizon or its upper 40 cm, whichever is thinner; ***and***
      ii. an exchangeable Na percentage (ESP) of ≥ 15 in some subhorizon starting ≤ 50 cm below the upper limit of the natric horizon; ***and***
5. has a thickness of one-tenth or more of the thickness of the overlying *mineral* material, if present, and one of the following:
   a. ≥ 7.5 cm (combined thickness if composed of lamellae) if the natric horizon has a texture class of sandy loam or finer; ***or***
   b. ≥ 15 cm (combined thickness if composed of lamellae).

Protovertic horizon

A protovertic horizon consists of *mineral* material and has:

1. ≥ 30% clay; ***and***
2. one or more of the following:
   a. wedge-shaped soil aggregates in ≥ 10% of the soil volume; ***or***
   b. slickensides (pressure faces with smooth striations or grooves that are produced by shrink-swell forces) at ≥ 5% of the surfaces of soil aggregates; ***or***
   c. shrink-swell cracks; ***or***
   d. a COLE of ≥ 0.06 averaged over the depth of the horizon; ***and***

3. a thickness of ≥ 15 cm.

Salic horizon

A salic horizon has:

1. at some time of the year an electrical conductivity of the saturation extract (ECe) at 25 °C of

    a. ≥ 15 dS m^{-1}; ***or***

    b. ≥ 8 dS m^{-1} if the pHwater of the saturation extract is ≥8.5; ***and***

2. at some time of the year a product of thickness (in centimetres) and ECe at 25 °C (in dS m^{-1}) of ≥ 450; ***and***

3. a thickness of ≥ 15 cm.

Spodic horizon

A spodic horizon consists of *mineral* material and:

1. has a pH (1:1 in water) of < 5.9 in ≥ 85% of the horizon, unless the soil is cultivated; ***and***

2. has in ≥ 85% of its uppermost 1 cm, one or both of the following:

    a. ≥ 0.5% *soil organic carbon*; ***or***

    b. an optical density of the oxalate extract (ODOE) value of ≥ 0.25; ***and***

3. one or both of the following:

    a. is overlain by *albic* material, that is not separated from the spodic horizon by a *lithic discontinuity* and that overlies the spodic horizon either directly or above a transitional horizon that has a thickness of one-tenth or less of the overlying *albic* material, ***and*** has in ≥ 85% of its uppermost 2.5 cm, one of the following Munsell colours, moist (crushed and smoothed sample):

        i. a hue of 5YR or redder; ***or***

    ii. a hue of 7.5YR and a value of ≤ 5 and a chroma of ≤ 4; ***or***
    iii. a hue of 10YR and a value and a chroma of ≤ 2; ***or***
    iv. a colour of 10YR 3/1; ***or***
    v. a hue of N and a value of ≤ 2; ***or***

  b. has one of the colours listed above or a colour with a hue of 7.5YR, a value of ≤ 5 and a chroma of 5 or 6, all moist (crushed and smoothed sample), in ≥ 85% of its uppermost 2.5 cm, ***and*** has one or more of the following:
    i. cementation by organic matter and Al with or without Fe, in ≥ 50% of the horizon and a very firm or firmer consistency in the cemented part; ***or***
    ii. ≥ 10% of the sand grains of the horizon showing cracked coatings; ***or***
    iii. a subhorizon with an Alox + ½Feox value of ≥ 0.5% that is ≥ 2 times higher than the lowest Alox + ½Feox value of all the mineral horizons above the spodic horizon; ***or***
    iv. a subhorizon with an ODOE value of ≥ 0.25 that is ≥ 2 times higher than the lowest ODOE value of all the mineral horizons above the spodic horizon; ***or***
    v. ≥ 10% (by volume) Fe lamellae in a layer ≥ 25 cm thick; ***and***

4. does not form part of a *natric* horizon; ***and***
5. if occurring under *tephric* material that satisfies the requirements of *albic* material: has a C_{py}/OC[2] and a C_f/C_{py} of ≥ 0.5 in its uppermost 2.5 cm; ***and***
6. has a thickness of ≥ 2.5 cm and its lower limit at
  a. the lower limit of the lowermost subhorizon fulfilling the diagnostic criteria 1 and 4 and having one of the colours listed under 3; ***or***

[2] C_{py}, C_f, and OC are pyrophosphate-extractable C, fulvic acid C, and organic C, respectlively, expressed as percent of the fine earth fraction on an oven-dried basis.

b. the lower limit of the lowermost subhorizon fulfilling the diagnostic criteria 1 and 4 and one or more of the diagnostic criteria listed under 3b, i- v;whichever is deeper.

Terric horizon

A terric horizon is a surface horizon consisting of *mineral* material and:

1. has a colour related to the source material; ***and***

2. has a base saturation (by 1 *M* NH4OAc, pH 7) of ≥ 50%; ***and***

3. does not show stratification; ***and***

4. occurs in locally raised land surfaces; ***and***

5. has a thickness of ≥ 20 cm.

Thionic horizon

A thionic horizon has:

1. a pH < 4 (1:1 by mass in water, or in a minimum of water to permit measurement); ***and***

2. one or more of the following:

   a. mottles or coatings with accumulations of iron or aluminium sulfate or hydroxysulfate minerals; ***or***

   b. direct superposition on *sulfidic* material; ***or***

   c. ≥ 0.05% (by mass) water-soluble sulfate; ***and***

3. a thickness of ≥ 15 cm.

Umbric horizon

An umbric horizon is a surface horizon consisting of *mineral* material. For diagnostic criteria 2 to 4, the weighted average of each value is calculated and then checked against the diagnostic criteria, either for the upper 20 cm, or for the entire mineral soil above *continuous rock* or

technic hard material if starting < 20 cm from the mineral soil surface. If the umbric horizon has subhorizons that start ≥ 20 cm from the mineral soil surface, a weighted average for those subhorizons is not calculated; each value is checked separately against the diagnostic criteria.

An umbric horizon has:

1. a soil structure sufficiently strong, that it is not both massive and hard or very hard, when dry (prisms larger than 30 cm in diameter are included in the meaning of massive if there is no structure further subdividing the prisms); ***and***
2. ≥ 0.6% *soil organic carbon*; ***and***
3. one or both of the following:
   a. in slightly crushed samples a Munsell colour value of ≤ 3 moist, and ≤ 5 dry, and a chroma of ≤ 3 moist; ***or***
   b. all of the following:
      i. a texture class of loamy sand or coarser; ***and***
      ii. in slightly crushed samples a Munsell colour a value of ≤ 5 and a chroma of ≤ 3, both moist; ***and***
      iii. ≥ 2.5% *soil organic carbon*; ***and***
4. ≥ 0.6% (absolute) more *soil organic carbon* than the parent material, if parent material is present, that has a Munsell colour value of ≤ 4, moist; ***and***
5. a base saturation of < 50% on a weighted average, throughout the entire thickness of the horizon; ***and***
6. a thickness of one of the following:
   a. ≥ 10 cm if directly overlying *continuous rock or technic hard* material; ***or***
   b. ≥ 20 cm.

Vertic horizon

A vertic horizon consists of *mineral* material and has:

1. ≥ 30% clay; ***and***
2. one or both of the following:
   a. wedge-shaped soil aggregates with a longitudinal axis tilted between ≥ 10° and ≤ 60° from the horizontal in ≥ 20% of the soil volume; ***or***
   b. slickensides (pressure faces with smooth striations or grooves that are produced by shrink-swell forces) at ≥ 10% of the surfaces of soil aggregates; ***and***
3. *shrink-swell cracks*; ***and***
4. a thickness of ≥ 25 cm.

2.3.2. DIAGNOSTIC PROPERTIES

Abrupt textural difference

An abrupt textural difference requires:

1. ≥ 8% clay in the underlying layer; ***and***
2. within ≤ 5 cm, one of the following:
    a. at least a doubling of the clay content if the overlying layer has < 20% clay; ***or***
    b. ≥ 20% (absolute) increase in clay content if the overlying layer has ≥ 20% clay.

Albeluvic glossae

Albeluvic glossae refer to a combination of stronger coloured parts and lighter coloured parts within the same layer, with all of the following:

1. the stronger coloured parts belong to an *argic* horizon; ***and***
2. the lighter coloured parts consist of *albic* material; ***and***
3. the stronger coloured parts have, compared with the lighter coloured parts, the following Munsell colour, moist:
    a. a hue ≥ 2.5 units redder, ***or***
    b. a value ≥ 1 unit lower, ***or***
    c. a chroma ≥ 1 unit higher; ***and***
4. the clay content of the stronger coloured parts is higher compared with the lighter coloured parts, as specified for the *argic* horizon; ***and***
5. the lighter coloured parts have a greater depth than width, with the following horizontal dimensions:
    a. ≥ 0.5 cm in *argic* horizons that have a clay or silty clay texture class; ***or***

b. ≥ 1 cm in *argic* horizons that have a texture class of silt, silt loam, silty clay loam, loam, clay loam or sandy clay; ***or***

c. ≥ 1.5 cm in *argic* horizons with other texture classes; ***and***

6. the lighter coloured parts start at the upper limit of the *argic* horizon and are continuous to a depth of ≥ 10 cm below the upper limit of the *argic* horizon; ***and***

7. the lighter coloured parts occupy areas ≥ 10 and ≤ 90% in both vertical and horizontal sections, within the upper 10 cm of the *argic* horizon; ***and***

8. do not occur within a plough layer.

Andic properties

Andic properties require:

1. an Al_{ox} + ½Fe_{ox} value of ≥ 2%; and

2. a bulk density 17 of ≤ 0.9 kg dm^{-3}; and

3. a phosphate retention of ≥ 85%.

Anthric properties

Anthric properties:

1. occur in soils with a *mollic* or *umbric* horizon; ***and***

2. show evidence of human disturbance by one or more of the following:

a. an abrupt lower boundary at ploughing depth and evidence of mixing of humus-richer and humus-poorer soil materials by cultivation; ***or***

b. lumps of applied lime; ***or***

c. ≥ 1.5 g kg^{-1} P_2O_5 soluble in 1percent citric acid; ***and***

3. show < 5% (by volume) of animal pores, coprolites or other traces of soil animal activity

a. in a depth between 20 and 25 cm from the soil surface, if the soil is unploughed; ***or***

b. in a depth range of 5 cm below the plough layer.

Aridic properties

Aridic properties require:

1. a *soil organic carbon* content, calculated as a weighted average in the upper 20 cm of the soil or down to the top of a diagnostic subsurface horizon, a cemented or indurated layer or to *continuous rock* or *technic hard* material, whichever is shallower; that meets one the following:

    a. < 0.2%; ***or***

    b. < 0.6% if the texture class in the fine earth fraction is sandy loam or finer; ***or***

    c. < 1%, if the soil is periodically flooded or if it has an ECe at 25 °C of ≥ 4 dS m^{-1} somewhere within ≤ 100 cm of the soil surface; ***and***

2. evidence of aeolian activity in one or more of the following forms:

    a. the sand fraction in some layer in the upper 20 cm of the soil or in in-blown material filling cracks contains rounded or subangular sand particles showing a matt surface (use a ×10 hand lens); these particles make up ≥ 10% of the medium and coarser sand fraction; ***or***

    b. wind-shaped rock fragments (*ventifacts*) at the surface; ***or***

    c. aeroturbation (e.g. cross-bedding) in some layer in the upper 20 cm of the soil; ***or***

    d. evidence of wind erosion; ***or***

e. evidence of wind deposition in some layer in the upper 20 cm of the soil; ***and***

3. broken and crushed samples with a Munsell colour value of ≥ 3 moist, and ≥ 5 dry, and a chroma of ≥ 2 moist in the upper 20 cm of the soil or down to the top of a diagnostic subsurface horizon, a cemented or indurated layer or to *continuous rock* or *technic hard material*, whichever is shallower; ***and***

4. a base saturation of ≥ 75% in the upper 20 cm of the soil or down to the top of a diagnostic subsurface horizon, a cemented or indurated layer or to *continuous rock* or *technic hard material*, whichever is shallower.

Continuous rock

Continuous rock is consolidated material underlying the soil, exclusive of cemented or indurated pedogenetic horizons such as *petrocalcic* horizon. Continuous rock is sufficiently consolidated to remain intact when an air-dried specimen, 25–30 mm on one side, is submerged in water for 1 hour. The material is considered continuous only if cracks into which roots can enter are on average ≥ 10 cm apart and occupy < 20% (by volume) of the continuous rock, with no significant displacement of the rock having taken place.

Gleyic properties

Gleyic properties comprise one of the following:

1. a layer with ≥ 95% (exposed area) having colours considered to be reductimorphic, that have:

   a. a Munsell colour hue of N, 10Y, GY, G, BG, B, PB, moist; ***or***

   b. a Munsell colour hue of 2.5Y or 5Y with a chroma of ≤ 2, moist; ***or***

2. a layer with > 5% (exposed area) mottles, the colour of which is considered to be oximorphic, that:

a. are predominantly around root channels, and if soil aggregates are present, predominantly at or near the surfaces of the aggregates; ***and***

b. have, moist, a Munsell colour hue ≥ 2.5 units redder than the surrounding material and a Munsell colour chroma ≥ 1 unit higher than the surrounding material; *or*

3. a combination of two layers: a layer fulfilling diagnostic criterion 2 and a directly underlying layer fulfilling diagnostic criterion 1.

Lithic discontinuity

When comparing layers directly superimposed on the other, a lithic discontinuity requires one or more of the following:

1. an abrupt difference in particle-size distribution that is not solely associated with a change in clay content resulting from pedogenesis; ***or***
2. both of the following:
    a. one or more of the following, calculated for the respective contents in the fine earth fraction:
        i. a difference of ≥ 25% in the ratio coarse sand to medium sand, ***and*** a difference of ≥ 5% (absolute) in the content of coarse sand and/or medium sand; ***or***
        ii. a difference of ≥ 25% in the ratio coarse sand to fine sand, ***and*** a difference of ≥ 5% (absolute) in the content of coarse sand and/or fine sand; ***or***
        iii. a difference of ≥ 25% in the ratio medium sand to fine sand, ***and*** a difference of ≥ 5% (absolute) in the content of medium sand and/or fine sand; ***and***

    b. the differences do not result from original variation within the parent material in the form of a patchwise distribution of different particle size fractions within a layer; ***or***

3. rock fragments that do not have the same lithology as the underlying *continuous rock*; ***or***

4. a layer containing rock fragments without weathering rinds overlying a layer containing rocks with weathering rinds; ***or***

5. a layer with angular rock fragments overlying or underlying a layer with rounded rock fragments; ***or***

6. a layer with a larger content of coarse fragments overlying a layer with a smaller content of coarse fragments; ***or***

7. abrupt differences in colour not resulting from pedogenesis; ***or***

8. marked differences in size and shape of resistant minerals between superimposed layers (as shown by micromorphological or mineralogical methods); ***or***

9. differences in the TiO_2/ZrO_2 ratios of the sand fraction by a factor of 2.

Protocalcic properties

Protocalcic properties refer to carbonate accumulations that show one or more of the following:

1. disrupt the soil structure or fabric; ***or***

2. occupy ≥ 5% of the soil volume with masses, nodules, concretions or spheroidal aggregates (*white eyes*) that are soft and powdery when dry; ***or***

3. cover with soft coatings ≥ 50% of structural faces, pore surfaces or undersides of rock or cemented fragments, thick enough to be visible when moist; ***or***

4. form permanent filaments (*pseudomycelia*).

Reducing conditions

Reducing conditions (from Latin *reducere*, to draw back) show one or more of the following:

1. a negative logarithm of the hydrogen partial pressure (rH, calculated as $Eh \cdot 29^{-1} + 2 \cdot pH$) of < 20; ***or***

2. the presence of free Fe^{2+}, as shown on a freshly broken and smoothed surface of a field-wet soil by the appearance of a strong red colour after wetting it with a 0.2% α,α-dipyridyl solution in 10% acetic acid; ***or***

3. the presence of iron sulfide; ***or***

4. the presence of methane.

Caution: α,α-dipyridyl solution is toxic if swallowed and harmful if absorbed through skin or inhaled. It has to be used with care. In soil materials with a neutral or alkaline soil reaction it may not give the strong red colour.

Retic properties

Retic properties refer to a combination of stronger coloured parts and lighter coloured parts within the same layer, with all of the following:

1. the stronger coloured parts belong to an *argic* or *natric* horizon; ***and***

2. the lighter coloured parts consist of *albic* material; ***and***

3. the stronger coloured parts have, compared with the lighter coloured parts, the following Munsell colour, moist:

   a. a hue ≥ 2.5 units redder, ***or***

   b. a value ≥ 1 unit lower, ***or***

   c. a chroma ≥ 1 unit higher; ***and***

4. the clay content of the stronger coloured parts is higher compared with the lighter coloured parts, as specified for the *argic* or *natric* horizon; ***and***

5. the lighter coloured parts are ≥ 0.5 cm wide; ***and***

6. the lighter coloured parts start at the upper limit of the *argic* or *natric* horizon; ***and***

7. the lighter coloured parts occupy areas ≥ 10 and ≤ 90% in both vertical and horizontal sections, within the upper 10 cm of the *argic* or *natric* horizon; ***and***

8. do not occur within a plough layer.

Shrink-swell cracks

Shrink-swell cracks:

1. open and close with changing water content of the soil; ***and***

2. are ≥ 0.5 cm wide, when the soil is dry, with or without infillings of material from the surface.

Stagnic properties

Stagnic properties comprise one of the following:

1. a mottled layer with two or more colours and one or both of the following:
    a. mottles and/or concretions and/or nodules, the colour of which is considered to be oximorphic, that:
        i. are, if soil aggregates are present, predominantly inside the aggregates; ***and***
        ii. are black, surrounded by lighter-coloured material, ***or*** have, moist, a Munsell colour hue ≥ 2.5 units redder than the surrounding material and a Munsell colour chroma ≥ 1 unit higher than the surrounding material; ***or***
    b. parts, the colour of which is considered to be reductimorphic, that:
        i. are predominantly around root channels, and if soil aggregates are present, predominantly at or near the surfaces of the aggregates; ***and***

   ii. have, moist, a Munsell colour value ≥ 1 unit higher than the surrounding material and a Munsell colour chroma ≥ 1 unit lower than the surrounding material; ***or***

2. a layer with *albic* material, the colour of which is considered as being reductimorphic, above an *abrupt textural difference*; ***or***
3. a combination of two layers: a layer with *albic* material, the colour of which is considered as being reductimorphic, and a directly underlying mottled layer with the colour properties as specified in diagnostic criterion 1.

Vitric properties

Vitric properties require:

1. ≥ 5% (by grain count) volcanic glass, glassy aggregates and other glass-coated primary minerals, in the fraction ≥ 0.02 and ≤ 2 mm; and
2. an Al_{ox} + ½Fe_{ox} value of ≥ 0.4%; and
3. a phosphate retention of ≥ 25%.

2.3.3. DIAGNOSTIC MATERIALS

Albic material

Albic material is fine earth that:

1. has in ≥ 90% of its volume a Munsell colour, dry, with:
   a. a value of 7 or 8 and a chroma of ≤ 3; ***or***
   b. a value of 5 or 6 and a chroma of ≤ 2; ***and***
2. has in ≥ 90% of its volume a Munsell colour, moist, with:
   a. a value of 6, 7 or 8 and a chroma of ≤ 4; ***or***

b. a value of 5 and a chroma of ≤ 3; ***or***

c. a value of 4 and a chroma of ≤ 2; ***or***

d. a value of 4 and a chroma of 3 if the colour is derived from parent material that has a hue of 5YR or redder, and the chroma is due to the colour of uncoated silt or sand grains.

Artefacts

Artefacts (from Latin *ars*, art, and *factus*, made) are solid or liquid substances that are:

1. one or both of the following:
    a. created or substantially modified by humans as part of an industrial or artisanal manufacturing process; ***or***
    b. brought to the surface by human activity from a depth, where they were not influenced by surface processes, and deposited in an environment, where they do not commonly occur, with properties substantially different from the environment where they are placed; ***and***
2. have substantially the same chemical and mineralogical properties as when first manufactured, modified or excavated.

Calcaric material

Calcaric material effervesces strongly with 1 *M* HCl in most of those parts of the fine earth that

1. do not disrupt the soil structure or fabric; ***and***
2. do not belong to masses, nodules, concretions or spheroidal aggregates (white eyes) that are soft and powdery when dry; ***and***
3. do not belong to soft coatings of structural faces or pore surfaces; ***and***
4. do not form permanent filaments (pseudomycelia).

Colluvic material

Colluvic material:

1. is found on slopes, footslopes, fans or similar relief positions; ***and***

2. shows evidence of downslope movement; ***and***

3. is not of fluviatile, lacustrine or marine origin; ***and***

4. if it buries a mineral soil, it has a lower bulk density than the buried soil material.

Dolomitic material

Dolomitic material effervesces strongly with heated 1 *M* HCl in most of the fine earth fraction. It applies to material that contains ≥ 2% of a mineral that has a ratio $CaCO_3/MgCO_3$ <1.5. With non-heated HCl it gives only a retarded and weak effervescence.

Fluvic material

Fluvic material

1. is of fluviatile, marine or lacustrine origin; ***and***

2. has one or both of the following:

   a. obvious stratification (including stratification tilted by cryoturbation) in ≥ 25% of the soil volume over a specified depth (including strata thicker than the specified depth); ***or***

   b. stratification evidenced by a layer with all of the following:

      i. has ≥ 0.2% *soil organic carbon*; ***and***

      ii. has a content of *soil organic carbon* ≥ 25% (relative) and ≥ 0.2% (absolute) higher than in the overlying layer; ***and***

      iii. does not form part of a *spodic* or *sombric* horizon.

Gypsiric material

Gypsiric material (from Greek *gypsos*, gypsum) is mineral material that contains ≥ 5% gypsum (by volume) in those parts of the fine earth that do not contain secondary gypsum.

Hyposulfidic material

Hyposulfidic material:

1. has ≥ 0.01% inorganic sulfidic S (dry mass); ***and***
2. does not consist of *hypersulfidic* material.

Limnic material

Limnic material is formed as subaquatic deposits (after drainage it may occur at the surface). Four types of limnic material are distinguished:

1. *Coprogenous earth or sedimentary peat*: dominantly organic, identifiable through many faecal pellets, Munsell colour value of ≤ 4 moist, slightly viscous water suspension, non- or slightly plastic and non-sticky consistence, shrinking upon drying, difficult to rewet after drying, and cracking along horizontal planes.
2. *Diatomaceous earth*: mainly diatoms (siliceous), identifiable by irreversible changing of the matrix colour (Munsell colour value of 3, 4 or 5 in field moist or wet condition) as a result of the irreversibly shrinkage of the organic coatings on diatoms (use 440× microscope).
3. *Marl*: strongly calcareous, identifiable by a Munsell colour value of ≥ 5 moist, and a reaction with 1 *M* HCl. The colour of marl usually does not change upon drying.
4. *Gyttja*: small coprogenic aggregates of strongly humified organic matter and minerals of predominantly clay to silt size, ≥ 0.5% *soil organic carbon*, a Munsell colour hue of 5Y, GY or G, moist, strong shrinkage after drainage and an rH value of ≥ 13.

Mineral material

Mineral material has < 20% *soil organic carbon* in the fine earth fraction (by mass).

Organic material

Organic material has ≥ 20% *soil organic carbon* in the fine earth fraction (by mass).

Soil organic carbon

Soil organic carbon is organic carbon that does not meet the diagnostic criteria of *artefacts*.

Sulfidic material

Sulfidic material has:

1. a pH (1:1 in water) ≥ 4; ***and***

2. ≥ 0.01% inorganic sulfidic S (dry mass).

Technic hard material

Technic hard material (from Greek *technikos*, skilfully made or constructed):

1. is consolidated material resulting from an industrial process; ***and***

2. has properties substantially different from those of natural materials; ***and***

3. is continuous ***or*** has free space covering < 5% of its horizontal extension.

Tephric material

Tephric material has:

1. ≥ 30% (by grain count) volcanic glass, glassy aggregates and other glass-coated primary minerals in the fraction between ≥ 0.02 and ≤ 2 mm; and
2. no *andic* or *vitric* properties.

2.4. Key to the reference soil groups with lists of principal and supplementary qualifiers

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Soils having *organic* material: 1. starting at the soil surface and having a thickness of ≥ 10 cm and directly overlying: a. *continuous rock* or *technic hard* material, *or* b. coarse fragments, the interstices of which are filled with *organic* material; *or* 2. starting ≤ 40 cm from the soil surface and having within ≤ 100 cm of the soil surface a combined thickness of *either*: a. ≥ 60 cm, if ≥ 75% (by volume) of the material consists of moss fibres; *or* b. ≥ 40 cm in other materials. **HISTOSOLS** *(see pages 160-163)*	Rockic/ Mawic Thionic Folic Floatic/ Subaquatic Fibric/ Hemic/ Sapric Leptic Murshic/ Drainic Ombric/ Rheic Hyperskeletic/ Skeletic Calcic Dystric/ Eutric	Alcalic Dolomitic/ Calcaric Fluvic Hyperorganic Lignic Limnic Magnesic Mineralic Novic Placic Relocatic Salic Sodic Sulfidic Technic Toxic Transportic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. a *hortic* or *terric* horizon ≥ 50 cm thick. **ANTHROSOLS** *(see pages 164-165)*	Hortic/ Terric	Alic/ Luvic Alcalic Dystric/ Eutric Arenic/ Clayic/ Loamic/ Siltic Calcic Dolomitic/ Calcaric Escalic Fluvic Gleyic Endoleptic Novic Salic Skeletic Sodic Spodic Stagnic Technic Toxic Vertic

Overview of Key to Reference Soil Groups		
Histosols	Andosols	Calcisols
Anthrosols	Podzols	Retisols
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	Cambisols
Solonetz	Chernozems	Arenosols
Vertisols	Kastanozems	Fluvisols
Solonchaks	Phaeozems	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils: 1. with all of the following: a. having ≥ 20% (by volume, weighted average) *artefacts* in the upper 100 cm from the soil surface or to *continuous rock* or *technic hard* material; *and* b. not having a layer containing *artefacts* that qualifies as an *argic, chernic,ferric, fragic, natric, spodic* or *vertic* horizon starting ≤ 100 cm from the soil surface; *and* c. not having *continuous rock* or a cemented or indurated layer starting ≤ 10 cm from the soil surface; *or* 2. having a continuous, very slowly permeable to impermeable, constructed geomembrane of any thickness starting ≤ 100 cm from the soil surface; *or* 3. having *technic hard* material starting ≤ 5 cm from the soil surface. **TECHNOSOLS** *(see pages 166-167)*	Ekranic Linic Urbic Spolic Garbic Isolatic Leptic Subaquatic Hyperskeletic	Alcalic/ Dystric/ Eutric/ Hortic/ Terric Arenic/ Clayic/ Loamic/ Siltic Aridic Calcic Cambic Carbonic Densic Dolomitic/ Calcaric Drainic Fluvic Folic/ Histic Gleyic Gypsic Gypsiric Humic/ Ochric Hyperartefactic Immissic Lignic Mollic/ Umbric Novic Raptic Relocatic Salic Skeletic Sodic Protospodic Stagnic Sulfidic Thionic Toxic Transportic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. one of the following: a. *continuous rock* or *technic hard* material starting ≤ 25 cm from the soil surface; *or* b. < 20% (by volume) fine earth, averaged over a depth of 75 cm from the soil surface or to *continuous rock* or *technic hard* material, whichever is shallower; *and* 2. no *calcic*, *chernic*, *duric*, *gypsic*, *petrocalcic*, *petroduric*, *petrogypsic*, *petroplinthic* or *spodic* horizon. **LEPTOSOLS** *(see pages 168-171)*	Nudilithic/ Lithic Hyperskeletic/ Skeletic Folic/ Histic Rendzic/ Mollic/ Umbric Cambic/ Brunic Gypsiric Dolomitic/ Calcaric Dystric/ Eutric	Andic Arenic/ Clayic/ Loamic/ Siltic Aric Protocalcic Colluvic Fluvic Gleyic Humic/ Ochric Nechic Novic Protic Raptic Salic Sodic Protospodic Stagnic Aridic Technic Tephric Transportic

Overview of Key to Reference Soil Groups		
Histosols	Andosols	Calcisols
Anthrosols	Podzols	Retisols
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	Cambisols
Solonetz	Chernozems	Arenosols
Vertisols	Kastanozems	Fluvisols
Solonchaks	Phaeozems	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having a *natric* horizon starting ≤ 100 cm from the soil surface. **SOLONETZ** *(see pages 172-173)*	Abruptic Gleyic Stagnic Mollic Salic Gypsic Calcic Vertic Chromic Haplic	Albic Arenic/ Clayic/ Loamic/ Aridic Siltic Neocambic Colluvic Columnic Cutanic Ferric Fluvic Fractic Humic/ Ochric Magnesic Hypernatric Novic Raptic Retic Skeletic Toxic Transportic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. a *vertic* horizon starting ≤ 100 cm from the soil surface; *and* 2. ≥ 30% clay between the soil surface and the *vertic* horizon throughout; *and* 3. *shrink-swell cracks* that start: a. at the soil surface; *or* b. at the base of a plough layer; *or* c. ≤ 5 cm from the soil surface if there is a surface layer of strong granular structural elements ≤ 10 mm in size (self-mulching surface); *or* d. ≤ 3 cm from the soil surface if there is a surface crust; *and* extend to the *vertic* horizon. **VERTISOLS** *(see pages 174-175)*	Salic Sodic Leptic Gypsic Calcic Pellic Chromic Haplic	Albic Aric Chernic/ Mollic Dolomitic/ Calcaric Drainic Hypereutric Ferric Gilgaic Gleyic Grumic / Mazic Gypsiric Humic/ Ochric Magnesic Mesotrophic Novic Raptic Skeletic Stagnic Sulfidic Thionic Toxic

Overview of Key to Reference Soil Groups		
Histosols	Andosols	Calcisols
Anthrosols	Podzols	Retisols
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	Cambisols
Solonetz	Chernozems	Arenosols
Vertisols	Kastanozems	Fluvisols
Solonchaks	Phaeozems	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. a *salic* horizon starting ≤ 50 cm from the soil surface; *and* 2. no *thionic* horizon starting ≤ 50 cm from the soil surface; *and* 3. not permanently submerged by water and not located below the line affected by tidal water . **SOLONCHAKS** *(see pages 176-177)*	Gleyic Stagnic Mollic Sodic Gypsic Calcic Fluvic Haplic	Alcalic Arenic/ Clayic/ Loamic/ Siltic Carbonatic/ Chloridic/ Sulfatic Colluvic Densic Dolomitic/ Calcaric Drainic Evapocrustic Folic/ Histic Gypsiric Humic/ Ochric Novic Raptic Hypersalic Skeletic Sulfidic Aridic Transportic Vertic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having one of the following: 1. a layer ≥ 25 cm thick, and starting ≤ 40 cm from the mineral soil surface, that has a. *gleyic* properties throughout; *and* b. *reducing conditions* in some parts of every sublayer; *or* 2. both of the following: a. a *mollic* or *umbric* horizon, > 40 cm thick, that has *reducing conditions* in some parts of every subhorizon, from 40 cm below the mineral soil surface to the lower limit of the *mollic* or *umbric* horizon; *and* b. directly underneath the *mollic*/*umbric* horizon, a layer ≥ 10 cm thick, that has its lower limit ≥ 65 cm below the mineral soil surface, and that has: i. *gleyic* properties throughout; *and* ii. *reducing conditions* in some parts of every sublayer. **GLEYSOLS** *(see pages 178-181)*	Thionic Subaquatic Folic/ Histic Chernic/ Mollic/ Umbric Stagnic Gypsic Calcic Spodic Fluvic Dolomitic/ Calcaric Dystric/ Eutric	Abruptic Alic/ Luvic Alcalic Arenic/ Clayic/ Loamic/ Siltic Aric Colluvic Drainic Humic/ Ochric Inclinic Limnic Nechic Novic Raptic Relocatic Salic Skeletic Sodic Sulfidic Aridic Technic Uterquic Vertic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. one or more layers with *andic* or *vitric* properties with a combined thickness of either: a. ≥ 30 cm, within ≤ 100 cm of the soil surface and starting ≤ 25 cm from the soil surface*; or* b. ≥ 60% of the entire thickness of the soil, if continuous rock starts > 25 and ≤ 50 cm from the soil surface; *and* 2. no *argic* or *spodic* horizon, unless buried, deeper than 50 cm from the mineral soil surface. **ANDOSOLS** *(see pages 182-183)*	Silandic Vitric Leptic Gleyic Folic/ Histic Chernic/ Mollic/ Umbric Calcic Skeletic Eutrosilic Dystric/ Eutric	Protoandic Arenic/ Clayic/ Loamic/ Siltic Aric Colluvic Dolomitic/ Calcaric Drainic Fluvic Fulvic/ Melanic Hyperhumic Nechic Novic Oxyaquic Placic Reductic Sodic Protospodic Technic Prototephric Thixotropic Toxic Transportic

Overview of Key to Reference Soil Groups		
Histosols Anthrosols Technosols Leptosols Solonetz Vertisols Solonchaks Gleysols	**Andosols** Podzols Planosols Stagnosols Chernozems Kastanozems Phaeozems Umbrisols	Calcisols Retisols Luvisols Cambisols Arenosols Fluvisols Regosols

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having a *spodic* horizon starting ≤ 200 cm from the mineral soil surface. **PODZOLS** *(see pages 184-189)*	Ortsteinic Albic/ Entic Leptic Hortic/ Terric Folic/ Histic Gleyic Stagnic Umbric Glossic/ Retic Alic Hyperskeletic/ Skeletic	Abruptic Arenic/ Loamic/ Siltic Aric Neocambic Densic Drainic Endoeutric Fragic Lamellic Novic Placic Raptic Transportic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having an *abrupt textural difference* ≤ 100 cm from the mineral soil surface; and directly above or below, a layer ≥ 5 cm thick, that has: 1. *stagnic* properties in which the area of reductimorphic colours plus the area of oximorphic colours is ≥ 50% of the layer's total area; *and* 2. *reducing conditions* for some time during the year in the major part of the layer's volume that has the reductimorphic colours. **PLANOSOLS** *(see pages 190-193)*	Thionic Leptic Folic/ Histic Chernic/ Mollic/ Umbric Gleyic Albic Fluvic Columnic Vertic Glossic/ Retic Alic/ Luvic Calcic Dolomitic/ Calcaric Dystric/ Eutric	Alcalic Arenic/ Clayic/ Loamic/ Siltic Aric Chromic Colluvic Densic Drainic Ferric Humic/ Ochric Inclinic Magnesic Nechic Novic Raptic Skeletic Sodic Sulfidic

Overview of Key to Reference Soil Groups		
Histosols	**Andosols**	Calcisols
Anthrosols	Podzols	Retisols
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	Cambisols
Solonetz	Chernozems	Arenosols
Vertisols	Kastanozems	Fluvisols
Solonchaks	Phaeozems	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having a layer starting ≤ 25 cm from the mineral soil surface, that is ≥ 50 cm thick or ≥ 25 cm thick and directly overlies *continuous rock* or *technic hard* material, and that has: 1. *stagnic* properties in which the area of reductimorphic colours plus the area of oximorphic colours is ≥ 50% of the layer's total area; *and* 2. *reducing conditions* for some time during the year in the major part of the layer's volume that has the reductimorphic colours. **STAGNOSOLS** *(see pages 194-195)*	Thionic Fragic Leptic Folic/ Histic Mollic/ Umbric Gleyic Albic Fluvic Vertic Glossic/ Retic Alic/ Luvic Calcic Dolomitic/ Calcaric Dystric/ Eutric	Alcalic Arenic/ Clayic/ Loamic/ Siltic Aric Colluvic Drainic Ferric Humic/ Ochric Inclinic Magnesic Nechic Novic Placic Raptic Rhodic/ Chromic Skeletic Sodic Sulfidic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. a *chernic* horizon; *and* 2. a *calcic* horizon or a layer with *protocalcic* properties starting ≤ 50 cm below the lower limit of the *mollicc* horizon, and if present, above a cemented or indurated layer; *and* 3. a base saturation (by 1 M NH_4OAc, pH 7) of ≥ 50% from the soil surface to the *calcic* horizon or the layer with *protocalcic* properties, throughout. **CHERNOZEMS** *(see pages 196-199)*	Gypsic Calcic Leptic Hortic Gleyic Fluvic Vertic Luvic Skeletic Vermic Haplic	Arenic/ Clayic/ Loamic/ Siltic Cambic Colluvic Densic Hyperhumic Novic Pachic Raptic Endosalic Sodic Stagnic Tonguic

Overview of Key to Reference Soil Groups		
Histosols	Andosols	Calcisols
Anthrosols	Podzols	Retisols
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	Cambisols
Solonetz	**Chernozems**	Arenosols
Vertisols	Kastanozems	Fluvisols
Solonchaks	Phaeozems	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. a *mollic* horizon; and 2. a *calcic* horizon or a layer with *protocalcic properties* starting ≤ 50 cm below the lower limit of the *mollic* horizon, and if present, above a cemented or indurated layer; and 3. a base saturation (by 1 M NH4OAc, pH 7) of ≥ 50% from the soil surface to the calcic horizon or the layer with protocalcic properties, throughout. **KASTANOZEMS** *(see pages 200-201)*	Someric Gypsic Calcic Leptic Hortic/ Terric Gleyic Fluvic Vertic Greyzemic Luvic Skeletic Vermic Haplic	Anthric Arenic/ Clayic/ Loamic/ Siltic Aric Cambic Chromic Colluvic Densic Hyperhumic Novic Oxyaquic Pachic Raptic Endosalic Sodic Stagnic Technic Tephric Tonguic Transportic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. a *mollic* horizon; and 2. a base saturation of ≥ 50% throughout to a depth of 100 cm from the soil surface or to continuous rock, whichever is shallower. **PHAEOZEMS** *(see pages 202-207)*	Rendzic Chernic Endocalcic Leptic Terric Folic Gleyic Stagnic Fluvic Vertic Glossic/ Retic Luvic Cambic Skeletic Vermic Gypsiric Dolomitic/ Calcaric Haplic	Abruptic Albic Anthric Arenic/ Clayic/ Loamic/ Siltic Aric Colluvic Columnic Densic Hyperhumic Nechic Novic Pachic Raptic Relocatic Rhodic/ Chromic Endosalic Sodic Technic Tonguic Transportic

Overview of Key to Reference Soil Groups		
Histosols	Andosols	Calcisols
Anthrosols	Podzols	Retisols
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	Cambisols
Solonetz	Chernozems	Arenosols
Vertisols	Kastanozems	Fluvisols
Solonchaks	**Phaeozems**	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having an *umbric* or *mollic* or *hortic* horizon. **UMBRISOLS** *(see pages 208-209)*	Chernic Fragic Leptic Hortic/ Terric Mollic Folic/ Histic Gleyic Stagnic Fluvic Glossic/ Retic Alic/ Luvic Cambic/ Brunic Skeletic Endodolomitic/ Endocalcaric Haplic	Abruptic Anthric Arenic/ Clayic/ Loamic/ Siltic Aric Colluvic Densic Drainic Hyperdystric/ Endoeutric Hyperhumic Nechic Novic Pachic Raptic Relocatic Rhodic/ Chromic Sulfidic Technic Thionic Transportic

Overview of Key to Reference Soil Groups		
Histosols Anthrosols Technosols Leptosols Solonetz Vertisols Solonchaks Gleysols	Andosols Podzols Planosols Stagnosols Chernozems Kastanozems Phaeozems **Umbrisols**	Calcisols Retisols Luvisols Cambisols Arenosols Fluvisols Regosols

Key to the Reference Soil Groups	Principal qualifiers	Supplementary Qualifiers
Other soils having: 1. both of the following: a. a *calcic* horizon starting ≤ 100 cm from the soil surface; *and* b. no *argic* horizon above the *calcic* horizon unless the *argic* horizon is permeated throughout with secondary carbonate. **CALCISOLS** *(see pages 210-211)*	Leptic Gypsic Luvic Cambic Hyperskeletic/ Skeletic Haplic	Arenic/ Clayic/ Loamic/ Siltic Aric Hypercalcic/ Hypocalcic Densic Fluvic Gleyic Novic Ochric Raptic Rhodic/ Chromic Endosalic Sodic Stagnic Aridic Transportic Vertic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary Qualifiers
Other soils having an *argic* horizon that starts ≤ 100 cm from the soil surface and has *retic* properties at its upper boundary. **RETISOLS** *(see pages 212-213)*	Fragic Glossic Leptic Terric Folic/ Histic Gleyic Stagnic Neocambic Albic Skeletic Endodolomitic/ Endocalcaric Dystric/ Eutric	Abruptic Arenic/ Clayic/ Loamic/ Siltic Aric Colluvic Cutanic Densic Drainic Humic/ Ochric Nechic Novic Raptic Transportic

Overview of Key to Reference Soil Groups		
Histosols	Andosols	Calcisols
Anthrosols	Podzols	**Retisols**
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	Cambisols
Solonetz	Chernozems	Arenosols
Vertisols	Kastanozems	Fluvisols
Solonchaks	Phaeozems	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary Qualifiers
Other soils having an *argic* horizon starting ≤ 100 cm from the soil surface. **LUVISOLS** *(see pages 214-219)*	Abruptic Fragic Leptic Terric Gleyic Stagnic Vertic Lamellic Albic Ferric Rhodic/ Chromic Gypsic Calcic Skeletic Endodolomitic/ Endocalcaric Haplic	Arenic/ Clayic/ Loamic/ Siltic Aric Aridic Neocambic Colluvic Cutanic Densic Epidystric/ Hypereutic Escalic Fluvic Humic/ Ochric Magnesic Nechic Novic Raptic Sodic Technic Transportic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary Qualifiers
Other soils having: 1. a *cambic* horizon a. starting ≤ 50 cm from the soil surface; *and* b. having its lower limit ≥ 25 cm from the soil surface; *or* 2. a *terric* horizon; *or* 3. a *fragic*, *salic*, *thionic* or *vertic* horizon starting ≤ 100 cm from the soil surface. **CAMBISOLS** *(see pages 220-221)*	Fragic Thionic Leptic Terric Folic/ Histic Gleyic Stagnic Fluvic Vertic Rhodic/ Chromic Skeletic Salic Sodic Gypsiric Dolomitic/ Calcaric Dystric/ Eutric	Geoabruptic Alcalic Arenic/Clayic/ Loamic/ Siltic Aric Protocalcic Colluvic Densic Escalic Ferric Humic/ Ochric Magnesic Nechic Novic Raptic Protospodic Sulfidic Aridic Technic Transportic

Overview of Key to Reference Soil Groups		
Histosols	Andosols	Calcisols
Anthrosols	Podzols	Retisols
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	**Cambisols**
Solonetz	Chernozems	Arenosols
Vertisols	Kastanozems	Fluvisols
Solonchaks	Phaeozems	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. a weighted average texture class of loamy sand or coarser, if layers of finer texture have a combined thickness of < 15 cm, to a depth of 100 cm from the mineral soil surface; *and* 2. < 40% (by volume) of coarse fragments in all layers within ≤ 100 cm of the mineral soil surface. **ARENOSOLS** *(see pages 222-223)*	Folic Gleyic Brunic Albic Rhodic/ Chromic/ Rubic Lamellic Endosalic Sodic Fluvic Protic Gypsiric Dolomitic/ Calcaric Dystric/ Eutric	Geoabruptic Aeolic Alcalic Aric Protocalcic Colluvic Humic/ Ochric Nechic Novic Placic Raptic Relocatic Protospodic Stagnic Sulfidic Technic Transportic Aridic

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having *fluvic* material: 1. ≥ 25 cm thick and starting ≤ 25 cm from the mineral soil surface; *or* 2. from the lower limit of a plough layer that is ≤ 40 cm thick, to a depth of ≥ 50 cm from the mineral soil surface. **FLUVISOLS** *(see pages 224-225)*	Subaquatic Pantofluvic/ Anofluvic/ Orthofluvic Leptic Folic/ Histic Gleyic Stagnic Skeletic Sodic Gypsiric Dolomitic/ Calcaric Dystric/ Eutric	Geoabruptic Alcalic Arenic/ Clayic/ Loamic/ Siltic Aric Protocalcic Densic Drainic Humic/ Ochric Limnic Magnesic Nechic Aridic Transportic Protovertic

Overview of Key to Reference Soil Groups		
Histosols	Andosols	Calcisols
Anthrosols	Podzols	Retisols
Technosols	Planosols	Luvisols
Leptosols	Stagnosols	Cambisols
Solonetz	Chernozems	Arenosols
Vertisols	Kastanozems	**Fluvisols**
Solonchaks	Phaeozems	Regosols
Gleysols	Umbrisols	

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils: **REGOSOLS** *(see pages 226-227)*	Leptic Folic Gleyic Stagnic Skeletic Brunic Colluvic Endosalic Sodic Protic Gypsiric Dolomitic/ Calcaric Dystric/ Eutric	Geoabruptic Aeolic Alcalic Arenic/ Clayic/ Loamic/ Siltic Aric Protocalcic Densic Drainic Escalic Fluvic Humic /Ochric Isolatic Lamellic Magnesic Nechic Raptic Relocatic Aridic Technic Toxic Transportic Protovertic

2.5. Definitions of qualifiers

Abruptic (ap) (from Latin *abruptus*, broken away): having an *abrupt textural difference* within ≤ 100 cm of the mineral soil surface.

> **Geoabruptic (go)** (from Greek *gaia*, earth): having an *abrupt textural difference* within ≤ 100 cm of the mineral soil surface that is not associated with the upper limit of an *argic* or *natric* horizon.

Aeolic (ay) (from Greek *aiolos*, wind): having at the soil surface a layer ≥ 10 cm thick, the material of which is deposited by wind and has < 0.6% *soil organic carbon*.

Albic (ab) (from Latin *albus*, white): having a layer of *albic* material ≥ 1 cm thick and starting ≤ 100 cm from the mineral soil surface, that does not contain carbonates, and does not contain gypsum; and that overlies a diagnostic horizon or forms part of a layer with *stagnic* properties.

Alcalic (ax) (from Arabic *al-qali*, salt-containing ash): having:

- a pH (in water) of ≥ 8.5 throughout within ≤ 50 cm of the mineral soil surface, *and*
- an effective base saturation of ≥ 50% in the major part between 20 and 100 cm from the mineral soil surface.

Alic (al) (from Latin *alumen*, alum): having an *argic* horizon starting ≤ 100 cm from the soil surface and having a CEC of ≥ 24 cmolc kg^{-1} clay throughout or to a depth of 50 cm of its upper limit, whichever is thinner; and having an effective base saturation of < 50% in half or more of the part between 50 and 100 cm from the mineral soil surface.

Andic (an) having within ≤ 100 cm of the soil surface one or more layers with *andic* or *vitric* properties with a combined thickness of ≥ 30 cm (in *Cambisols* ≥ 15 cm), of which ≥ 15 cm (in *Cambisols* ≥ 7.5 cm) have *andic* properties.

Protoandic (qa) having within ≤ 100 cm of the soil surface one or more layers with a combined thickness of ≥ 15 cm, and with an Al_{ox} + ½Fe_{ox} value of ≥ 1.2%, a bulk density of ≤ 1 kg dm^{-3}, a phosphate retention of ≥ 55%; and not having a layer with *andic* properties within ≤ 100 cm of the soil surface.

Anthric (ak) (from Greek *anthropos*, human being): having *anthric* properties.

Arenic (ar) (from Latin *arena*, sand): having a texture class of sand or loamy sand in a layer ≥ 30 cm thick, within ≤ 100 cm of the mineral soil surface or in the major part between the mineral soil surface and *continuous rock, technic hard* material starting < 60 cm from the surface.

Aric (ai) (from Latin *arare*, to plough): being ploughed to a depth of ≥ 20 cm from the soil surface.

Aridic (ad) (from Latin *aridus*, dry): having *aridic* properties.

Protoaridic (qd) (from Greek *protou*, before): having a mineral topsoil layer ≥ 5 cm thick, with a Munsell colour value, dry, of ≥ 5 that turns darker on moistening; < 0.4% *soil organic carbon*, a platy structure in ≥ 50% of the volume, a surface crust; and not having *aridic* properties.

Brunic (br) (from Low German *brun*, brown): having a layer ≥ 15 cm thick, and starting ≤ 50 cm from the soil surface, that meets diagnostic criteria 2–4 of the *cambic* horizon but fails diagnostic criterion 1, and does not consist of *albic* material.

Calcaric (ca) (from Latin *calcarius*, containing lime): having *calcaric* material throughout between 20 and 100 cm from the soil surface, or between 20 cm and *continuous rock, or technic hard* material; and not having a *calcic* horizon starting ≤ 100 cm from the soil surface.

Calcic (cc) (from Latin *calx*, lime): having a *calcic* horizon starting ≤ 100 cm from the soil surface.

> **Hypercalcic (jc)** (from Greek *hyper*, over): having a *calcic* horizon with a calcium carbonate equivalent in the fine earth fraction of ≥ 50% (by mass) and starting ≤ 100 cm from the soil surface.
>
> **Hypocalcic (wc)** (from Greek *hyper*, over): having a *calcic* horizon with a calcium carbonate equivalent in the fine earth fraction of < 25% (by mass) and starting ≤ 100 cm from the soil surface.
>
> **Protocalcic (qc)** (from Greek *protou*, before): having a layer with *protocalcic* properties starting ≤ 100 cm from the soil surface; and not having a *calcic* horizon starting ≤ 100 cm from the soil surface.

Cambic (cm) (from Late Latin *cambiare*, to change): having a *cambic* horizon not consisting of *albic* material and starting ≤ 50 cm from the soil surface.

> **Neocambic (nc)** (from Greek *neos*, new): having a *cambic* horizon, not consisting of *albic* material, starting ≤ 50 cm from the soil surface and overlying:
>
> - *albic* material that overlies an *argic*, a *natric* or a *spodic* horizon, *or*
> - a layer with *retic* properties.

Carbonatic (cn) (from Latin *carbo*, coal): having[4] a *salic* horizon with a soil solution (in water) with a pH of ≥ 8.5 and $[HCO_3^-] > [SO_2^-] > 2\times[Cl^-]$ (*in Solonchaks only*).

Carbonic (cx) (from Latin *carbo*, coal): having a layer ≥ 10 cm thick, and starting ≤ 100 cm from the soil surface, with ≥ 20% (by mass) organic carbon that meets the diagnostic criteria of *artefacts*.

Chernic (ch) (from Russian *chorniy*, black): having a *chernic* horizon.

Chloridic (cl) (from Greek *chloros*, yellow-green)₃: having a *salic* horizon with a soil solution (1:1 in water) with [Cl-] > 2×[SO_4^{2-}] > 2×[HCO-] (*in Solonchaks on*ly).

Chromic (cr) (from Greek *chroma*, colour): having between 25 and 150 cm of the soil surface a layer, ≥ 30 cm thick, that has, in ≥ 90% of its exposed area, a Munsell colour hue redder than 7.5YR and a chroma of > 4, both moist.

Clayic (ce) (from English *clay*): having a texture class of clay, sandy clay or silty clay, in a layer ≥ 30 cm thick, within ≤ 100 cm of the mineral soil surface or in the major part between the mineral soil surface and *continuous rock, or technic hard* material starting < 60 cm from the surface.

Colluvic (co) (from Latin *colluvio*, mixture): having *colluvic* material ≥ 20 cm thick, and starting at the mineral soil surface.

Columnic (cu) (from Latin *columna*, column): having a layer ≥ 15 cm thick, and starting ≤ 100 cm from the soil surface, that has a columnar structure.

Cutanic (ct) (from Latin *cutis*, skin): having an *argic* or *natric* horizon that meets diagnostic criterion 2b for the respective horizon.

Densic (dn) (from Latin densus, dense): having natural or artificial compaction ≤ 100 cm from the soil surface to the extent that roots cannot penetrate, or can only penetrate it with severe difficulty (2).

Differentic (df) (from Latin *differentia, difference*): having an argic or natric horizon that meets diagnostic criterion 2a for the respective horizon.

Dolomitic (do) (from the mineral dolomite, named after the French geoscientist *Déodat de Dolomieu*): having *dolomitic* material throughout between 20 and 100 cm from the soil surface or between 20 cm and *continuous rock, or technic hard* material.

Drainic (dr) (from French *drainer*, to drain): having artificial drainage.

Dystric (dy) (from Greek *dys*, bad, and *trophae*, food): having:

- in *Histosols*, a pHwater < 5.5 in half or more of the part with *organic* material, within 100 cm of the soil surface,

- in other soils, an effective base saturation of < 50% in half or more of the part between 20 and 100 cm from the mineral soil surface or the *continuous rock*, *or technic hard* material.

> **Hyperdystric (jd)** (from Greek *hyper*, over): having:
>
> - in *Histosols*, a pHwater < 5.5 throughout in the *organic* material within 100 cm of the soil surface and < 4.5 in some layer with *organic* material within ≤ 100 cm of the soil surface,
>
> - in other soils, an effective base saturation of < 50% throughout between 20 and 100 cm from the mineral soil surface, and < 20% in some layer between 20 and 100 cm from the mineral soil surface.

Ekranic (ek) (from French *écran*, shield): having *technic hard* material starting ≤ 5 cm from the soil surface (*in Technosols only*).

Entic (et) (from Latin *recens*, young): having a loose *spodic* horizon and not having a layer with *albic* material (*in Podzols only*).

Escalic (ec) (from Spanish *escala*, terrace): occurring in human-made terraces.

Eutric (eu) (from Greek *eu*, good, and *trophae*, food): having:

- in *Histosols*, a pHwater ≥ 5.5 in the major part with *organic* material within 100 cm of the soil surface,
- in other soils, an effective base saturation of ≥ 50% in the major part between 20 and 100 cm from the mineral soil surface, *continuous rock*, or *technic hard* material.

Hypereutric (je) (from Greek *hyper*, over): having:

- in *Histosols*, a pHwater ≥ 5.5 throughout in the *organic* material within 100 cm of the soil surface and ≥ 6.5 in some layer with *organic* material within ≤ 100 cm of the soil surface,

- in other soils, an effective base saturation of ≥ 50% throughout between 20 and 100 cm from the mineral soil surface and ≥ 80% in some layer between 20 and 100 cm from the surface.

Evapocrustic (ev) (from Latin *e*, out, and *vapor*, steam, and *crusta*, crust): having a saline crust ≤ 2 cm thick, on the soil surface (*in Solonchaks only*).

Ferric (fr) (from Latin *ferrum*, iron): having a *ferric* horizon starting ≤ 100 cm of the soil surface (2).

Manganiferric (mf): having a *ferric* horizon starting ≤ 100 cm from the soil surface in which ≥ 50% of the concretions and/or nodules and/or mottles are black.

Ferritic (fe) (from Latin *ferrum*, iron): having a layer ≥ 30 cm thick, and starting ≤ 100 cm from the soil surface, with Fedith in the fine earth fraction of ≥ 10%.

Fibric (fi) (from Latin *fibra*, fiber): having, after rubbing, two-thirds or more (by volume) of the *organic* material consisting of recognizable plant tissue within 100 cm of the soil surface (*in Histosols only*).

Floatic (ft) (from English *to float*): having *organic* material floating on water (*in Histosols only*).

Fluvic (fv) (from Latin *fluvius*, river): having *fluvic* material ≥ 25 cm thick, and starting ≤ 75 cm from the mineral soil surface.

Folic (fo) (from Latin *folium*, leaf): having a *folic* horizon at the surface.

Fractic (fc) (from Latin *fractus*, broken): having a layer ≥ 10 cm thick, and starting ≤ 100 cm from the soil surface, consisting of a broken cemented or indurated horizon, the remnants of which:

- occupy a volume of ≥ 40%, *and*
- have an average horizontal length of < 10 cm and/or occupy a volume of < 80%.

Fragic (fg) (from Latin *fragilis*, fragile): having a *fragic* horizon starting ≤ 100 cm from the soil surface.

Fulvic (fu) having a *fulvic* horizon starting ≤ 30 cm from the soil surface.

Garbic (ga) (from English *garbage*): having a layer ≥ 20 cm thick, within ≤ 100 cm of the soil surface, with ≥ 20% (by volume, weighted average) *artefacts* containing ≥ 35% (by volume) organic waste (*in Technosols only*).

Gilgaic (gg) (from Aboriginal Australian *gilgai*, water hole): having at the soil surface, microhighs and microlows with a difference in level of ≥ 10 cm, i.e. gilgai microrelief (*in Vertisols only*).

Gleyic (gl) (from Russian *gley*, mucky soil mass): having a layer ≥ 25 cm, and starting ≤ 75 cm from the mineral soil surface, that has *gleyic* properties throughout and *reducing conditions* in some parts of every sublayer.

Glossic (gs) (from Greek *glossa*, tongue): having *albeluvic glossae* starting ≤ 100 cm from the soil surface.

Greyzemic (gz) (from English grey, and Russian zemlya, earth): having uncoated silt and sand grains on structural faces in the lower half of a mollic horizon.

Gypsic (gy) (from Greek *gypsos*, gypsum): having a *gypsic* horizon starting ≤ 100 cm from the soil surface.

Hypogypsic (wg) (from Greek *hypo*, under): having a *gypsic* horizon with a gypsum content in the fine earth fraction of < 25% (by mass) and starting ≤ 100 cm from the soil surface.

Gypsiric (gp) (from Greek *gypsos*, gypsum): having *gypsiric* material throughout between 20 and 100 cm from the soil surface or between 20 cm and *continuous rock, or technic hard* material; and not having a *gypsic* horizon starting ≤ 100 cm from the soil surface.

Haplic (ha) (from Greek *haplous*, simple): having a typical expression of certain features (typical in the sense that there is no further or meaningful characterization) and only used if none of the preceding qualifiers applies.

Hemic (hm) (from Greek *hemisys*, half): having, after rubbing, less than two-thirds and one-sixth or more (by volume) of the *organic* material consisting of recognizable plant tissue within 100 cm of the soil surface (*in Histosols only*).

Histic (hi) (from Greek *histos*, tissue): having a *histic* horizon starting at the soil surface.

Hortic (ht) (from Latin *hortus*, garden): having a *hortic* horizon.

Humic (hu) (from Latin *humus*, earth): having ≥ 1% *soil organic carbon* in the fine earth fraction as a weighted average to a depth of 50 cm from the mineral soil surface.

Hyperhumic (jh) (from Greek *hyper*, over): having ≥ 5% *soil organic carbon* in the fine earth fraction as a weighted average to a depth of 50 cm from the mineral soil surface.

Hyperartefactic (ja) (from Greek *hyper*, over, and Latin *ars*, art, and *factus*, made): having ≥ 50% (by volume, weighted average) *artefacts* within 100 cm of the soil surface or to *continuous rock*, or *technic hard* material, whichever is shallower (*in Technosols only*).

Hypercalcic (jc): *see Calcic*.

Hypereutric (je): *see Eutric.*

Hyperhumic (jh): *see Humic*.

Hyperorganic (jo) (from Greek *hyper*, over, and *organon*, tool): having *organic* material ≥ 200 cm thick (*in Histosols only*).

Hyperskeletic (jk) (from Greek *hyper*, over, and *skeletos*, dried out): having < 20% (by volume) fine earth, averaged over a depth of 75 cm from the soil surface or to *continuous rock*, or *technic hard* material, whichever is shallower.

Hypocalcic (wc): *see Calcic*.

Hypogypsic (wg): *see Gypsic*.

Immissic (im) (from Latin *immissus*, sent inside): having at the soil surface a layer ≥ 10 cm thick, with ≥ 20% (by mass) recently sedimented dust, soot or ash that meets the criteria of *artefacts*.

Inclinic (ic) (from Latin *inclinare*, to bow): having

- a slope inclination of ≥ 5%, *and*
- a layer ≥ 25 cm thick, and starting ≤ 75 cm from the mineral soil surface, with *gleyic* or *stagnic* properties and a subsurface water flow for some time of the year.

Isolatic (il) (from Italian *isola*, island): having, above *technic hard* material, above a geomembrane or above a continuous layer of *artefacts* starting ≤ 100 cm from the soil surface, soil material containing fine earth without any contact to other soil material containing fine earth (e.g. soils on roofs or in pots).

Lamellic (ll) (from Latin *lamella*, metal blade): having two or more lamellae (≥ 0.5 and < 7.5 cm thick) that have higher clay contents than

the directly overlying layers as stated in the diagnostic criteria 2a of the *argic* horizon, with a combined thickness of ≥ 5 cm; the uppermost lamella starting ≤ 100 cm from the soil surface.

Leptic (le) (from Greek *leptos*, thin): having *continuous rock* or *technic hard* material starting ≤ 100 cm from the soil surface.

> **Technoleptic (tl)** (from Greek *technae*, art): having *technic hard* material starting ≤ 100 cm from the soil surface.

Lignic (lg) (from Latin *lignum*, wood): having inclusions of intact wood fragments that make up ≥ 25% of the soil volume, within 50 cm from the soil surface (*in Histosols only*).

Limnic (lm) (from Greek *limnae*, pool): having one or more layers with *limnic* material with a combined thickness of ≥ 10 cm within ≤ 50 cm of the soil surface.

Linic (lc) (from Latin *linea*, line): having a continuous, very slowly permeable to impermeable constructed geomembrane of any thickness starting ≤ 100 cm from the soil surface.

Lithic (li) (from Greek *lithos*, stone): having *continuous rock* or *technic hard* material starting ≤ 10 cm from the soil surface (*in Leptosols only*).

Loamic (lo) (from English *loam*): having a texture class of loam, sandy loam, sandy clay loam, clay loam or silty clay loam in a layer ≥ 30 cm thick, within ≤ 100 cm of the mineral soil surface or in the major part between the mineral soil surface and *continuous rock, or technic hard* material starting < 60 cm from the surface.

Luvic (lv) (from Latin *eluere*, to wash): having an *argic* horizon starting ≤ 100 cm from the soil surface and having a CEC of ≥ 24 $cmol_c$ kg^{-1} clay throughout or to a depth of 50 cm of its upper limit, whichever is thinner; and having an effective base saturation of ≥ 50% in the major

part between 50 and 100 cm from the mineral soil surface *or* in the lower half of the mineral soil above *continuous rock*.

Magnesic (mg) (from the chemical element *magnesium* – no agreed etymology): having an exchangeable Ca to Mg ratio of < 1 in the major part within 100 cm of the soil surface or to *continuous rock*.

Mawic (mw) (from Kiswahili *mawe*, stones): having a layer of coarse fragments, the interstices of which are filled with *organic* material, and that is directly overlain by *organic* material (*in Histosols only*).

Melanic (ml) having a *melanic* horizon starting ≤ 30 cm from the soil surface (in *Andosols* only).

Mesotrophic (ms) (from Greek *mesos*, middle, and *trophae*, food): having an effective base saturation of < 75% at a depth of 20 cm from the soil surface (*in Vertisols only*).

Mineralic (mi) (from Celtic *mine*, mineral): having, within ≤ 100 cm of the soil surface, one or more layers of *mineral* material with a combined thickness of ≥ 20 cm, in between layers of *organic* material (*in Histosols only*).

Mollic (mo) (from Latin *mollis*, soft): having a *mollic* horizon.

> **Anthromollic (am)** (from Greek *anthropos*, human being): having a *mollic* horizon and *anthric* properties .

Murshic (mh) (from Polish *mursz*, decay): having a drained *histic* horizon ≥ 20 cm thick, and starting ≤ 10 cm from the soil surface or below a *folic* horizon, with a bulk density of ≥ 0.2 kg dm^{-3} and one or both of the following (*in Histosols only*):

- moderate to strong granular or blocky structure, *or*
- cracks

Natric (na) (from Arabic *natroon*, salt): having a *natric* horizon starting ≤ 100 cm from the soil surface.

Nechic (ne) (from Amharic nech, white): having uncoated mineral grains of silt or sand size in a darker matrix somewhere within ≤ 5 cm of the mineral soil surface.

Neocambic (nc): *see Cambic*.

Novic (nv) (from Latin *novus*, new): having a layer, ≥ 5 cm and < 50 cm thick, overlying a buried soil.

> **Areninovic (aj)** (from Latin *arena*, sand): having a layer, ≥ 5 cm and < 50 cm thick, with a texture class of sand or loamy sand in its major part, overlying a buried soil.
>
> **Clayinovic (cj)** (from English *clay*): having a layer, ≥ 5 cm and < 50 cm thick, with a texture class of clay, sandy clay or silty clay in its major part, overlying a buried soil.
>
> **Loaminovic (lj)** (from English *loam*): having a layer, ≥ 5 cm and < 50 cm thick, with a texture class of loam, sandy loam, sandy clay loam, clay loam or silty clay loam in its major part, overlying a buried soil.
>
> **Siltinovic (sj)** (from English *silt*): having a layer, ≥ 5 cm and < 50 cm thick, with a texture class of silt or silt loam in its major part, overlying a buried soil.

Ochric (oh) (from Greek *ochros*, pale): having ≥ 0.2 % *soil organic carbon* (weighted average) in the layer from the mineral soil surface to a depth of 10 cm; and not having a *mollic* or *umbric* horizon and not fulfilling the set of criteria of the Humic qualifier.

Ombric (om) (from Greek *ombros*, rain): having a *histic* horizon saturated predominantly with rainwater (*in Histosols only*).

Ortsteinic (os) (from German *Ortstein*, locally occurring stone): having a *spodic* horizon that has a subhorizon, ≥ 2.5 cm thick, that is cemented in ≥ 50% of its horizontal extension (*in Podzols only*).

Pachic (ph) (from Greek *pachys*, thick): having a *mollic* or *umbric* horizon ≥ 50 cm thick.

Pellic (pe) (from Greek *pellos*, dusty): having in the upper 30 cm of the soil a Munsell colour value of ≤ 3 and a chroma of ≤ 2, both moist (*in Vertisols only*)

Placic (pi) (from Greek *plax*, flat stone): having a layer, between ≥ 0.1 and < 2.5 cm thick, within ≤ 100 cm of the mineral soil surface, that is cemented or indurated by a combination of organic matter, Fe, Mn and/or Al and is continuous to the extent that vertical fractures, if present, have an average horizontal spacing of ≥ 10 cm and occupy < 20% (by volume).

Protic (pr) (from Greek *protou*, before): showing no soil horizon development, with the exception of a *cryic* horizon, which may be present.

Protoandic (qa) see *Andic*.

Protocalcic (qc): *see Calcic.*

Protospodic (qp): *see Spodic*.

Prototephric (qf) see *Tephric*.

Protovertic (qv): *see Vertic.*

Raptic (rp) (from Latin *raptus*, broken): having a *lithic discontinuity* at some depth ≤ 100 cm from the mineral soil surface.

Relocatic (rc) (from Latin *re*, again, and *locatus*, put): being in situ remodelled by human activity to a depth of ≥ 100 cm (e.g. by deep ploughing, refilling soil pits or levelling land) and no horizon development after remodelling throughout, at least between 20 cm and 100 cm from the soil surface or between the lower limit of any plough layer, > 20 cm thick, and 100 cm from the soil surface (in *Technosols*, Relocatic is redundant, except in combination with the Ekranic or Linic qualifier); a destroyed diagnostic subsurface horizon may be added with a hyphen, e.g. Spodi-Relocatic, Spodi-Epirelocatic.

Rendzic (rz) (from Polish *rzendzic*, to grate in contact with a plough blade): having a *mollic* horizon that contains or directly overlies *calcaric* material containing ≥ 40% calcium carbonate equivalent or that directly overlies calcareous rock containing ≥ 40% calcium carbonate equivalent.

> **Somerirendzic (sr)** (from Spanish somero, superficial): having a mollic horizon, < 20 cm thick, that directly overlies calcareous rock containing ≥ 40% calcium carbonate equivalent.

Retic (rt) (from Latin *rete*, net): having *retic* properties starting ≤ 100 cm from the soil surface, but not having *albeluvic glossae*.

Rheic (rh) (from Greek *rhen*, to flow): having a *histic* horizon saturated predominantly with groundwater or flowing water (*in Histosols only*).

Rhodic (ro) (from Greek *rhodon*, rose): having between 25 and 150 cm of the soil surface, a layer ≥ 30 cm thick, that has, in ≥ 90% of its exposed area, a Munsell colour hue redder than 5YR moist, a value of < 4 moist, and a value dry, no more than one unit higher than the moist value .

Rockic (rk) (from English *rock*): having *continuous rock* or *technic hard* material that is directly overlain by *organic* material (*in Histosols only*).

Rubic (ru) (from Latin *ruber*, red): having between 25 and 100 cm of the soil surface, a layer ≥ 30 cm thick, that does not consist of *albic* material and that has, in ≥ 90% of its exposed area, a Munsell colour hue redder than 10YR and/or a chroma of ≥ 5, both moist (*in Arenosols only*).

Salic (sz) (from Latin *sal*, salt): having a *salic* horizon starting ≤ 100 cm from the soil surface.

> **Hypersalic (jz)** (from Greek *hyper*, over): having within ≤ 100 cm of the soil surface a layer that has an ECe of ≥ 30 dS m^{-1} at 25 °C.
>
> **Protosalic (qz)** (from Greek *protou*, before): having within ≤ 100 cm of the soil surface a layer that has an ECe of ≥ 4 dS m^{-1} at 25 °C; and not having a *salic* horizon starting ≤ 100 cm from the soil surface.

Sapric (sa) (from Greek *sapros*, rotted): having, after rubbing, less than one-sixth (by volume) of the *organic* material consisting of recognizable plant tissue within 100 cm of the soil surface (*in Histosols only*).

Silandic (sn): having one or more layers with a combined thickness of ≥ 15 cm with *andic* properties and a Si_{ox} content of ≥ 0.6% or an Al_{py}/Al_{ox} of < 0.5 within ≤ 100 cm of the soil surface (in Andosols only).

Siltic (sl) (from English *silt*): having a texture class of silt or silt loam in a layer ≥ 30 cm thick, within ≤ 100 cm of the mineral soil surface or in the major part between the mineral soil surface and *continuous rock*.

Skeletic (sk) (from Greek *skeletos*, dried out): having ≥ 40% (by volume) coarse fragments averaged over a depth of 100 cm from the soil surface or to *continuous rock or technic hard* material, whichever is shallower.

Akroskeletic (kk) (from Greek *akra*, top): having ≥ 40% of the soil surface covered by fragments that have a greatest dimension ≥ 6 cm (stones, boulders or large boulders).

Orthoskeletic (ok) (from Greek *orthos*, right): having:

- ≥ 40% of the soil surface covered by fragments that have a greatest dimension ≥ 6 cm (stones, boulders or large boulders), *and*
- ≥ 40% (by volume) coarse fragments averaged over a depth of 100 cm from the soil surface or to *continuous rock or technic hard* material, whichever is shallower.

Sodic (so) (from Spanish *soda*, gaseous water): having a layer ≥ 20 cm thick, and starting ≤ 100 cm from the soil surface, that has ≥ 15% Na plus Mg and ≥ 6% Na on the exchange complex; and not having a *natric* horizon starting ≤ 100 cm from the soil surface.

Argisodic (as) (from Latin *argilla*, white clay): having an *argic* horizon, starting ≤ 100 cm from the soil surface, that has ≥ 15% Na plus Mg and ≥ 6% Na on the exchange complex throughout the *argic* horizon or within its upper 40 cm, whichever is thinner.

Protosodic (qs) (from Greek *protou*, before): having a layer ≥ 20 cm thick, and starting ≤ 100 cm from the soil surface, that has ≥ 6% Na on the exchange complex; and not having a *natric* horizon starting ≤ 100 cm from the soil surface.

Somerirendzic (sr): *see Rendzic.*

Spodic (sd) (from Greek *spodos*, wood ash): having a *spodic* horizon starting ≤ 200 cm from the mineral soil surface.

Protospodic (qp) (from Greek *protou*, before): having a layer ≥ 2.5 cm thick, and starting ≤ 100 cm from the mineral soil surface, with:

- ≥ 0.5% *soil organic carbon* in its uppermost 1 cm, *and*
- an Al_{ox} + ½Fe_{ox} value of ≥ 0.5% that is ≥ 2 times higher than the lowest Al_{ox} + ½Fe_{ox} value of all overlying mineral layers; *and*

not having a *spodic* horizon starting ≤ 200 cm from the mineral soil surface.

Spolic (sp) (from Latin *spoliare*, to exploit): having a layer ≥ 20 cm thick, within ≤ 100 cm of the soil surface, with ≥ 20% (by volume, weighted average) *artefacts* containing ≥ 35% (by volume) industrial waste (mine spoil, dredgings, slag, ash, rubble, etc.) (*in Technosols only*).

Stagnic (st) (from Latin *stagnare*, to stagnate): having a layer ≥ 25 cm thick, and starting ≤ 75 cm from the mineral soil surface, that does not form part of a *hydragric* horizon and that has:

- *stagnic* properties in which the area of reductimorphic colours plus the area of oximorphic colours is ≥ 25% of the layer's total area, *and*
- *reducing conditions* for some time during the year in the major part of the layer's volume that has the reductimorphic colours.

Protostagnic (qw) (from Greek *protou*, before): having a layer ≥ 25 cm thick, and starting ≤ 75 cm from the mineral soil surface, that does not form part of a *hydragric* horizon and that has:

- *stagnic* properties in which the area of reductimorphic colours plus the area of oximorphic colours is ≥ 10% and < 25% of the layer's total area, *and*
- *reducing conditions* for some time during the year in the major part of the layer's volume that has the reductimorphic colours.

Subaquatic (sq) (from Latin *sub*, under, and *aqua*, water): being permanently submerged by water not deeper than 200 cm.

Sulfatic (su) (from Latin *sulpur*, sulfur): having a *salic* horizon with a soil solution (1:1 in water) with $[SO_4^{2-}] > 2\times [HCO_3^-] > 2\times [Cl^-]$ (*in Solonchaks only*).

Sulfidic (sf) (from Latin *sulpur*, sulfur): having *sulfidic* material ≥ 15 cm thick, and starting ≤ 100 cm from the soil surface.

> **Hyposulfidic (ws)** (from Greek *hypo*, under): having *hyposulfidic* material ≥ 15 cm thick, and starting ≤ 100 cm from the soil surface.

Technic (te) (from Greek *technae*, art): having ≥ 10% (by volume, weighted average) *artefacts* in the upper 100 cm from the soil surface or to *continuous rock*; or having a layer ≥ 10 cm thick, and starting ≤ 90 cm from the soil surface, with ≥ 50% (by volume, weighted average) *artefacts*.

> **Hypertechnic (jt)** (from Greek *hyper*, over): having ≥ 20% (by volume, weighted average) *artefacts* in the upper 100 cm from the soil surface or to *continuous rock*.
>
> **Prototechnic (qt)** (from Greek *protou*, before): having ≥ 5% (by volume, weighted average) *artefacts* in the upper 100 cm from the soil surface or to *continuous rock*; or having a layer ≥ 10 cm thick, and starting ≤ 90 cm from the soil surface, with ≥ 25% (by volume, weighted average) *artefacts*.

Technoleptic (tl): *see Leptic.*

Tephric (tf) having *tephric* material ≥ 10 cm thick and to a depth of ≥ 30 cm from the soil surface or to continuous rock.

Prototephric (qf) having a layer with *tephric* material ≥ 10 and < 30 cm thick and not reaching continuous rock.

Terric (tr) (from Latin *terra*, earth): having a *terric* horizon, *and*

- in Anthrosols, not having a *hortic*, *irragric*, *plaggic* or *pretic* horizon with a thickness of ≥ 50 cm, *and*
- in other soils, not having a *hortic*, *irragric*, *plaggic* or *pretic* horizon.

Thionic (ti) (from Greek *theion*, sulfur): having a *thionic* horizon starting ≤ 100 cm from the soil surface.

Hypothionic (wi) (from Greek *hypo*, under): having a *thionic* horizon starting ≤ 100 cm from the soil surface and having a pH (1:1 in water) between ≥ 3.5 and < 4.

Thixotropic (tp) having in some layer within ≤ 50 cm of the soil surface, material that changes, under pressure or by rubbing, from a plastic solid into a liquefied stage and back into the solid condition.

Tonguic (to) (from English *tongue*): showing tonguing of a *chernic*, *mollic* or *umbric* horizon into an underlying layer.

Toxic (tx) (from Greek *toxikon*, arrow poison): having in some layer within ≤ 50 cm of the soil surface, toxic concentrations of organic or inorganic substances other than ions of Al, Fe, Na, Ca and Mg, or having radioactivity dangerous to humans.

Phytotoxic (yx) (from Greek *phyton*, plant): having in some layer within ≤ 50 cm of the soil surface, sufficiently high concentrations of ions other than Al, Fe, Na, Ca and Mg, to markedly affect plant growth.

Zootoxic (zx) (from Greek *zoae*, life): having in some layer within ≤ 50 cm of the soil surface, sufficiently high and persistent concentrations of organic or inorganic substances

to markedly affect the health of animals, including humans, that ingest plants grown on these soils.

Transportic (tn) (from Latin *transportare*, to transport): having at the soil surface a layer ≥ 20 cm thick, or with a thickness of ≥ 50% of the entire soil if *continuous rock or technic hard* material if starting ≤ 40 cm from the soil surface, with soil material that does not meet the criteria of *artefacts*; and that has been moved from a source area outside the immediate vicinity of the soil by intentional human activity, usually with the aid of machinery, and without substantial reworking or displacement by natural forces.

Organotransportic (ot) (from Greek *organon*, tool): having at the soil surface a layer ≥ 20 cm thick, or with a thickness of ≥ 50% of the entire soil if *continuous rock or technic hard* material is starting ≤ 40 cm from the soil surface, with *organic* material that does not meet the criteria of *artefacts;* and that has been moved from a source area outside the immediate vicinity of the soil by intentional human activity, usually with the aid of machinery, and without substantial reworking or displacement by natural forces.

Umbric (um) (from Latin *umbra*, shade): having an *umbric* horizon.

Anthroumbric (aw) (from Greek *anthropos*, human being): having an *umbric* horizon and *anthric* properties.

Urbic (ub) (from Latin *urbs*, city): having a layer ≥ 20 cm thick, within ≤ 100 cm of the soil surface, with ≥ 20% (by volume, weighted average) *artefacts* containing ≥ 35% (by volume) rubble and refuse of human settlements (*in Technosols only*).

Uterquic (uq) (from Latin *uterque*, both): having a layer with dominant *gleyic* properties and some parts with *stagnic* properties.

Vermic (vm) (from Latin *vermis*, worm): having ≥ 50% (by volume, weighted average) of worm holes, casts, or filled animal burrows in the upper 100 cm of the soil or to *continuous rock*, *technic hard* material or a cemented or indurated layer, whichever is shallower.

Vertic (vr) (from Latin *vertere*, to turn): having a *vertic* horizon starting ≤ 100 cm from the soil surface (2).

> **Protovertic (qv)** (from Greek *protou*, before): having a *protovertic* horizon starting ≤ 100 cm from the soil surface; and not having a *vertic* horizon starting ≤ 100 cm from the soil surface.

Vitric (vi) having within ≤ 100 cm of the soil surface, one or more layers with *andic* or *vitric* properties with a combined thickness of ≥ 30 cm (in *Cambisols* ≥ 15 cm), of which ≥ 15 cm (in *Cambisols* ≥ 7.5 cm) have *vitric* properties.

2.6. Summary of analytical procedures for soil characterization

Summary of recommended analytical procedures to be used for soil characterization for the World Reference Base for Soil Resources. Full descriptions can be found in *Procedures for soil analysis* (Van Reeuwijk, 2002) and the USDA *Soil Survey Laboratory Methods Manual* (Burt, 2004).

Sample preparation

Samples are air-dried or alternatively oven-dried at a maximum of 40 °C. The fine earth fraction is obtained by sieving the dry sample with a 2 mm sieve. Clods not passing through the sieve are crushed (not ground) and sieved again. Gravel, rock fragments, etc. not passing through the sieve are treated separately.

In special cases where air-drying causes unacceptable irreversible changes in certain soil properties (e.g. in peat and soils with *andic* properties), samples are kept and treated in the field-moist state.

Moisture content

Calculation of results of soil analyses is done on the basis of *oven-dry* (105 °C) soil mass.

Particle-size analysis

The mineral part of the soil is separated into various size fractions and the proportion of these fractions is determined. The determination comprises all material, i.e. including gravel and coarser material, but the procedure itself is applied to the fine earth (< 2 mm) only.

The pre-treatment of the sample is aimed at complete dispersion of the primary particles. Therefore, cementing materials (usually of secondary origin) such as organic matter and calcium carbonate may have to be removed. In some cases, de-ferration also needs to be applied. However, depending on the aim of study, it may be fundamentally wrong to remove cementing materials. Thus, all pre-treatments are considered optional. However, for soil characterization purposes, removal of organic matter by H_2O_2 and of carbonates by HCl is routinely carried out. After this pre-treatment, the sample is shaken with a dispersing agent and sand is separated from clay and silt with a 63 μm sieve. The sand is fractionated by dry sieving; the clay and silt fractions are determined by the pipette method or alternatively, by the hydrometer method.

Water-dispersible clay

This is the clay content found when the sample is dispersed with water without any pre-treatment to remove cementing compounds and without use of a dispersing agent. The proportion of natural clay to total clay can be used as a structure stability indicator.

Soil water retention

The water content is determined of soil samples that have been equilibrated with water at various suction (tension) values. For low suction values, undisturbed core samples are equilibrated on a silt and kaolin bath; for high suction values, disturbed samples are equilibrated in pressure plate extractors. The bulk density is calculated from the core sample mass.

Bulk density

Soil bulk density is the mass per unit volume of soil. As bulk density changes with water content, the water status of the sample must be specified.

Two different procedures can be used:

- **Undisturbed core samples**. A metal cylinder of known volume is pressed into the soil. The moist sample mass is recorded. This may be the field-moist state or the state after equilibrating the sample at a specified water tension. The sample is then oven-dried and weighed again. The bulk density is the ratio of dry mass to volume at the determined water content and/or the specified water tension.

- **Coated clods**. Field-occurring clods are coated with plastic lacquer (e.g. Saran dissolved in methyl ethyl ketone) to allow determination of underwater mass. This gives the volume of the clod. The moist sample mass is recorded. This may be the field-moist state or the state after equilibrating the clod at specified water suction. The sample is then oven-dried and weighed again. The bulk density is the ratio of dry mass to volume at the specified water suction.

Note: The determination of bulk density is very sensitive to errors, particularly caused by non-representativeness of the samples (stones, cracks, roots, etc.). Therefore, determinations should always be made in triplicate or more.

Coefficient of linear extensibility (COLE)

The COLE gives an indication of the reversible shrink–swell capacity of a soil. It is calculated from the dry bulk density and the bulk density at 33 kPa water suction. The COLE value is expressed in centimetres per centimetre or as a percentage value.

pH

The pH of the soil is potentiometrically measured in the supernatant suspension of a soil:liquid mixture. If not stated otherwise, soil:liquid are in a ratio of 1:5 (volume:volume) (according to ISO standards). The liquid is either distilled water

(pHwater) or a 1 M KCl solution (pHKCl). However, in some definitions, a 1:1 soil:water ratio is used.

Organic carbon

The Walkley–Black procedure is followed. This involves a wet combustion of the organic matter with a mixture of potassium dichromate and sulfuric acid at about 125°C. The residual dichromate is titrated against ferrous sulfate. To compensate for incomplete destruction, an empirical correction factor of 1.3 is applied in the calculation of the result.

Note: Other procedures, including carbon analysers (e. g. dry combustion) may also be used. In these cases a qualitative test for carbonates on effervescence with HCl is recommended, and if applicable, a correction for inorganic C (see Carbonate below) is required.

Carbonates

The rapid titration method by Piper (also called acid neutralization method) is used. The sample is treated with dilute HCl and the residual acid is titrated. The results are referred to as calcium carbonate equivalent as the dissolution is not selective for calcite and also other carbonates such as dolomite are dissolved to some extent.

Note: Other procedures such as the Scheibler volumetric method or the Bernard calcimeter may also be used.

Gypsum

Gypsum is dissolved by shaking the sample with water. It is then selectively precipitated from the extract by adding acetone. This precipitate is re-dissolved in water and the Ca concentration is determined as a measure for gypsum.

Cation exchange capacity (CEC) and exchangeable bases

The ammonium acetate pH 7 method is used. The sample is leached with ammonium acetate (pH 7) and the bases are measured in the percolate. The sample is subsequently leached with sodium acetate (pH 7), the excess salt is then removed and the adsorbed Na exchanged by leaching with ammonium acetate (pH 7). The Na in this percolate is a measure for the CEC.

Alternatively, after leaching with ammonium acetate, the sample can be washed free of excess salt, the whole sample distilled and the evolved ammonia determined.

Leaching in tubes may also be replaced by shaking in flasks. Each extraction must be repeated three times and the three extracts should be combined for analysis.

Note 1: Other procedures for CEC may be used provided the determination is done at pH 7.

Note 2: In special cases where CEC is not a diagnostic criterion, e.g. saline and alkaline soils, the CEC may be determined at pH 8.2.

Note 3: Where low-activity clays are involved, the CEC of the organic matter has to be deducted. This can be done by the graphical method (FAO, 1966), or by analysing the CEC of the organic matter or the mineral colloids separately.

Exchange acidity and exchangeable aluminium

Exchange acidity (H + Al) and exchangeable Al are released upon exchange by an unbuffered 1 M KCl solution. Exchange acidity may also be designated actual acidity (as opposed to potential or extractable acidity).

Base saturation and effective base saturation

WRB2014/2015 uses two different types of base saturation.

First, the **effective base saturation** is used to separate Acrisols from Lixisols, Alisols from Luvisols and the Dystric qualifier from the Eutric qualifier. It is defined in WRB as:

exchangeable (Ca+Mg+K+Na) / exchangeable (Ca+Mg+K+Na+Al),

where: exchangeable bases are extracted by 1 M NH_4OAc (pH 7) and exchangeable Al - by 1 M KCl (unbuffered).

Second, the **base saturation** (pH 7) is used for all other purposes. It is defined in WRB as:

exchangeable (Ca+Mg+K+Na) / CEC (pH 7)

where: CEC and exchangeable bases are extracted by 1 M NH_4OAc (pH 7).

Note: The base saturation of saline, calcareous and gypseous soils can be considered to be 100%.

Extractable iron, aluminium, manganese and silicon

These analyses comprise:

- Fe_{dith}, Al_{dith}, Mn_{dith}: Free Fe, Al and Mn compounds in the soil extracted by a dithionite-citrate-bicarbonate solution. (Both the Mehra and Jackson and the Holmgren procedures may be used.)

- Fe_{ox}, Al_{ox}, Si_{ox}: Active, short-range-order or amorphous Fe, Al and Si compounds extracted by an acid ammonium oxalate solution (pH 3). (Blakemore et al., 1987.)

- Fe_{py}, Al_{py}: Organically bound Fe and Al extracted by a pyrophosphate solution.

Salinity

Attributes associated with salinity in soils are determined in the saturation extract. The attributes include: pH, electrical conductivity (ECe), sodium adsorption ratio (SAR) and the cations and anions of the dissolved salts. These include Ca, Mg, Na, K, carbonate and bicarbonate, chloride, nitrate and sulfate. The SAR and the exchangeable sodium percentage (ESP) may be estimated from the concentrations of the dissolved cations.

Phosphate and phosphate retention

These analyses comprise:

- **Olsen method**: Extraction with a 0.5 M $NaHCO_3$ solution at pH 8.5 (Olsen et al. 1954).

- **Citric acid method**: Extraction with a 1% citric acid solution (Blanck, 1931; van Reeuwijk, 2002).

- **Mehlich 1 method**: Extraction with a solution of 0.05 M HCl and 0.025 M H_2SO_4 (Mehlich, 1953).

- For phosphate retention, the **Blakemore procedure** is used. The sample is equilibrated with a phosphate solution at pH 4.6 and the proportion of phosphate withdrawn from solution is determined (Blakemore et al., 1987).

Optical density of oxalate extract (ODOE)

The sample is percolated or shaken with an acid ammonium oxalate solution (pH 3). The optical density of the extract is measured at 430 nm wavelength.

Melanic index

The sample is shaken with a 0.5 M NaOH solution and the absorbance of the extract is measured at 450 and 520 nm, respectively. The melanic index is obtained by dividing the absorbance at 450 nm by the absorbance at 520 nm.

Sulfides

Reduced inorganic S is converted to H_2S by a hot acidic $CrCl_2$ solution. The evolved H_2S is trapped quantitatively in a Zn acetate solution as solid ZnS. The ZnS is then treated with HCl to release H_2S into solution, which is quickly titrated with I_2 solution to the blue-coloured end point indicated by the reaction of I_2 with starch (Sullivan et al., 2000). Caution: Toxic residues have to be managed carefully.

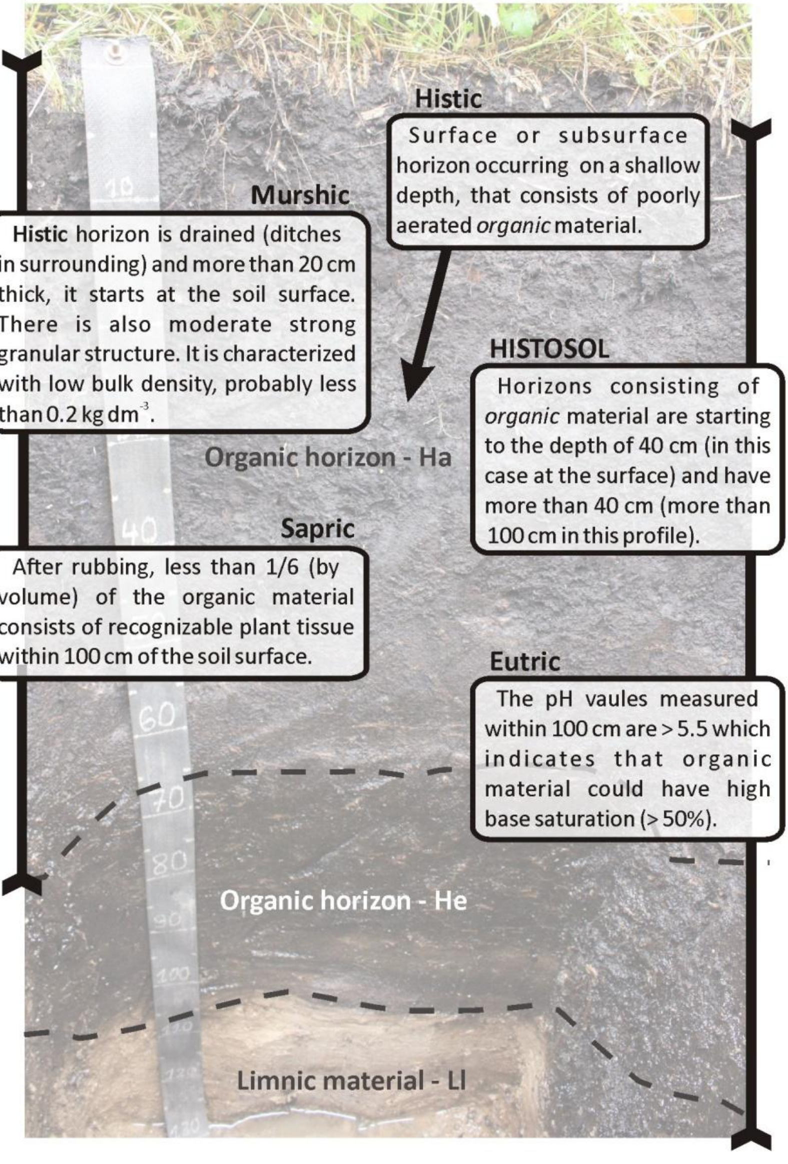
3. Illustrated explanatory quide

3.1. Soil profiles

Overview of Key to Reference Soil Groups		
Histosols Anthrosols Technosols Leptosols Solonetz Vertisols Solonchaks Gleysols	Andosols Podzols Planosols Stagnosols Chernozems Kastanozems Phaeozems Umbrisols	Calcisols Retisols Luvisols Cambisols Arenosols Fluvisols Regosols

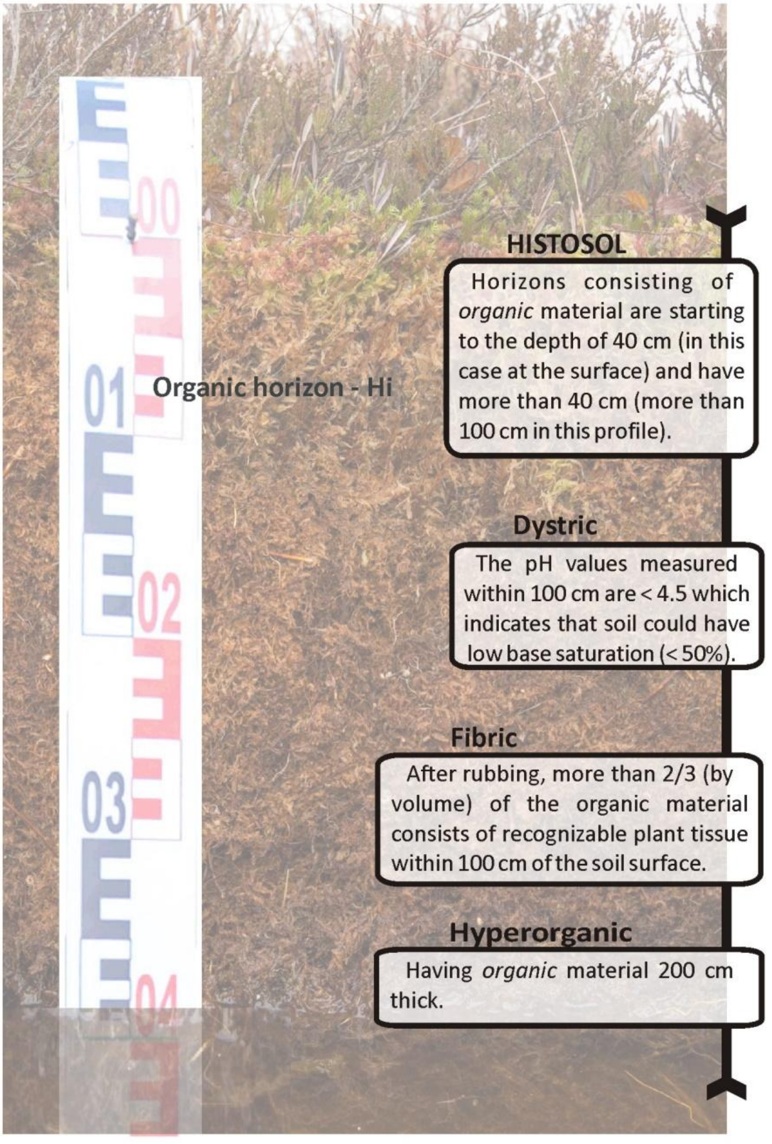
HISTOSOL

Eutric Murshic Sapric
HISTOSOL



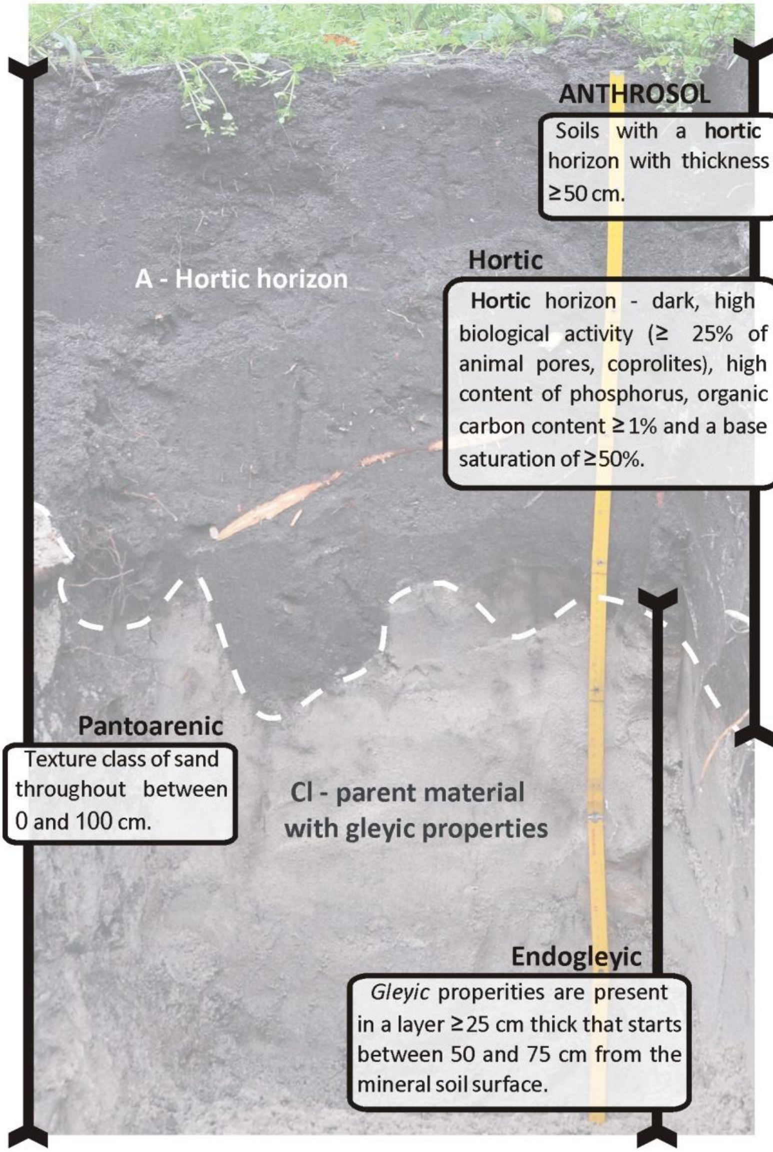
HISTOSOL

Dystric Fibric HISTOSOL (Hyperorganic)



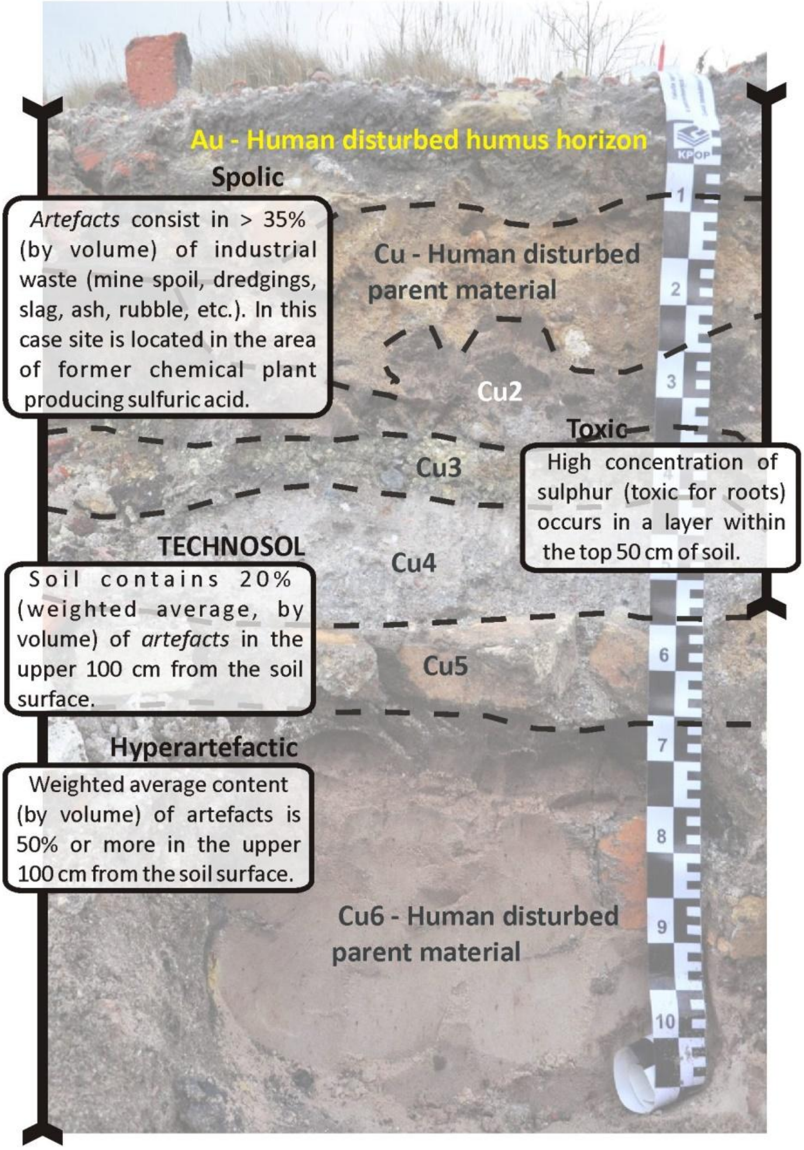
ANTHROSOL

Hortic
ANTHROSOL
(Pantoarenic, Endogleyic)



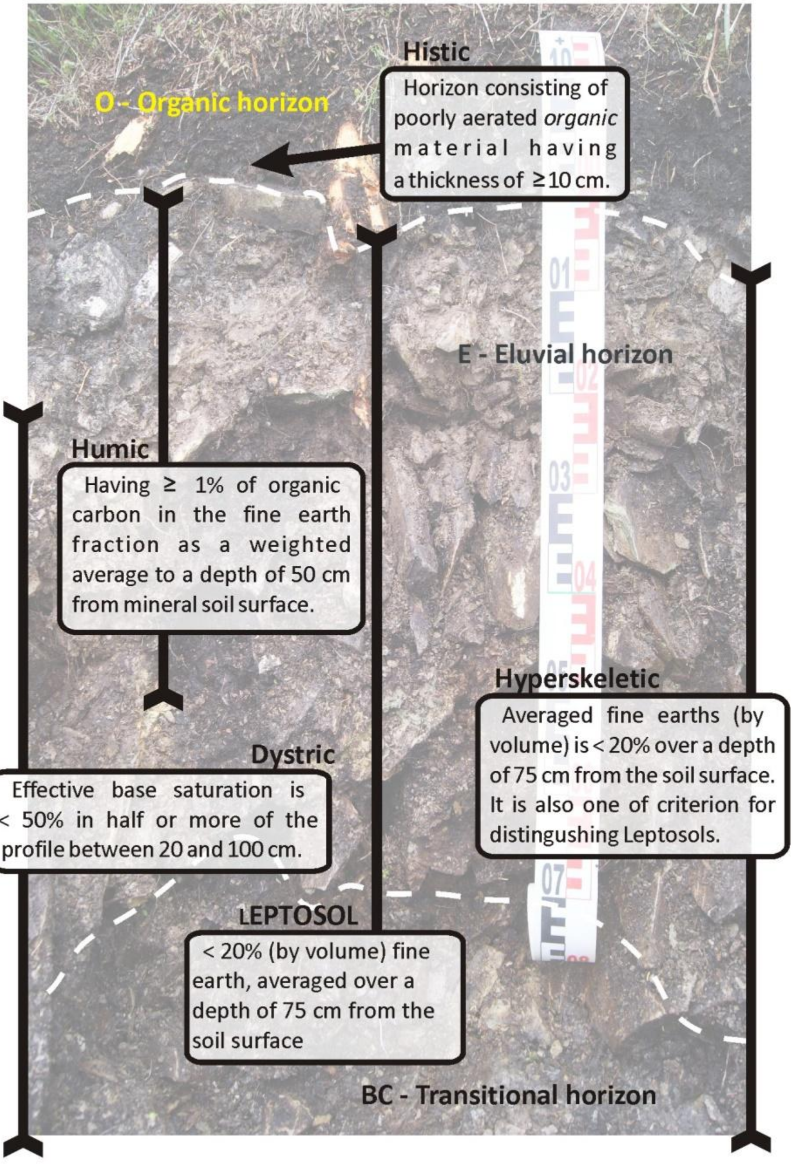
TECHNOSOL

Spolic
TECHNOSOL
(Hyperartefactic, Toxic)



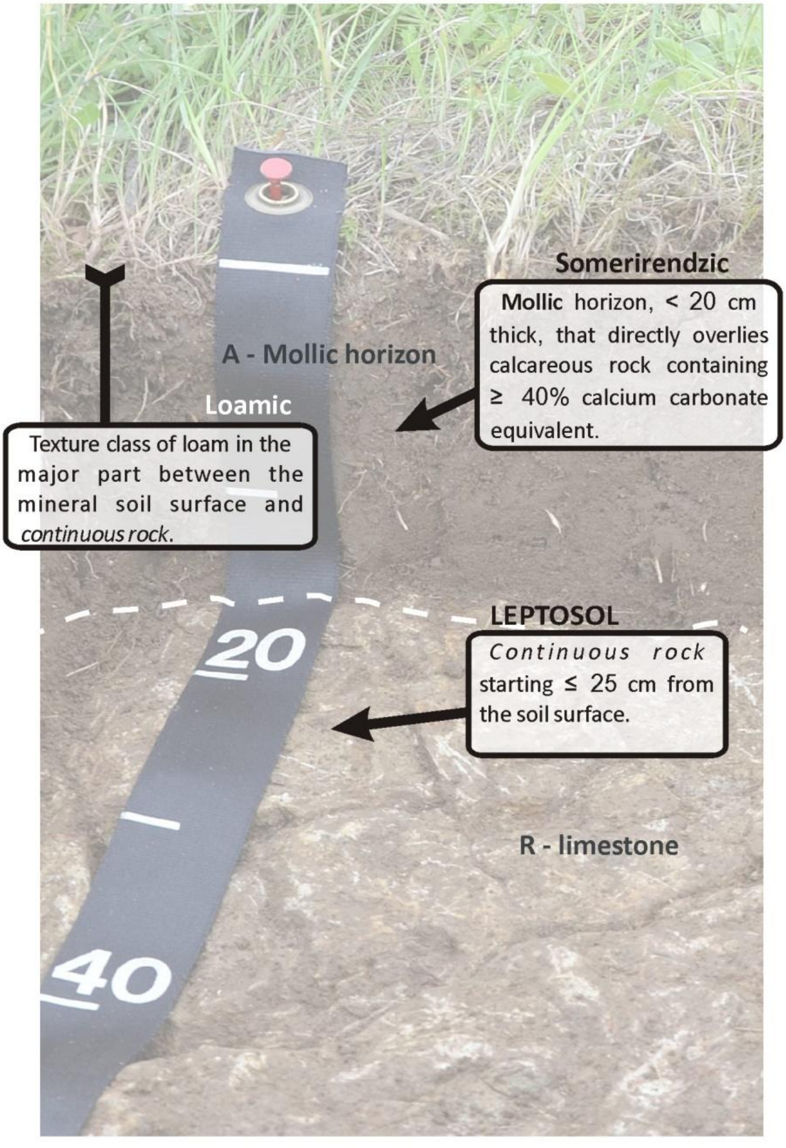
LEPTOSOL

Dystric Histic Hyperskeletic
LEPTOSOL
(Humic)



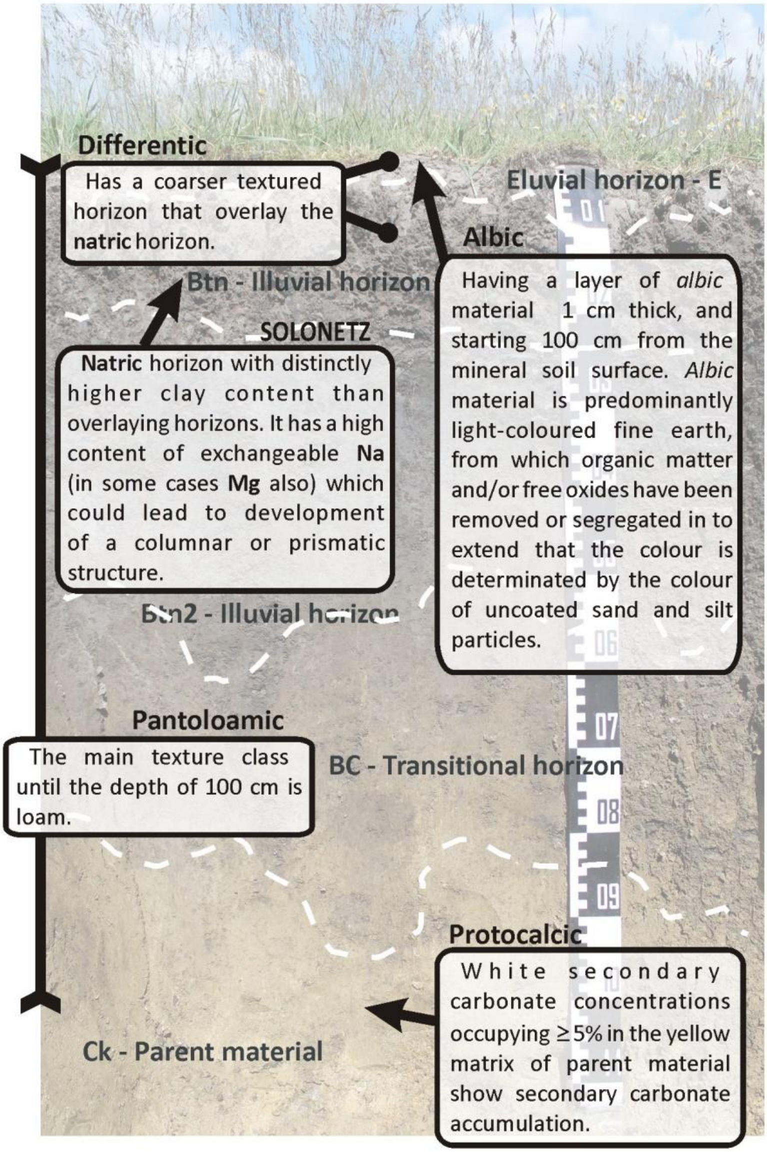
LEPTOSOL

Somerirendzic LEPTOSOL (Loamic)



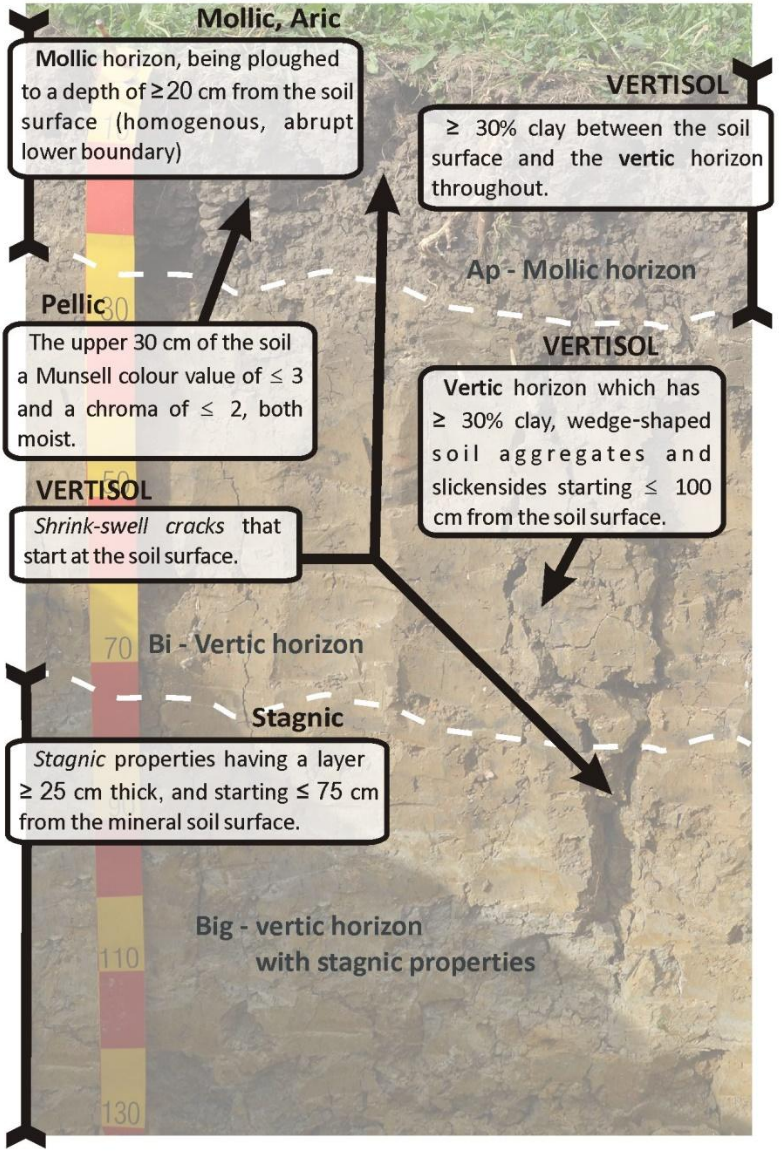
SOLONETZ

Protocalcic
SOLONETZ
(Albic, Pantoloamic, Differentic)



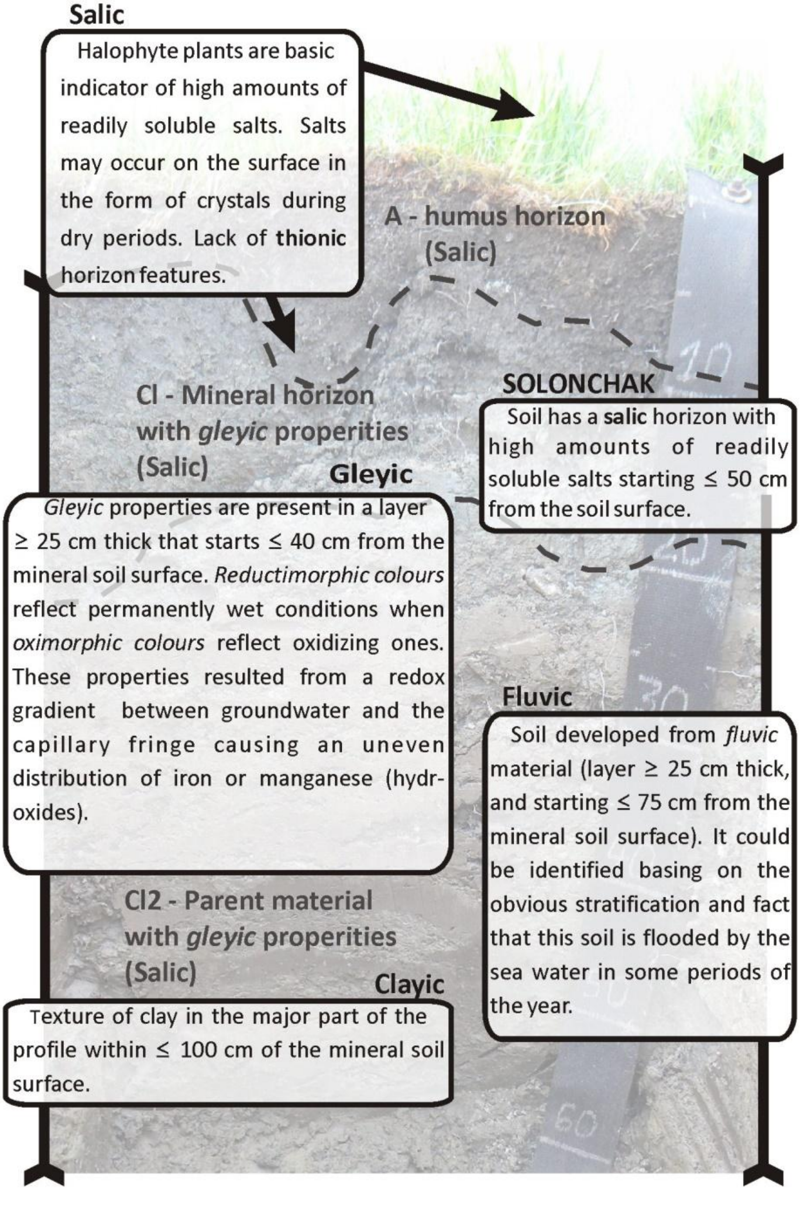
VERTISOL

Pellic
VERTISOL
(Aric, Mollic, Stagnic)



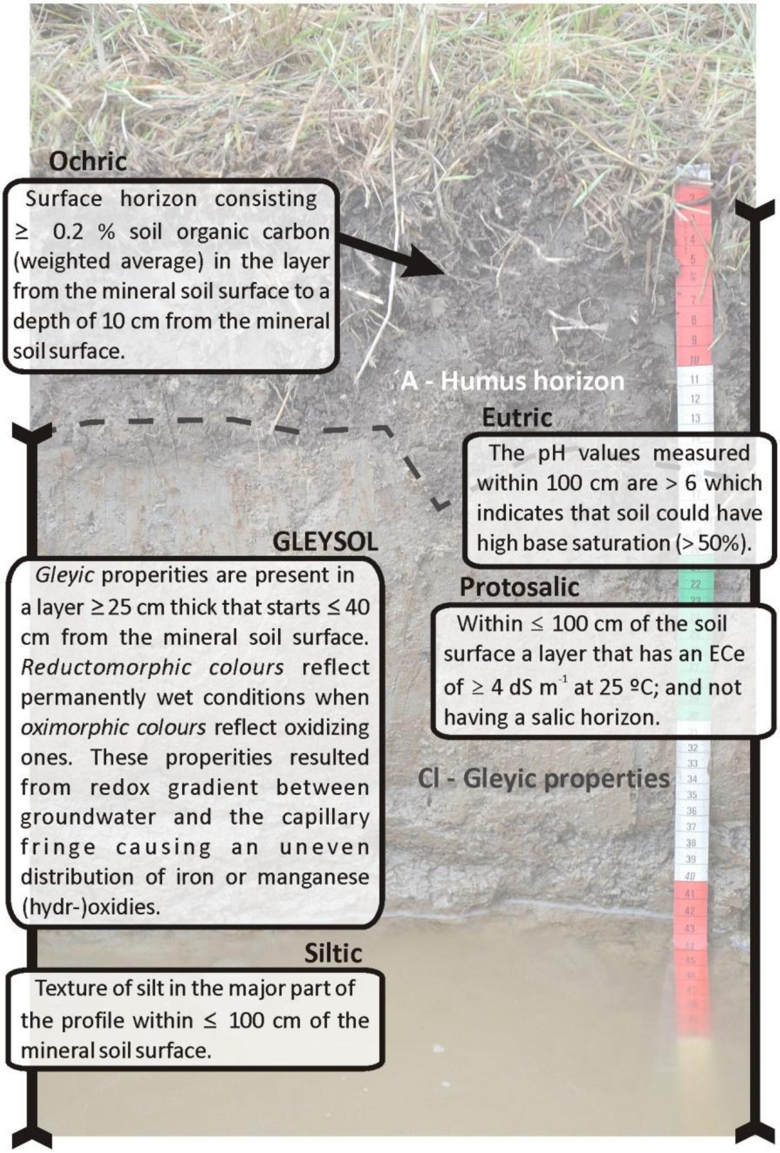
SOLONCHAK

Fluvic Gleyic SOLONCHAK (Clayic)

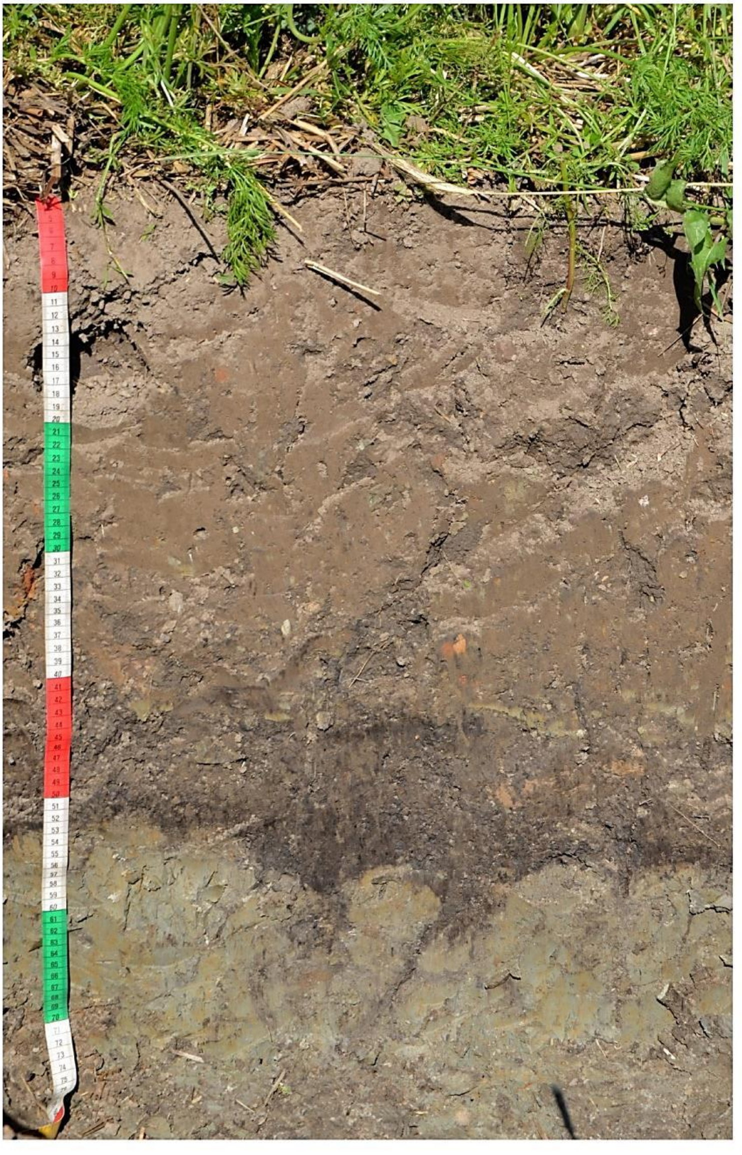


GLEYSOL

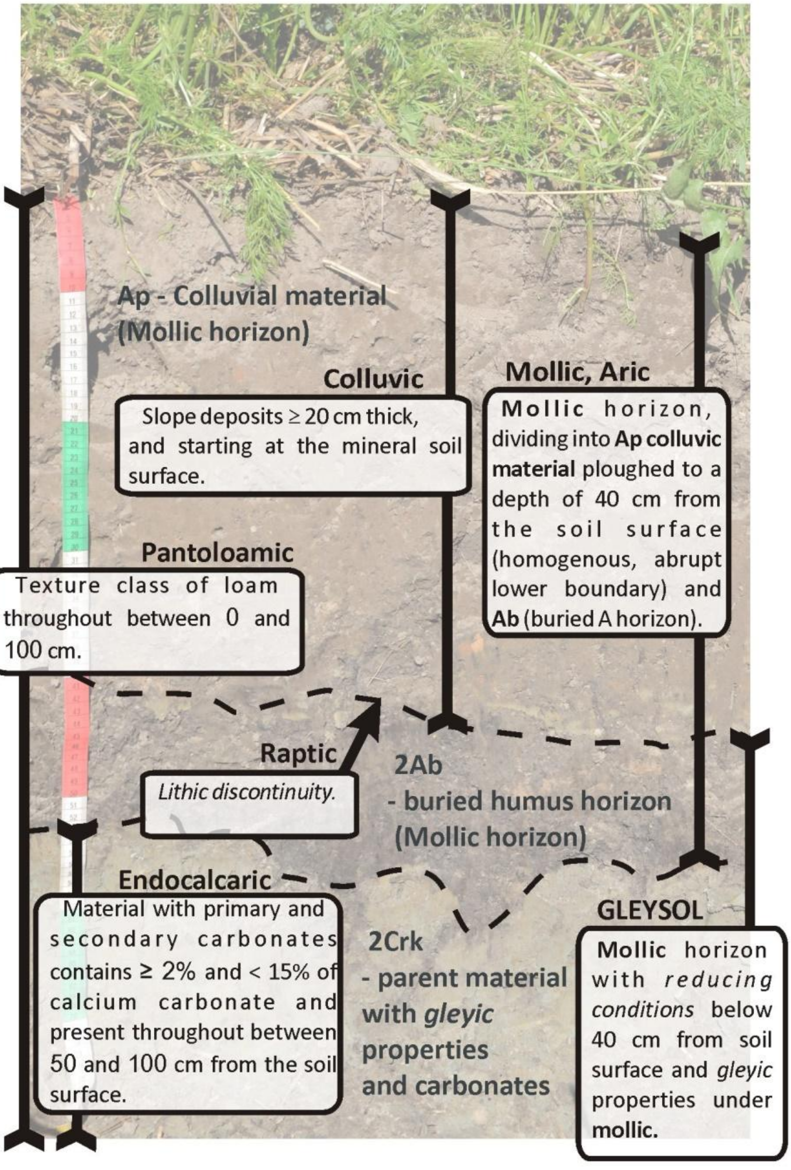
Eutric GLEYSOL (Protosalic, Siltic, Ochric)



GLEYSOL

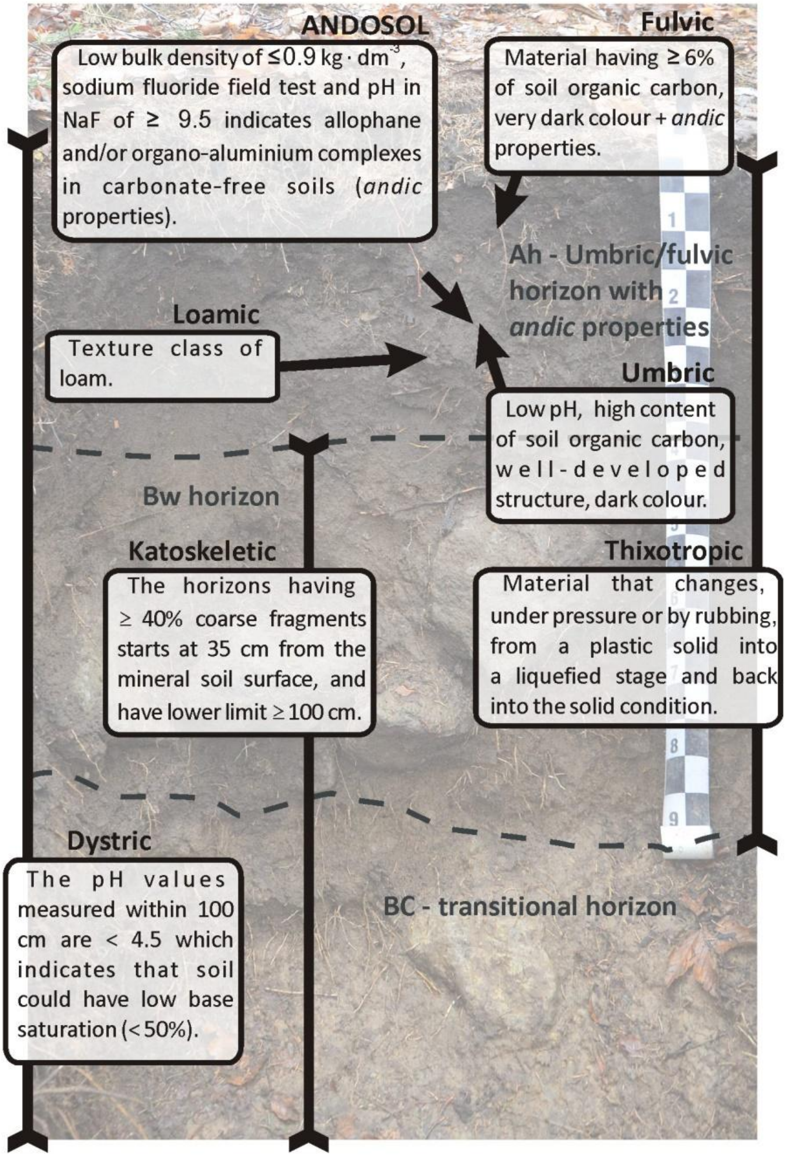


Endocalcaric Mollic GLEYSOL (Aric, Colluvic, Pantoloamic, Raptic)

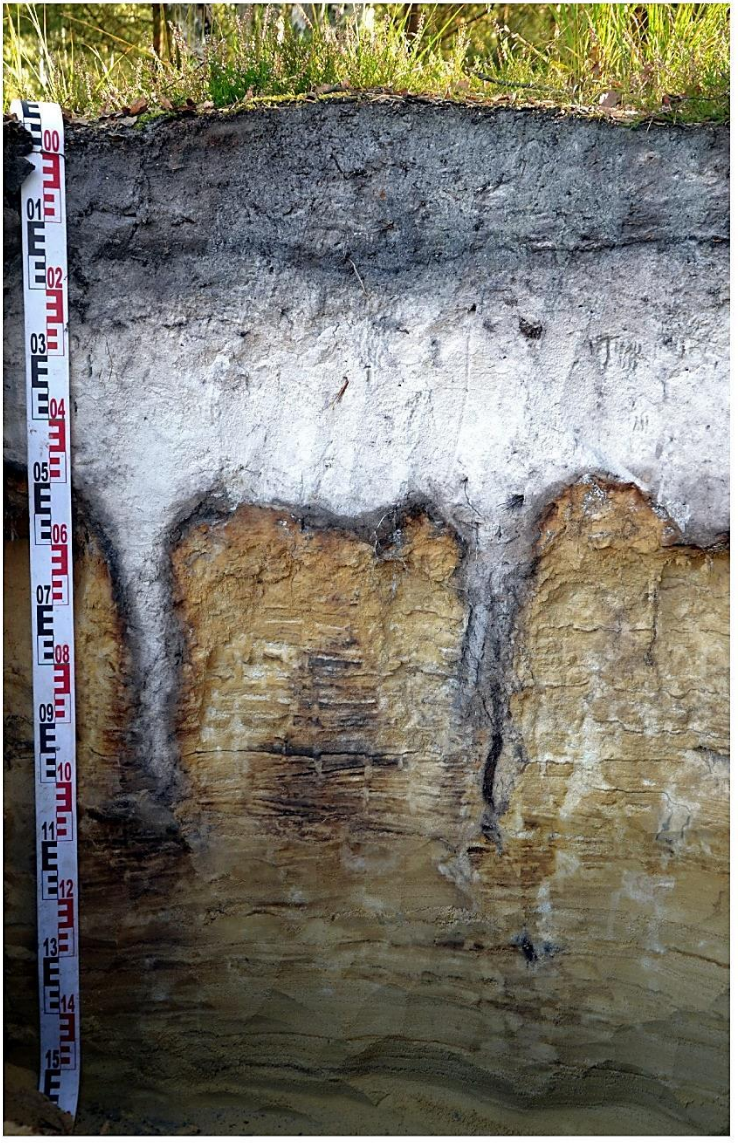


ANDOSOL

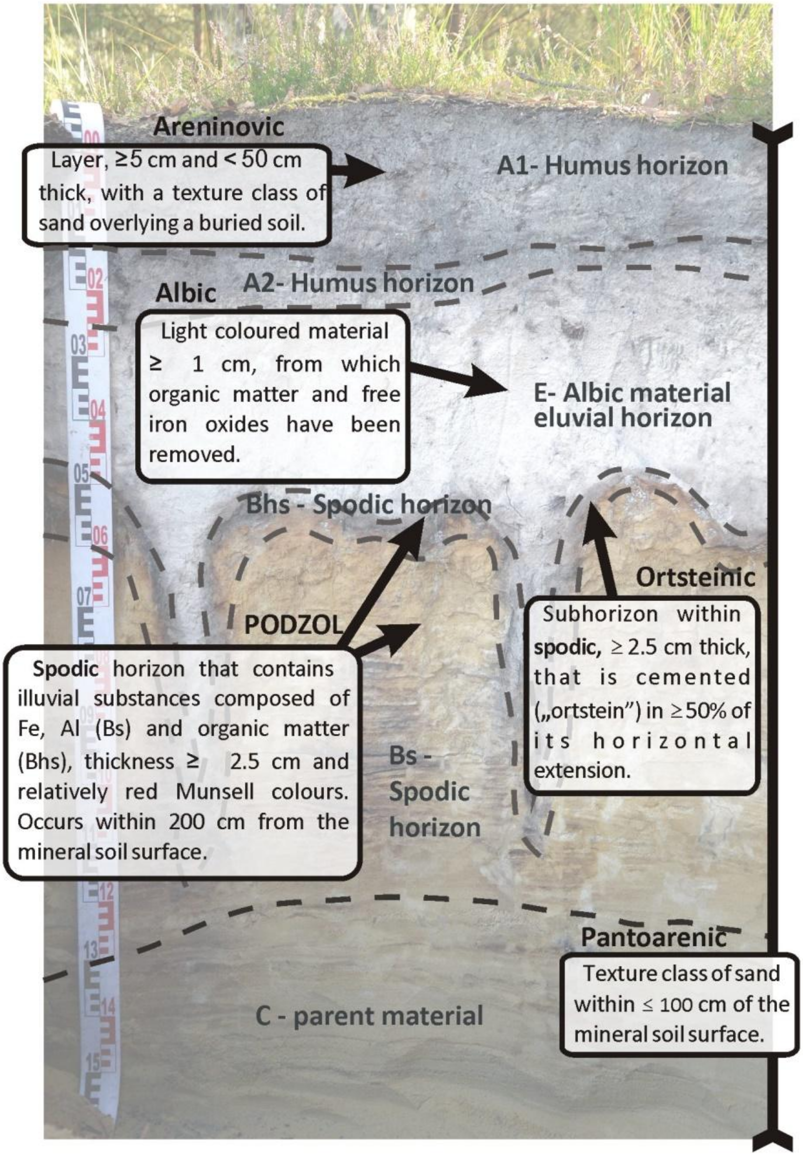
Dystric Katoskeletic Umbric ANDOSOL (Fulvic, Loamic, Thixotropic)



PODZOL

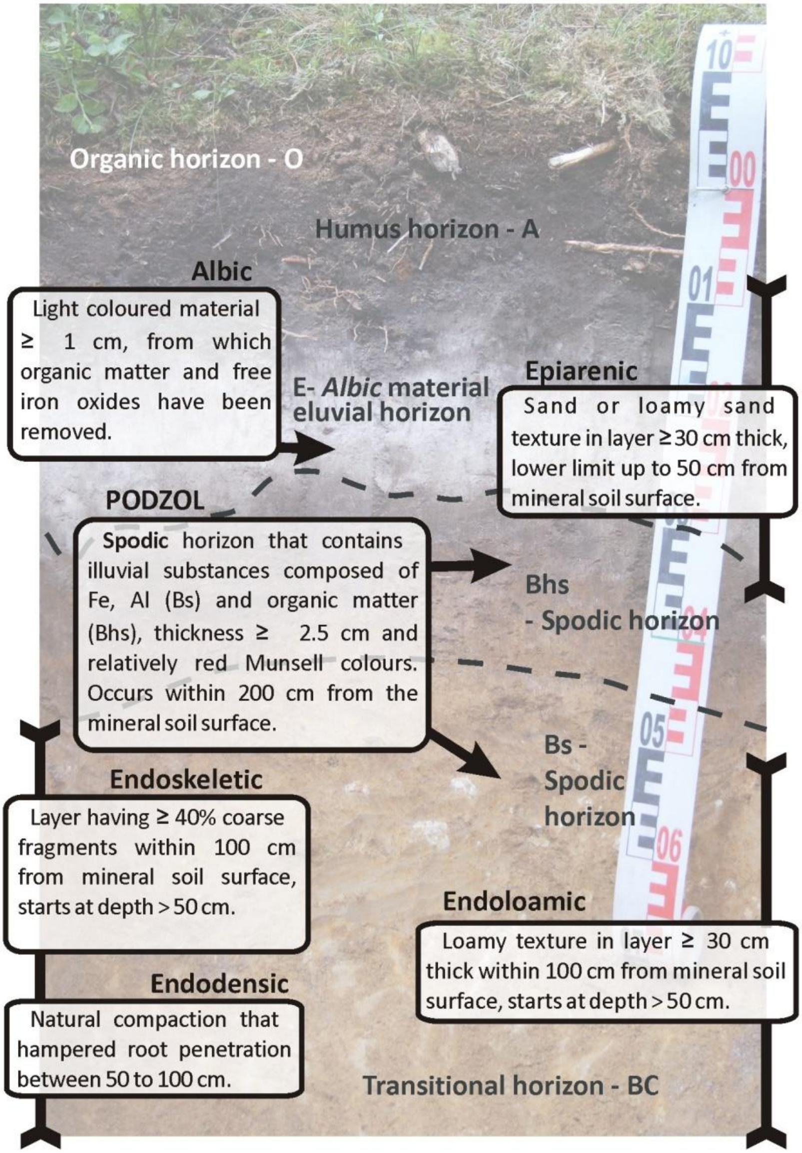


Albic Ortsteinic PODZOL (Pantoarenic, Areninovic)



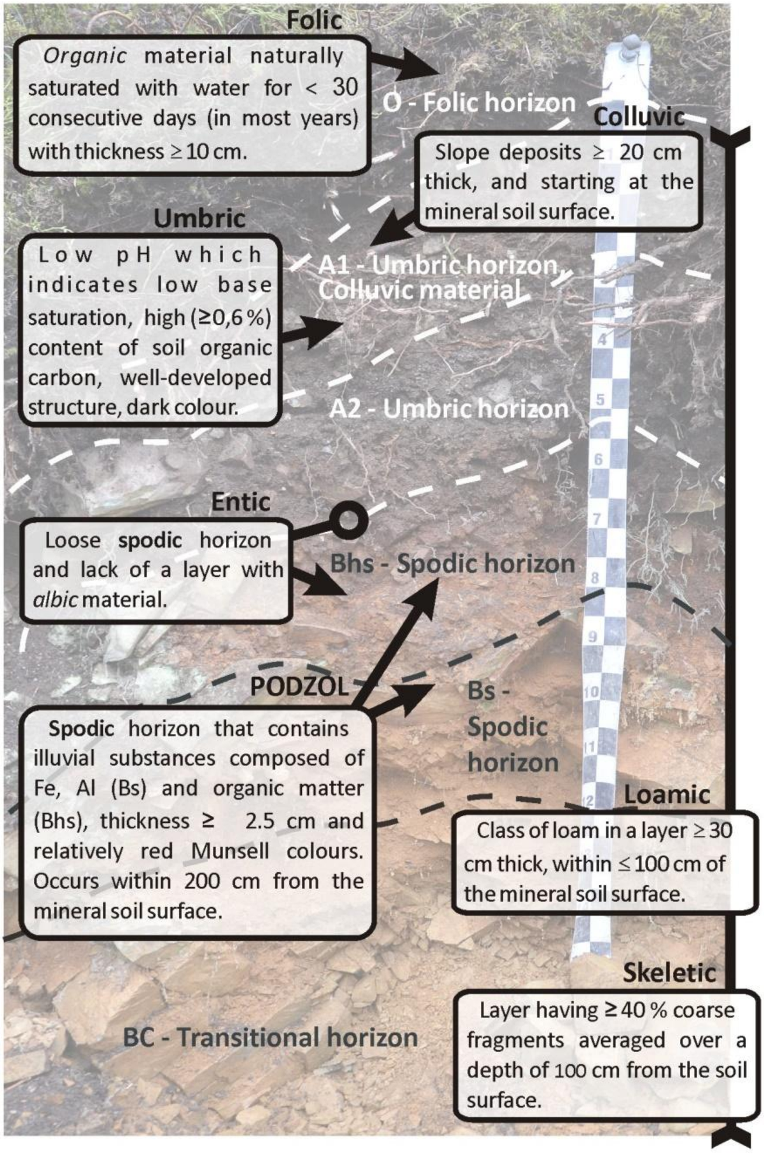
PODZOL

Endoskeletic Albic PODZOL (Epiarenic, Endoloamic, Endodensic)



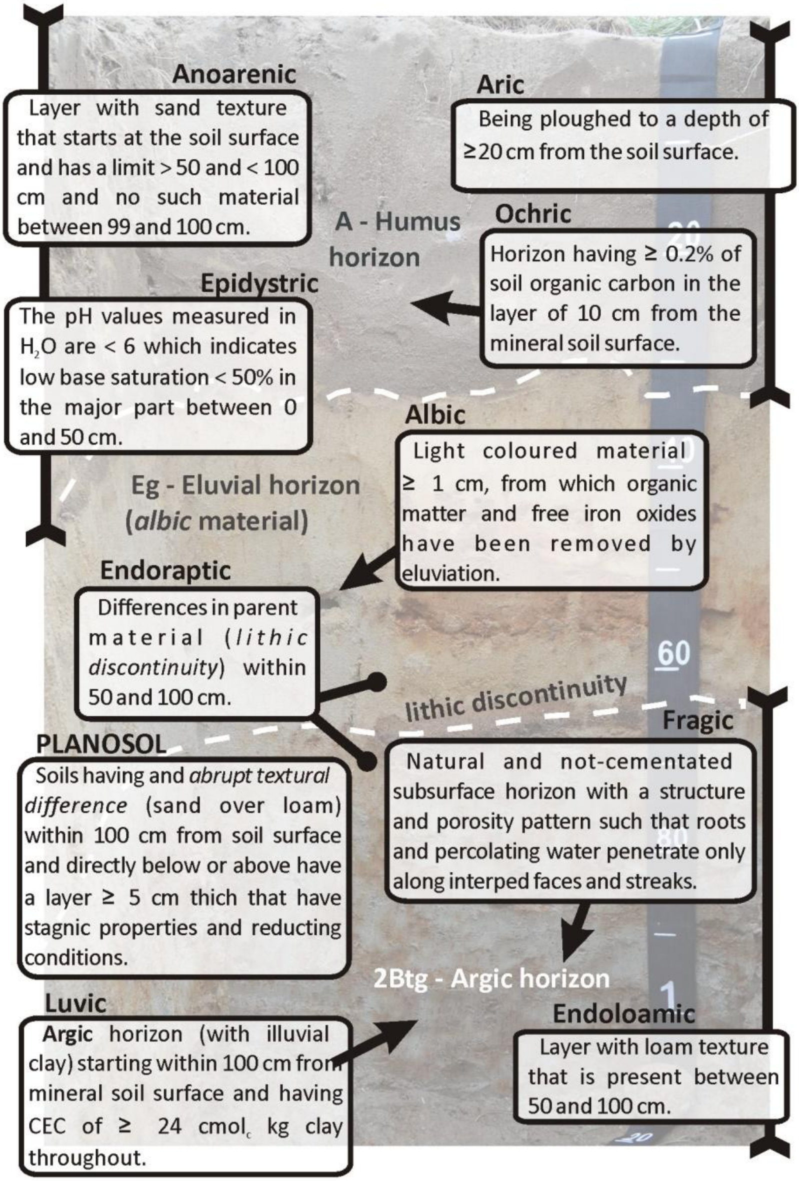
PODZOL

Skeletic Umbric Folic Entic PODZOL (Colluvic, Loamic)



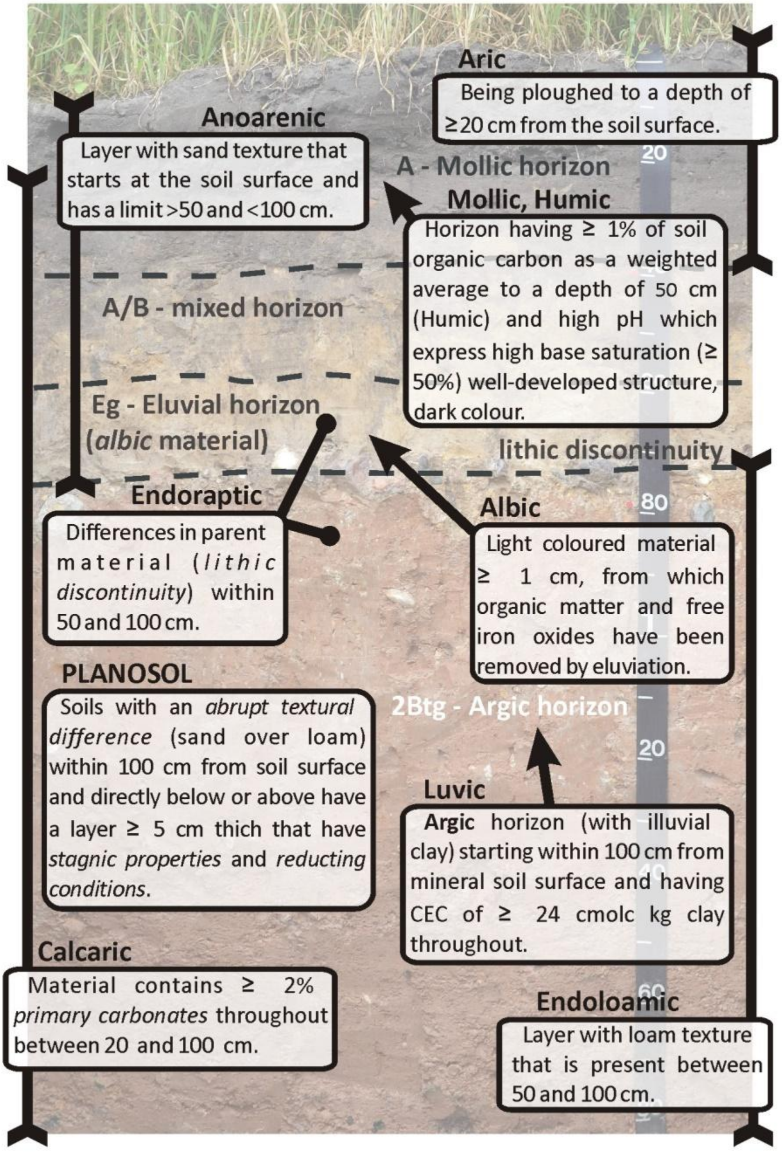
PLANOSOL

Epidystric Luvic Albic Fragic PLANOSOL (Aric, Anoarenic, Endoloamic, Endoraptic, Ochric)



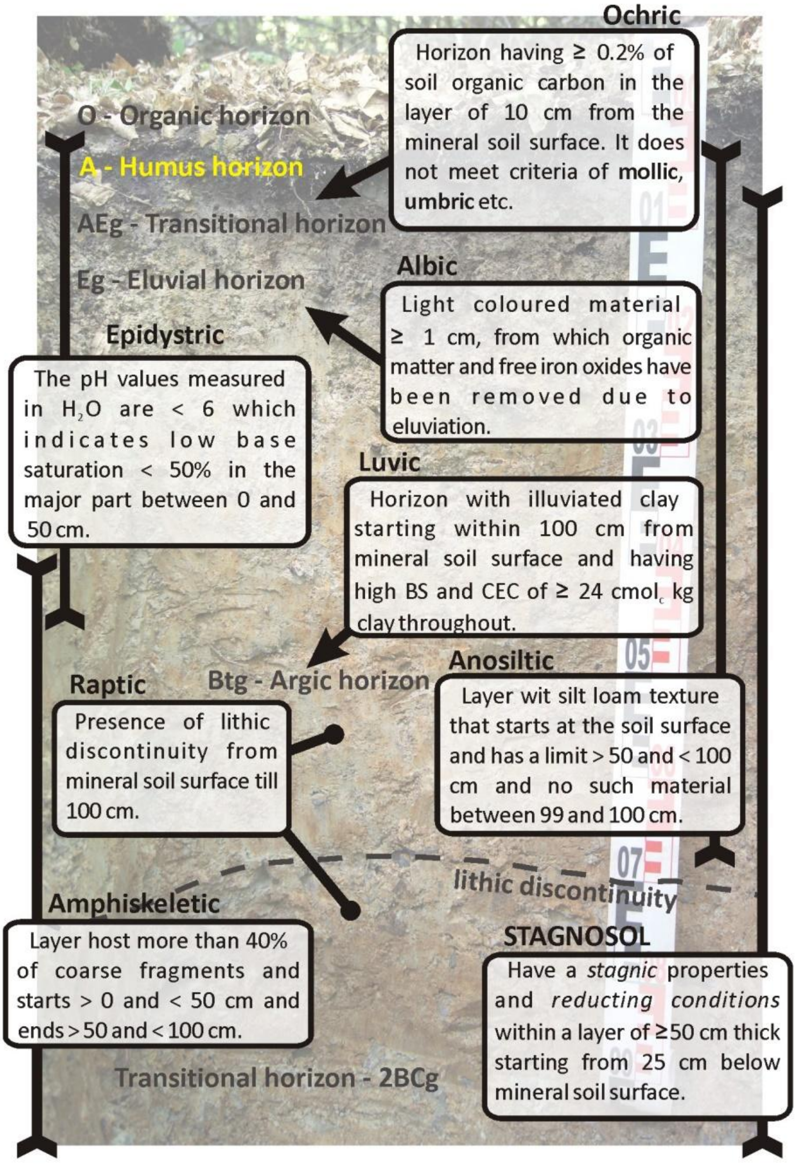
PLANOSOL

Calcaric Luvic Albic Mollic PLANOSOL (Anoarenic, Aric, Humic, Endoloamic, Endoraptic)

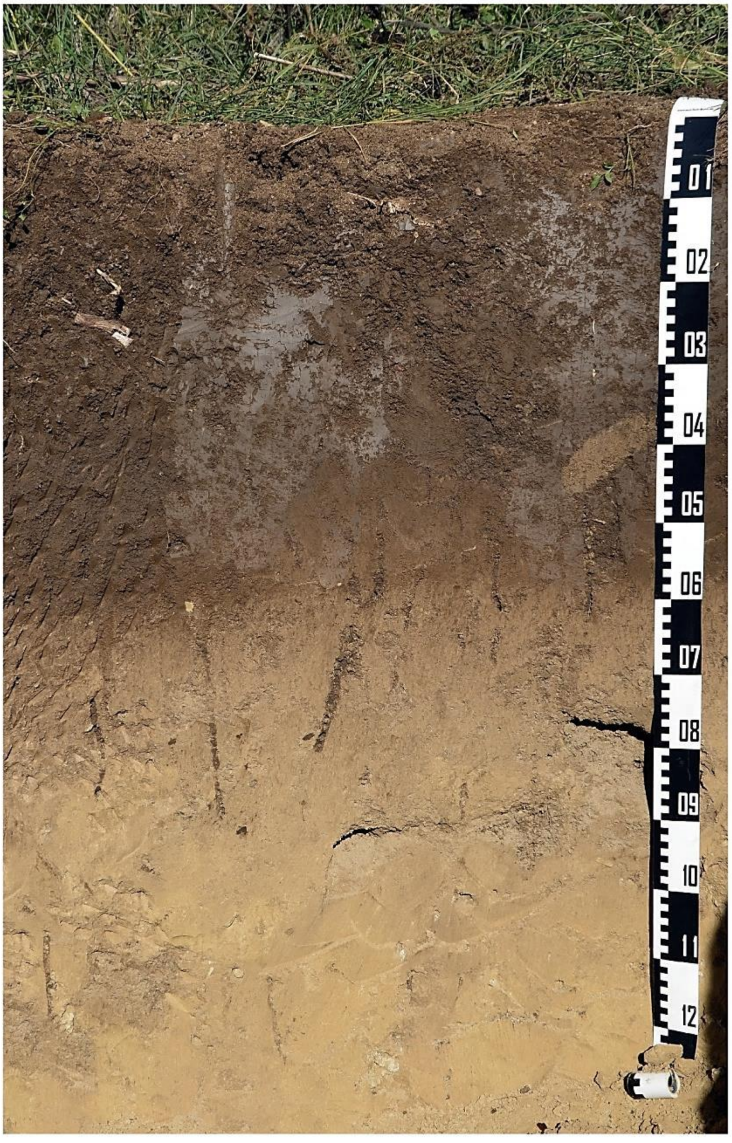


STAGNOSOL

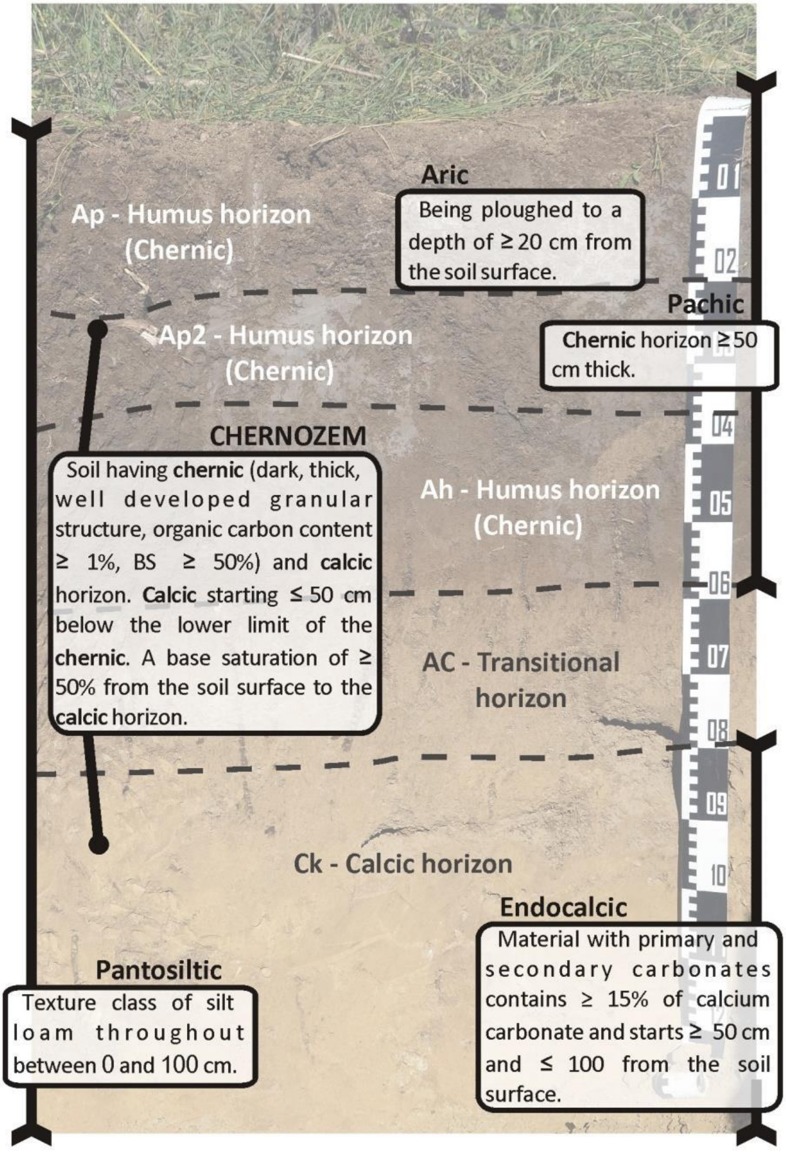
Epidystric Luvic Albic
STAGNOSOL
(Anosiltic, Ochric, Raptic, Amphiskeletic)



CHERNOZEM

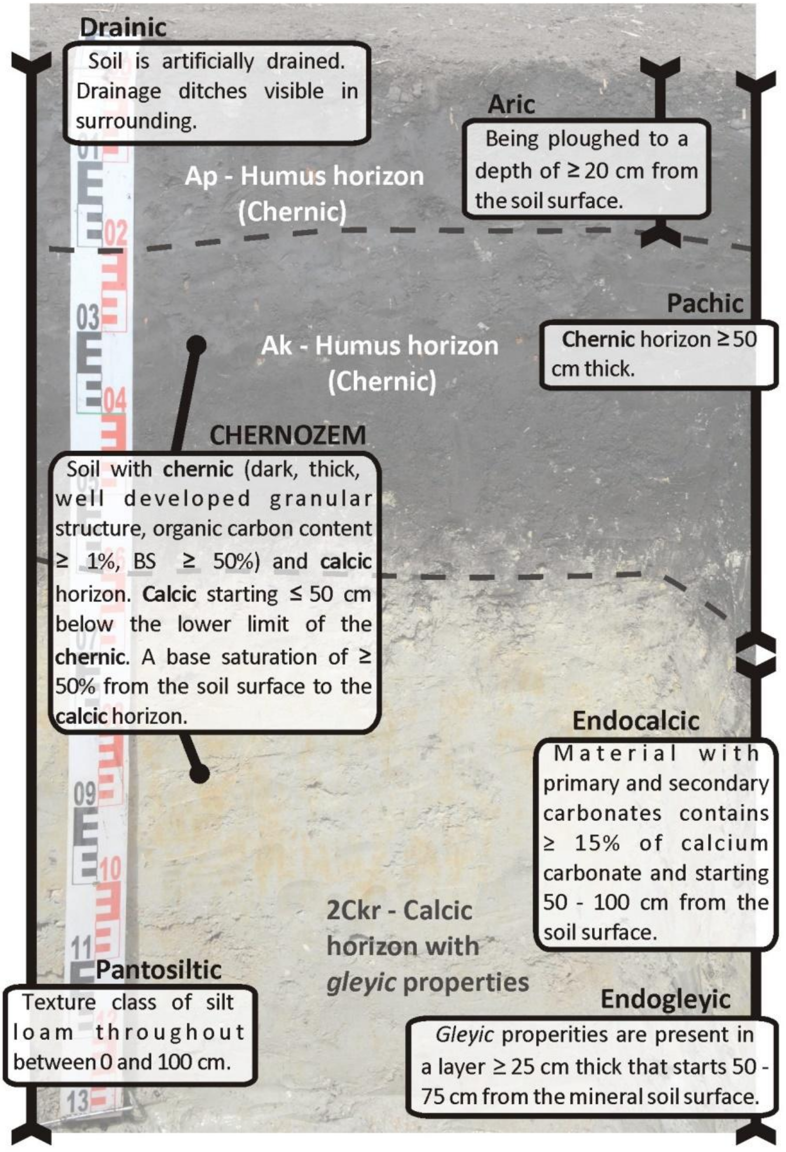


Endocalcic
CHERNOZEM
(Aric, Pachic, Pantosiltic)



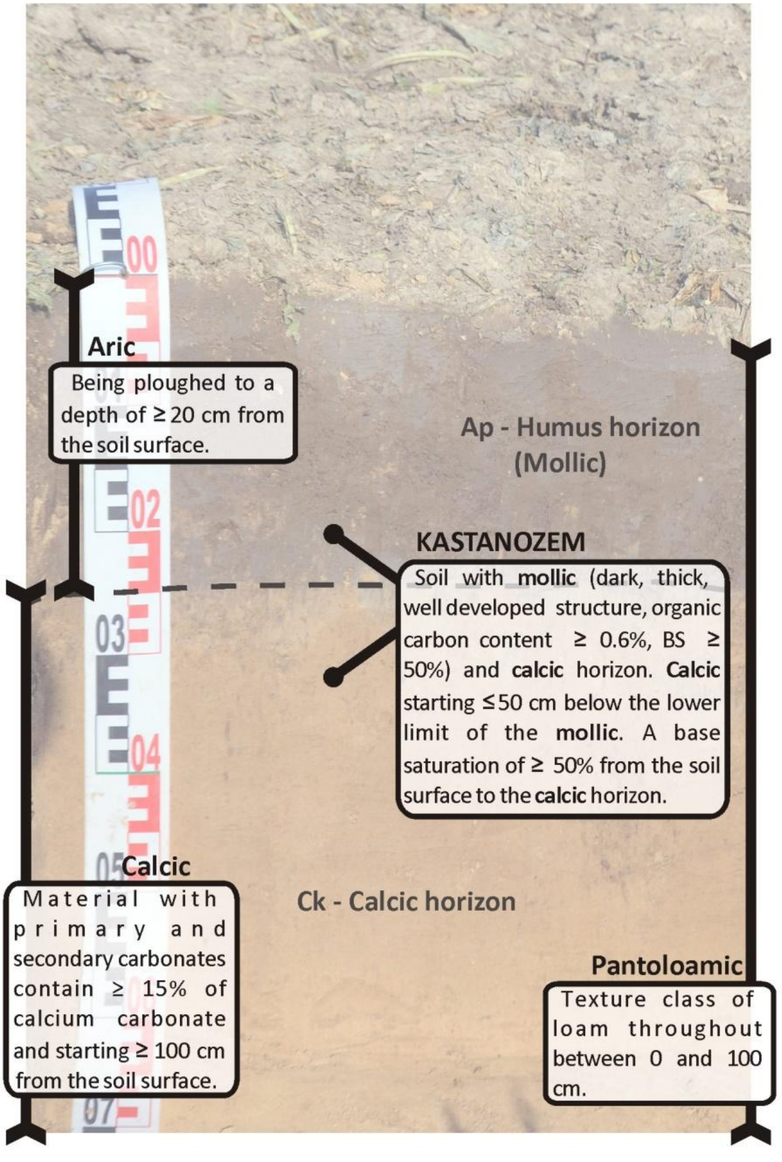
CHERNOZEM

Endogleyic Endocalcic CHERNOZEM (Aric, Pachic, Pantosiltic)

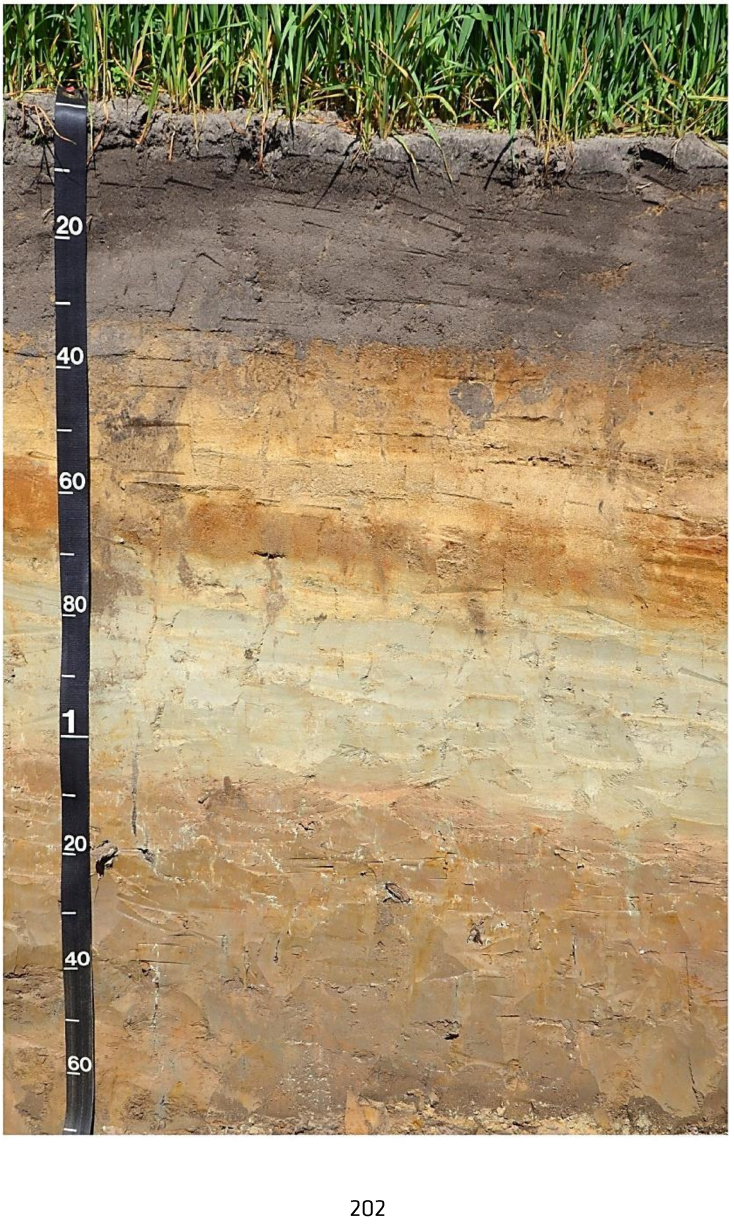


KASTANOZEM

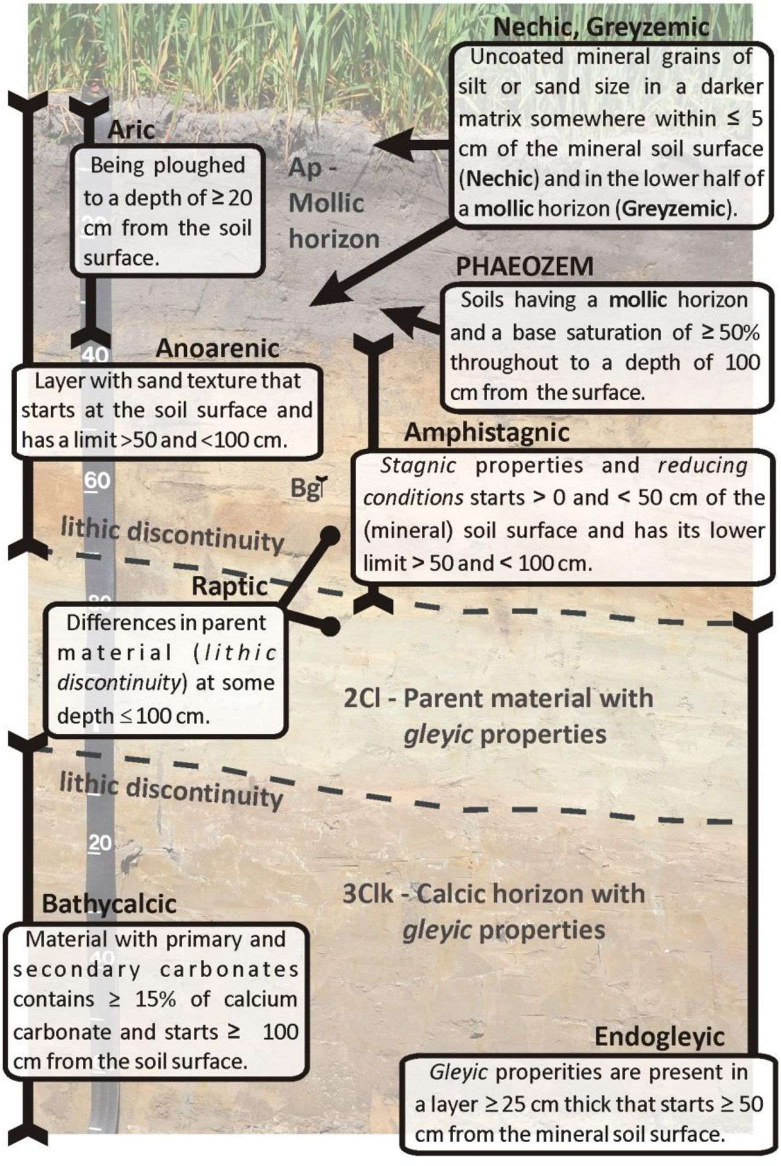
Calcic
KASTANOZEM
(Aric, Pantoloamic)



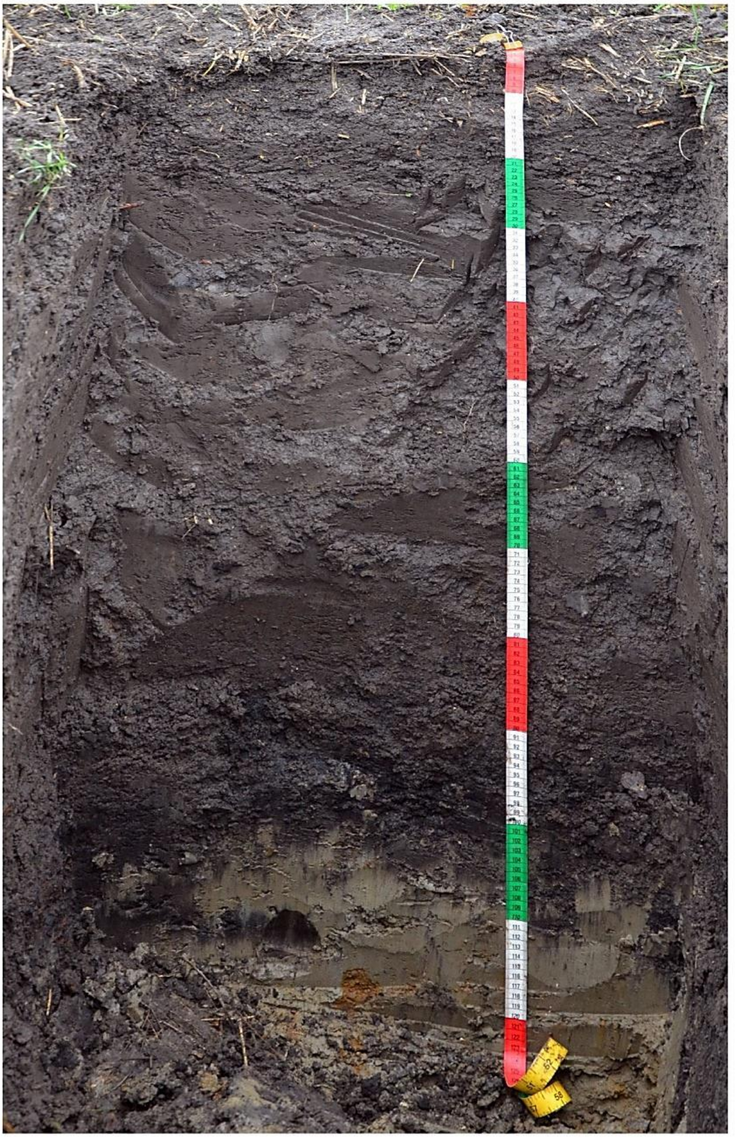
PHAEOZEM



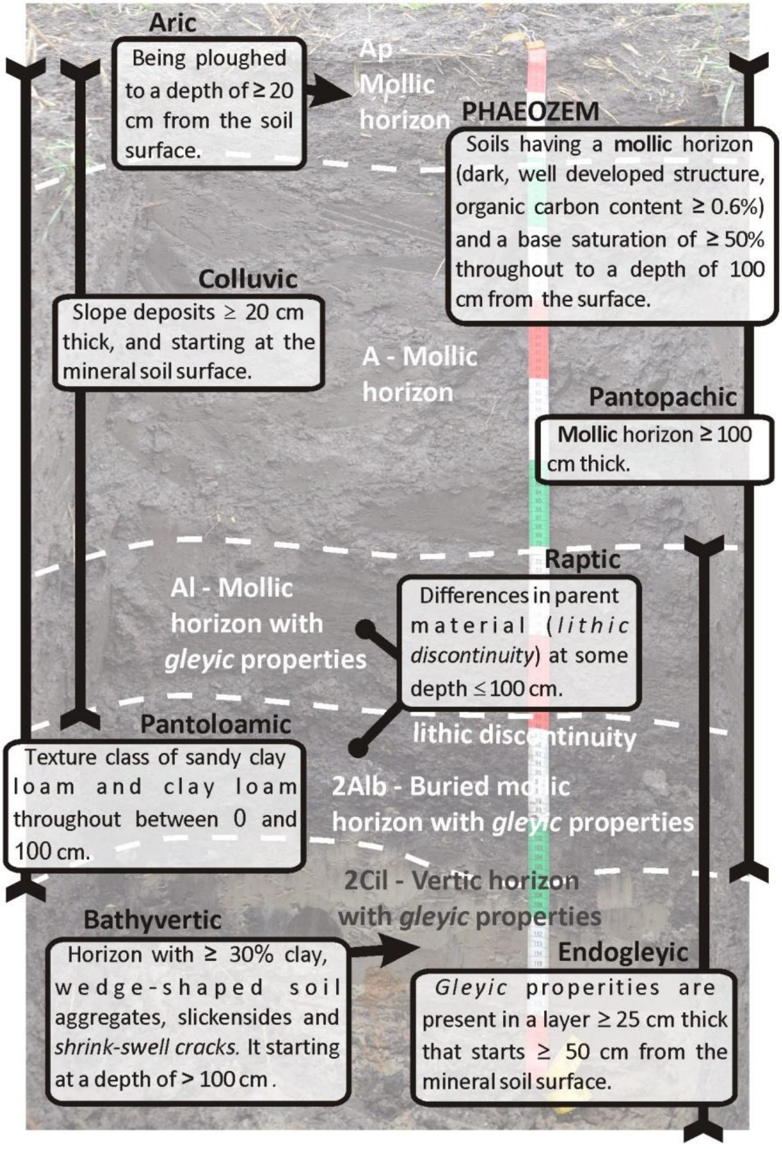
Greyzemic Amphiystagnic Endogleyic PHAEOZEM (Anoarenic, Aric, Nechic, Raptic, Bathycalcic)



PHAEOZEM

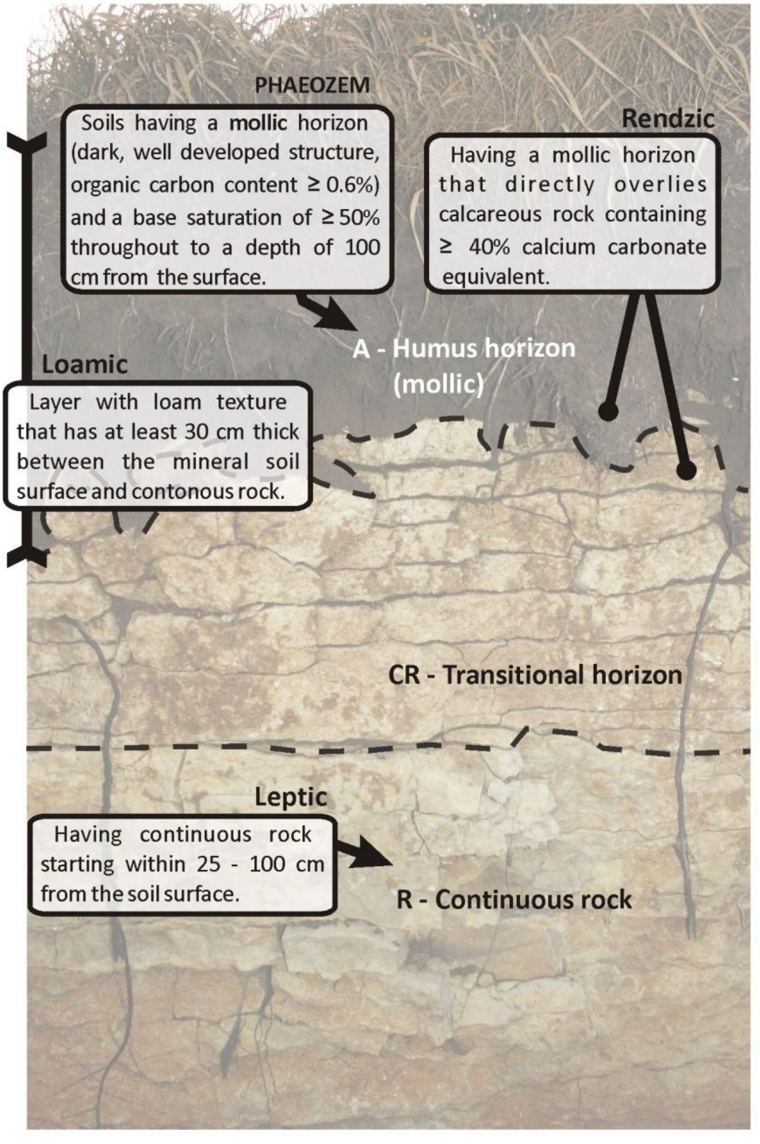


Endogleyic PHAEOZEM (Aric, Colluvic, Pantoloamic, Pantopachic, Raptic, Bathyvertic)



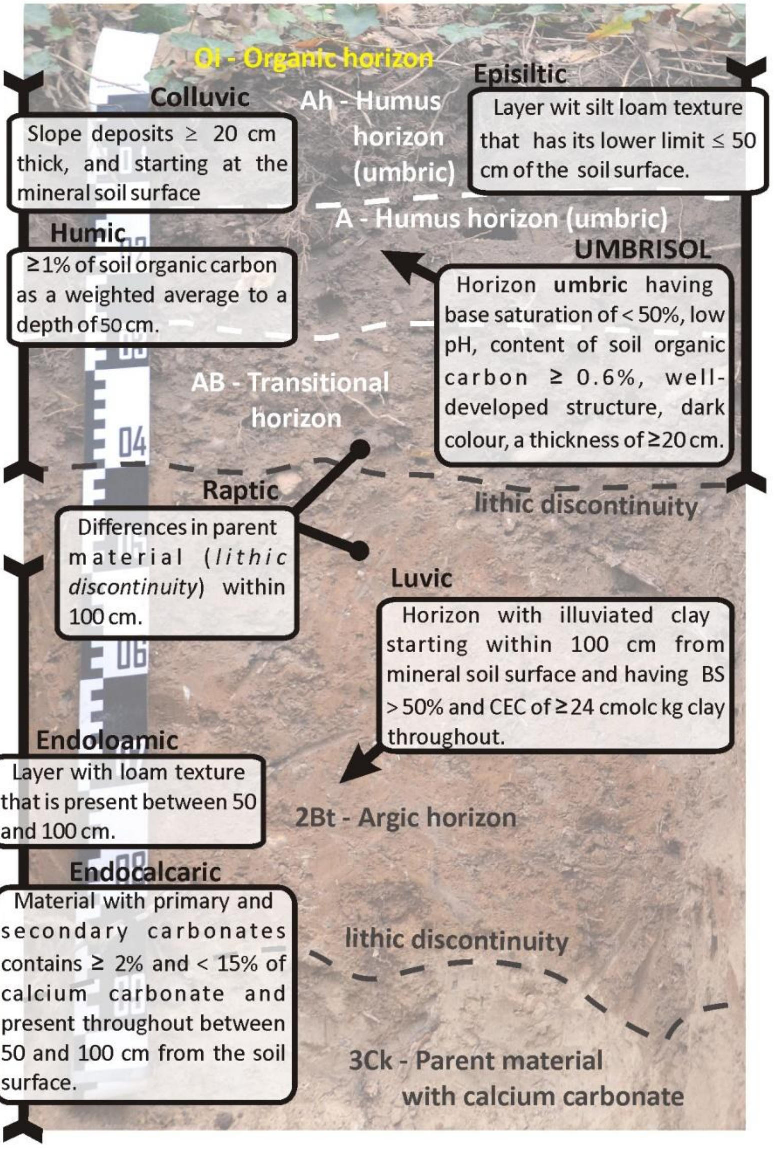
PHAEOZEM

Leptic Rendzic PHAEOZEM (Loamic)



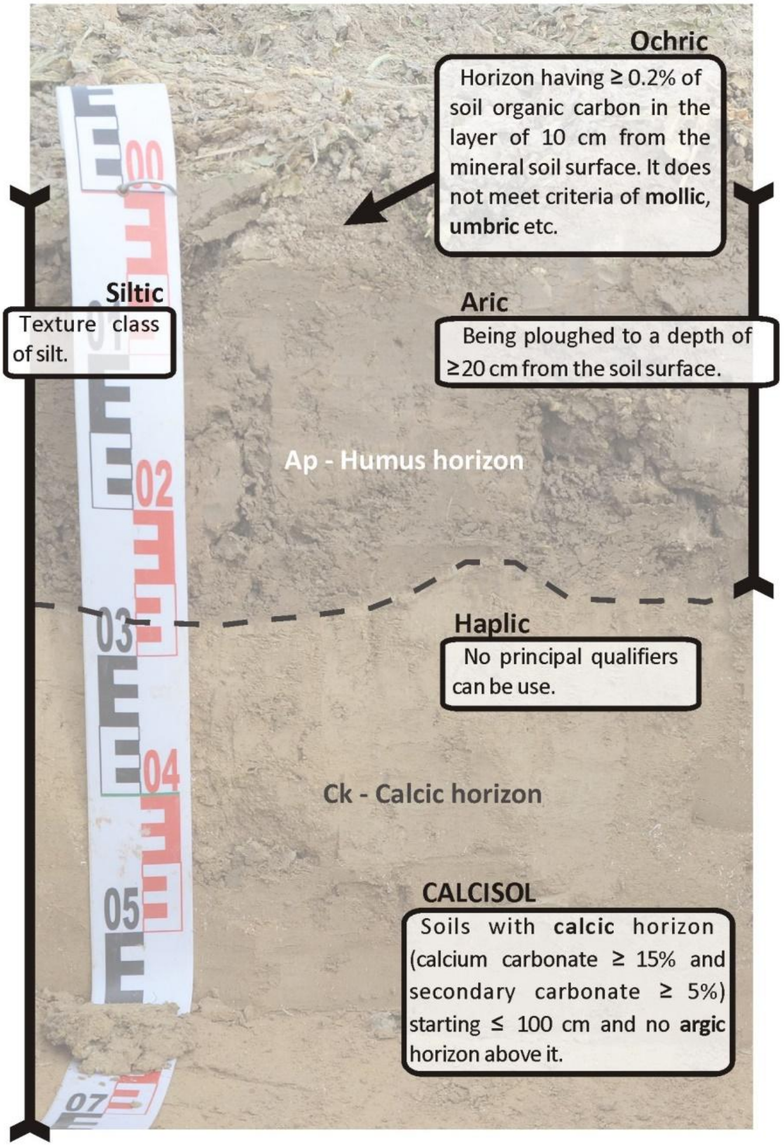
UMBRISOL

Luvic
UMBRISOL
(Colluvic, Humic, Episiltic, Endoloamic, Raptic, Endocalcaric)

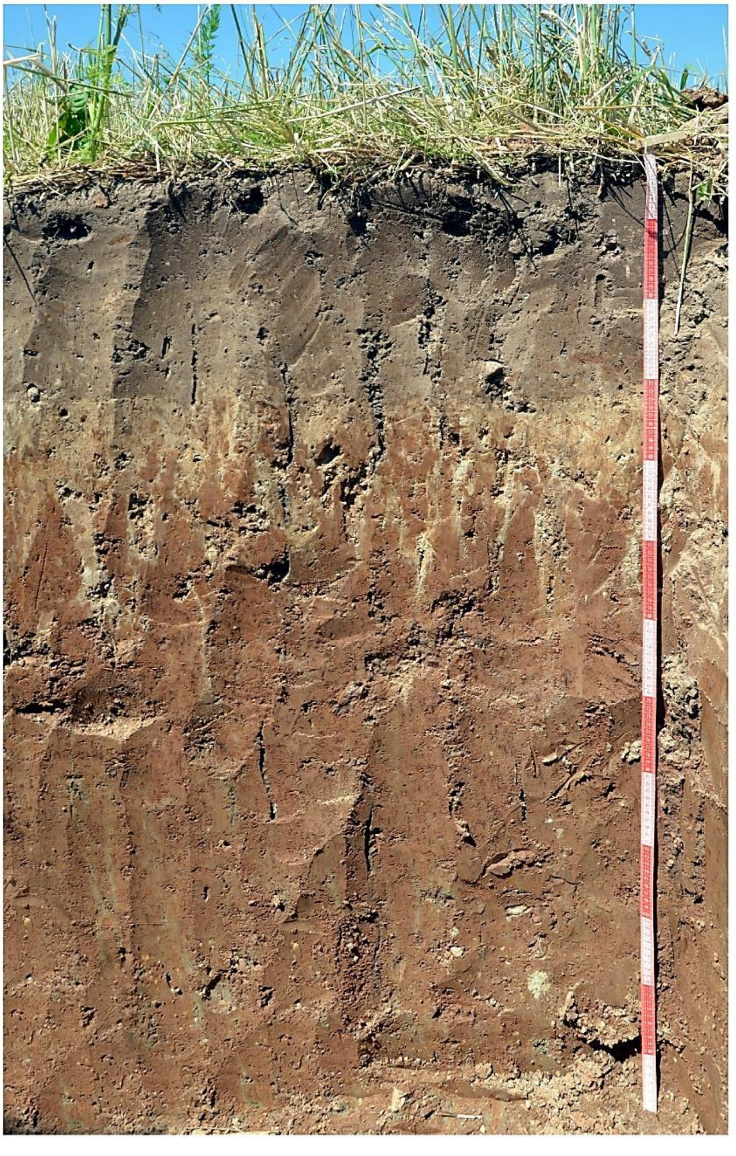


CALCISOL

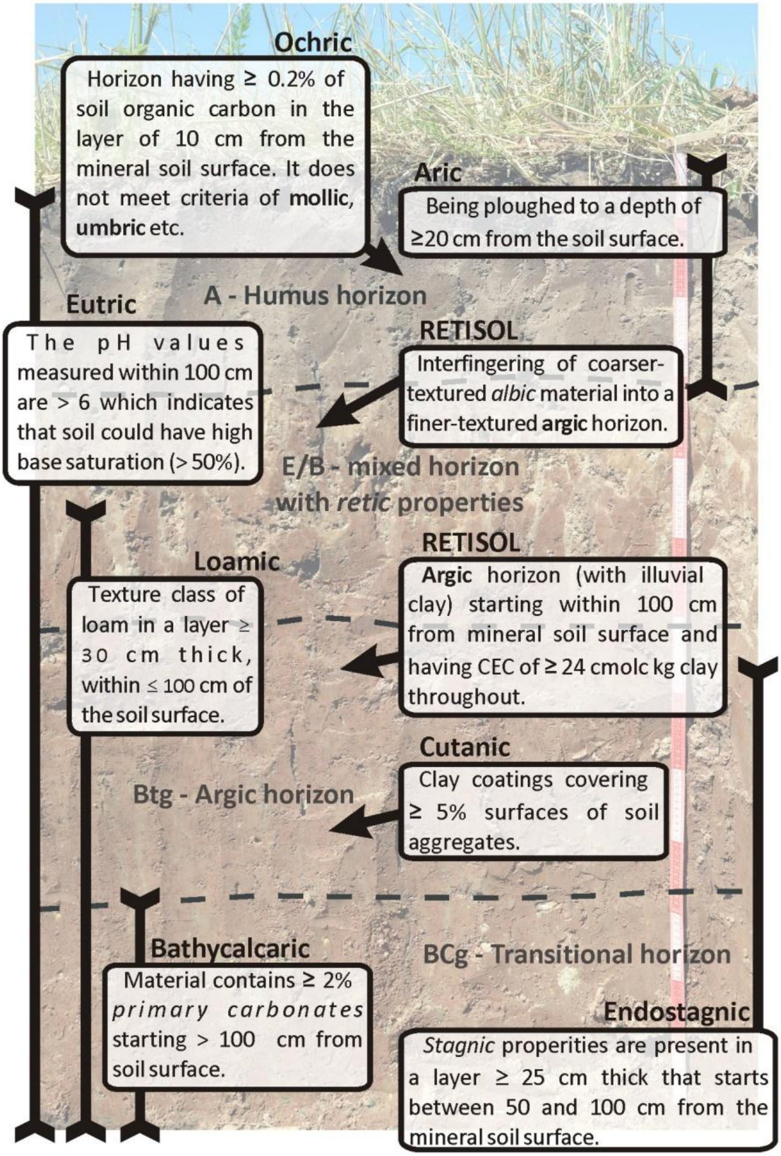
Haplic
CALCISOL
(Aric, Ochric, Siltic)



RETISOL

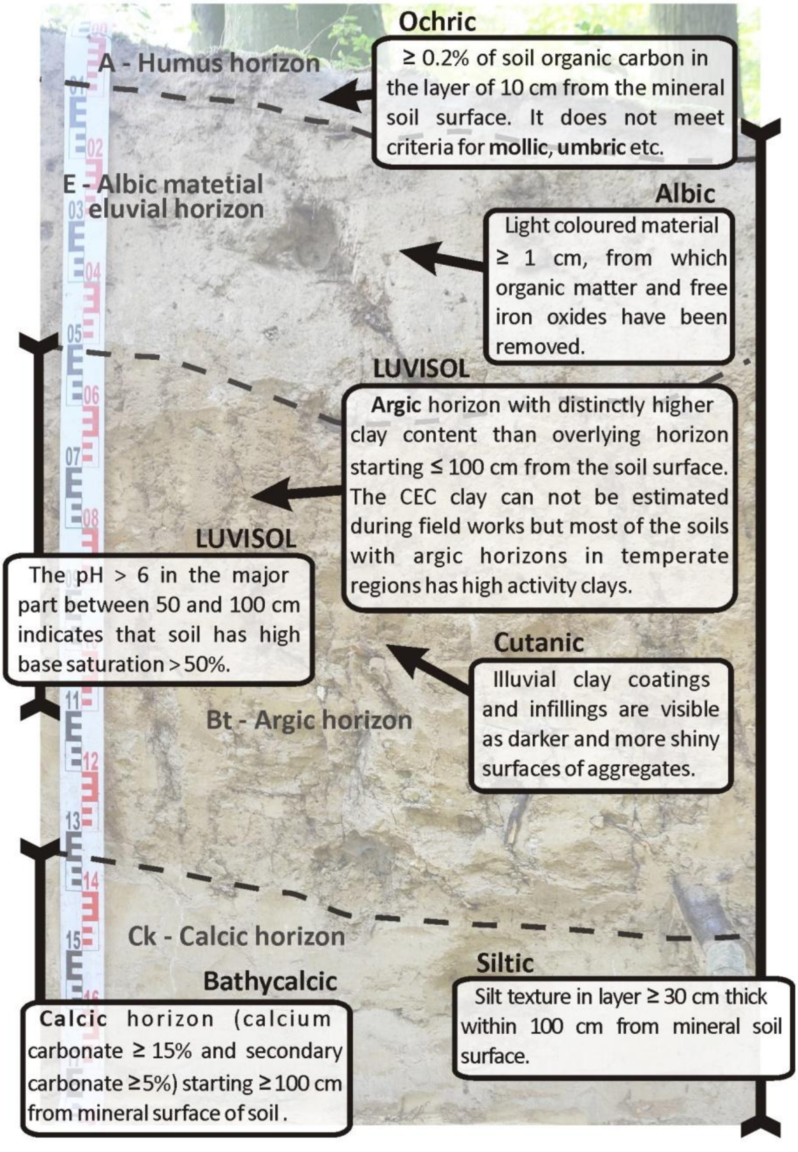


Eutric Endostagnic
RETISOL
(Aric, Cutanic, Loamic, Ochric, Bathycalcaric)



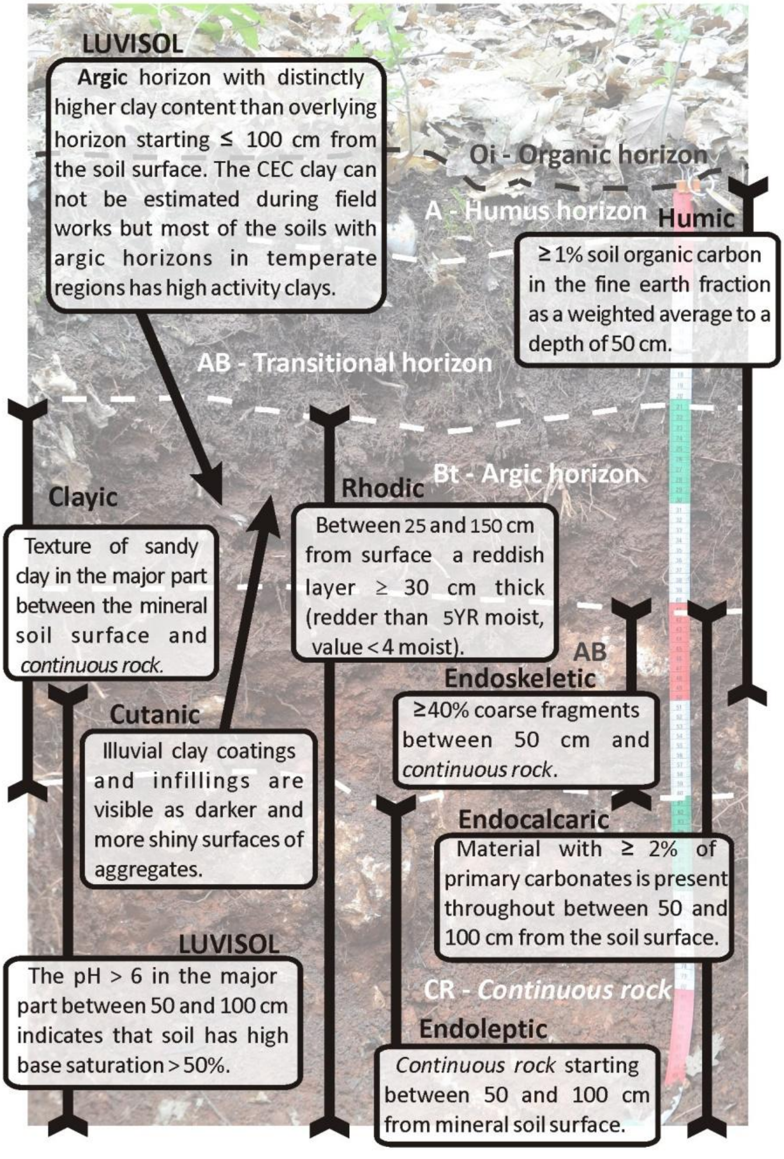
LUVISOL

Albic LUVISOL (Cutanic, Ochric, Siltic, Bathycalcic)



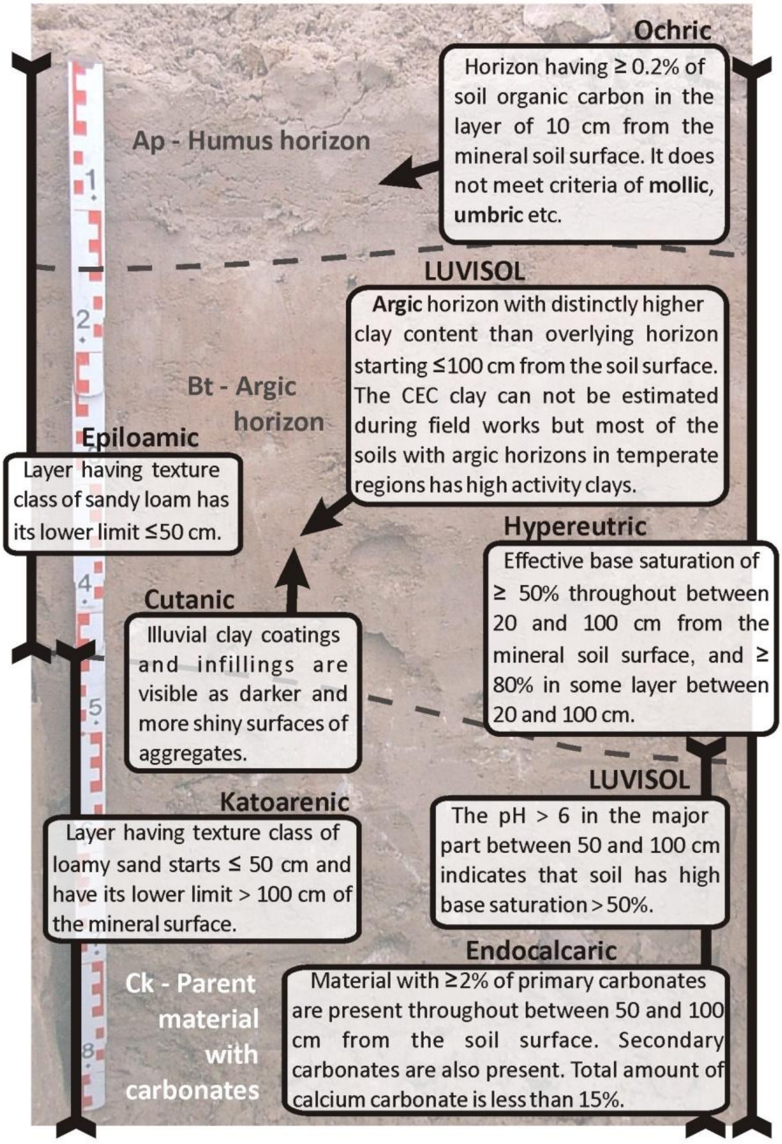
LUVISOL

Endocalcaric Endoskeletic Rhodic Endoleptic LUVISOL (Clayic, Cutanic, Humic)

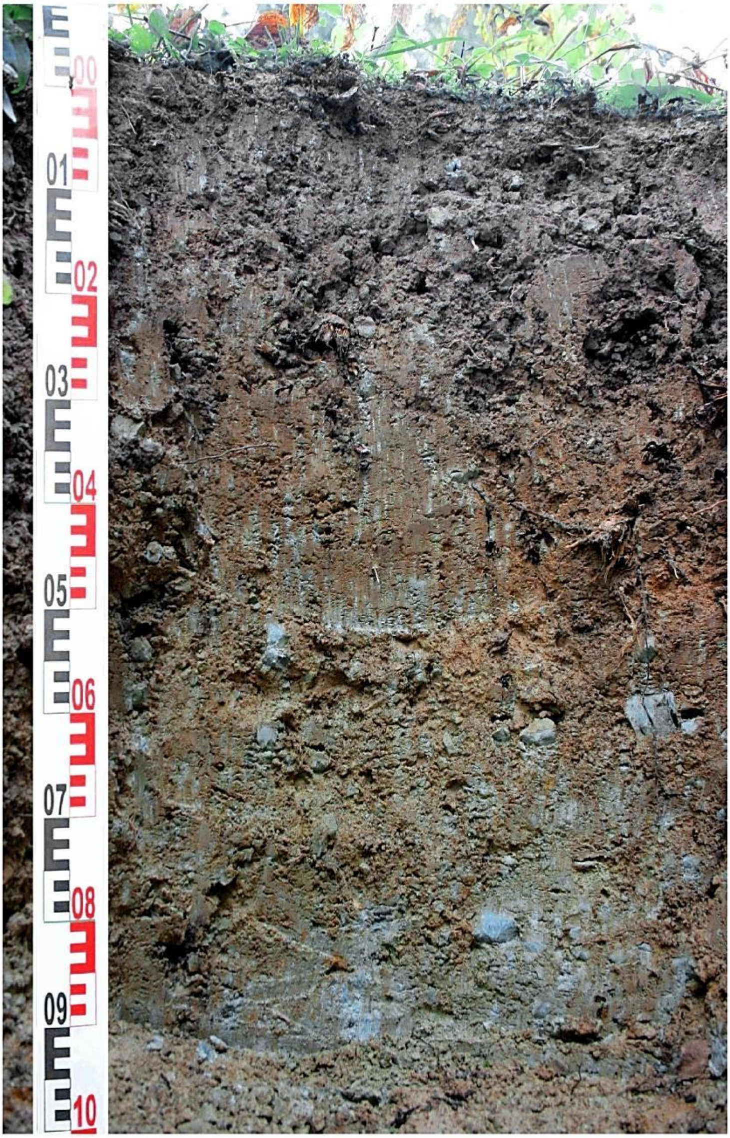


LUVISOL

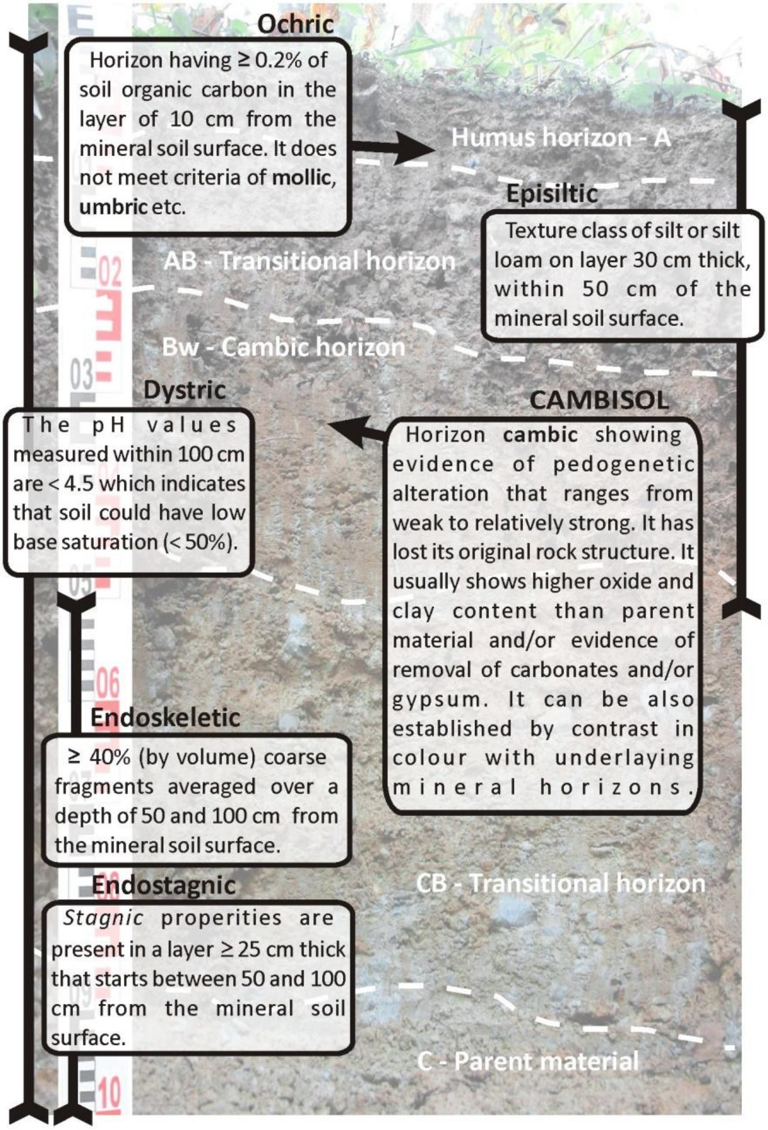
Endocalcaric LUVISOL (Epiloamic, Katoarenic, Cutanic, Hypereutric, Ochric)



CAMBISOL

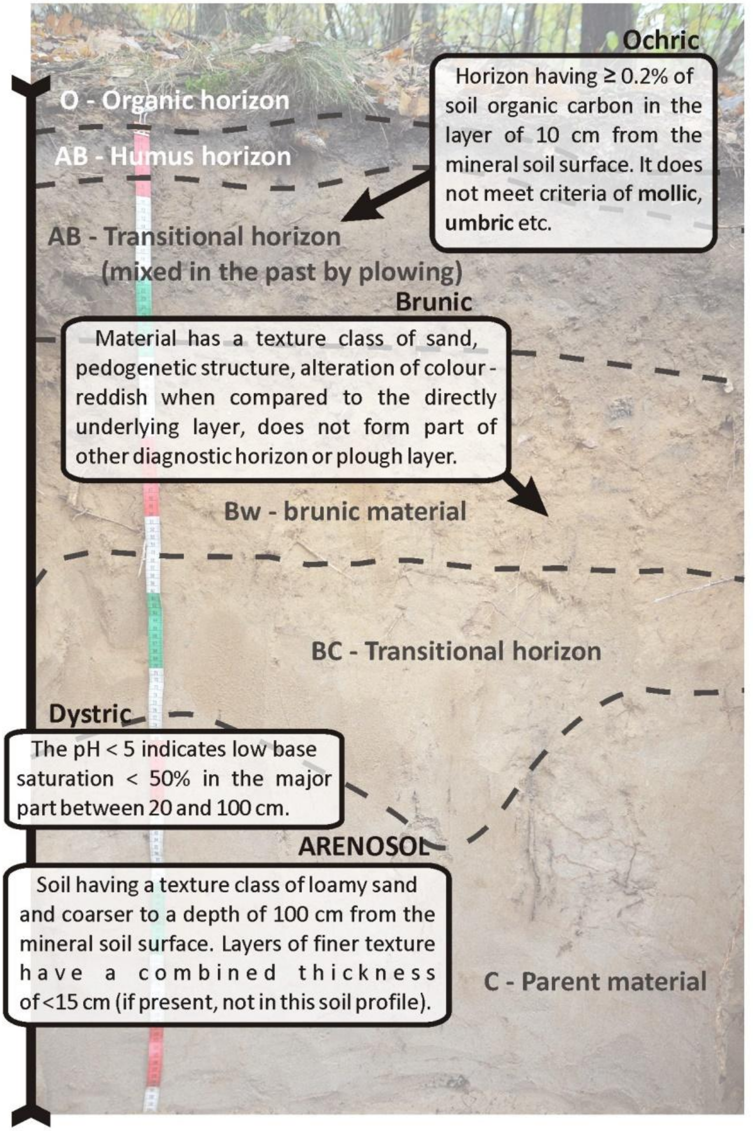


Dystric Endoskeletic Endostagnic CAMBISOL (Episiltic, Ochric)

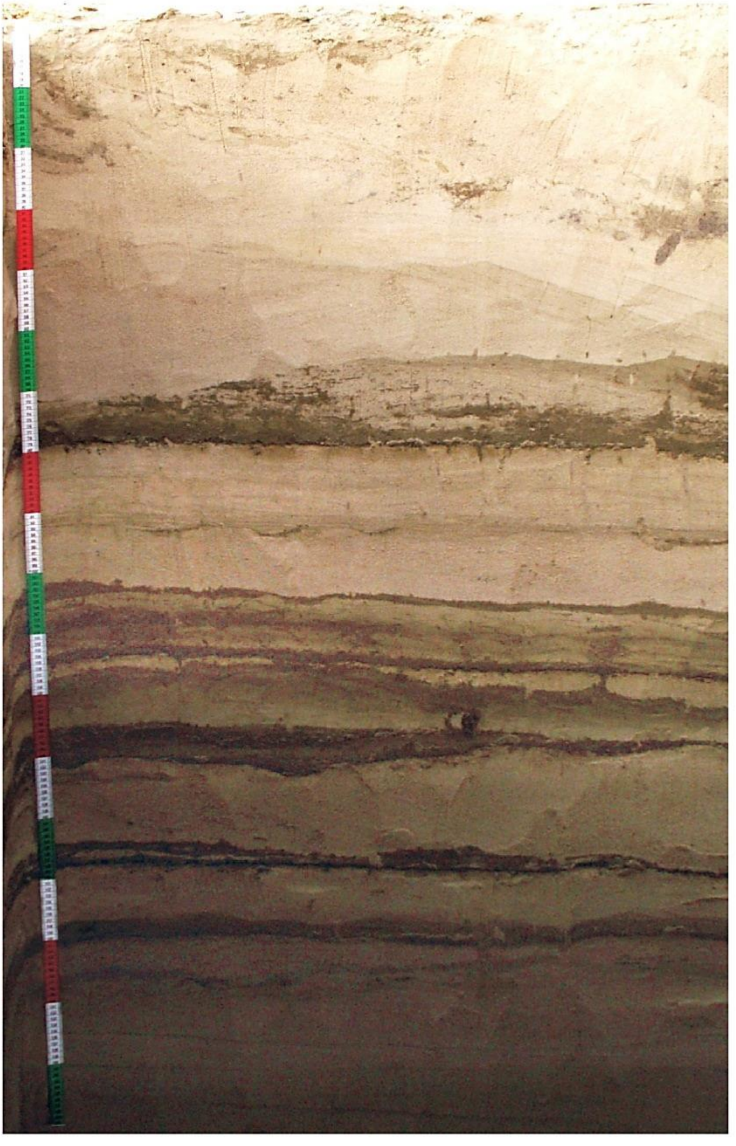


ARENOSOL

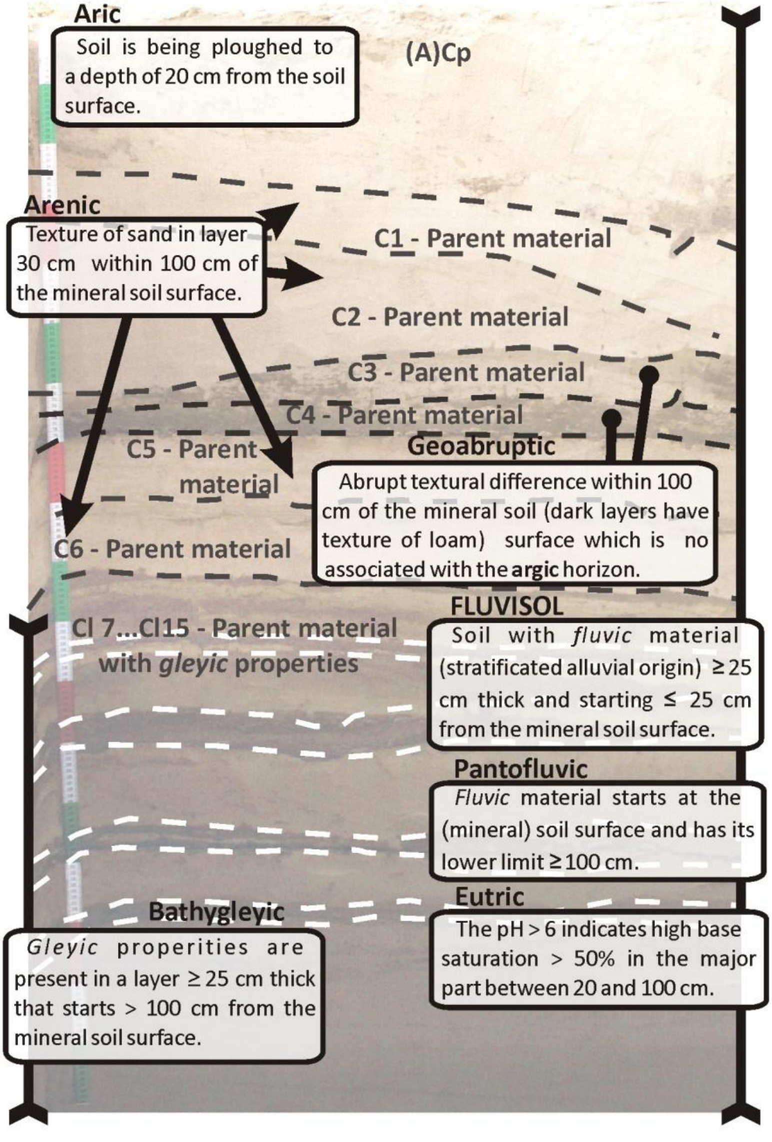
Dystric Brunic ARENOSOL (Ochric)



FLUVISOL

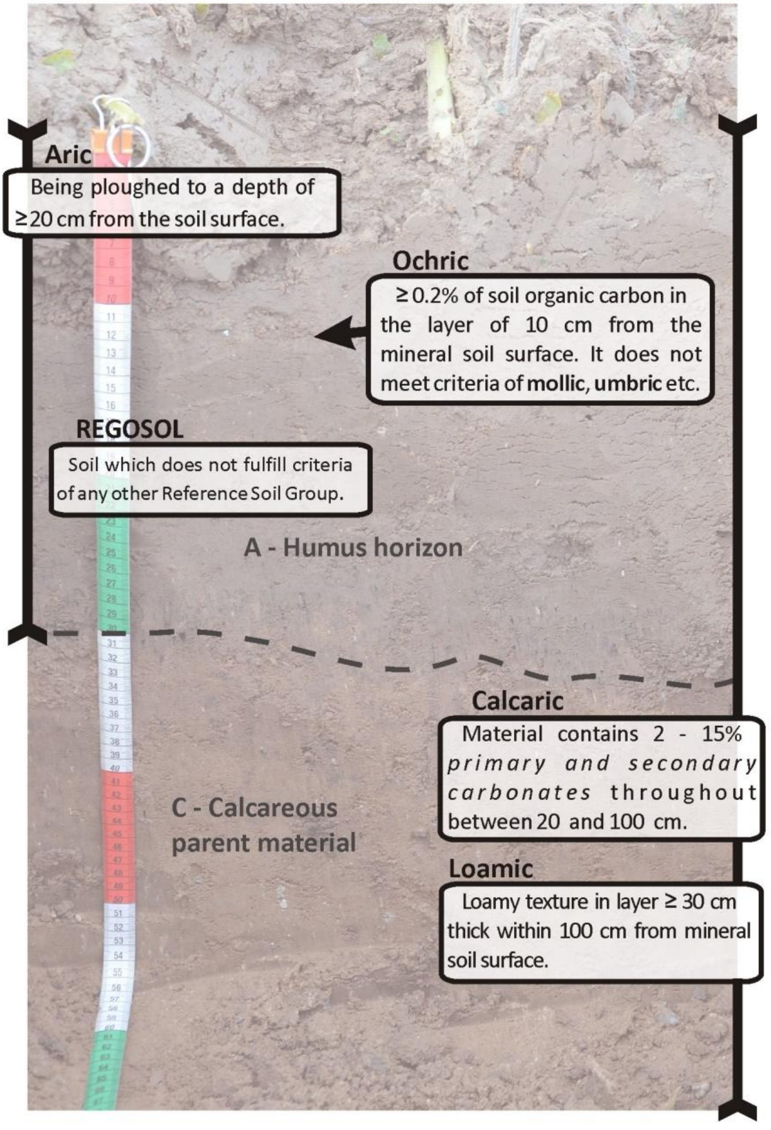


Eutric Pantofluvic FLUVISOL (Geoabruptic, Arenic, Aric, Bathygleyic)



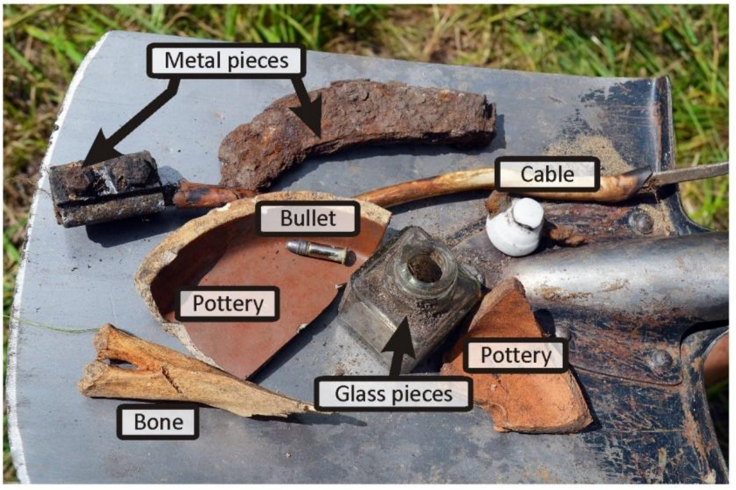
REGOSOL

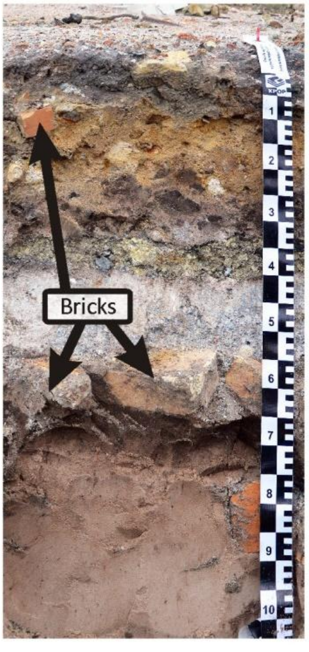
Calcaric
REGOSOL
(Aric, Loamic, Ochric)



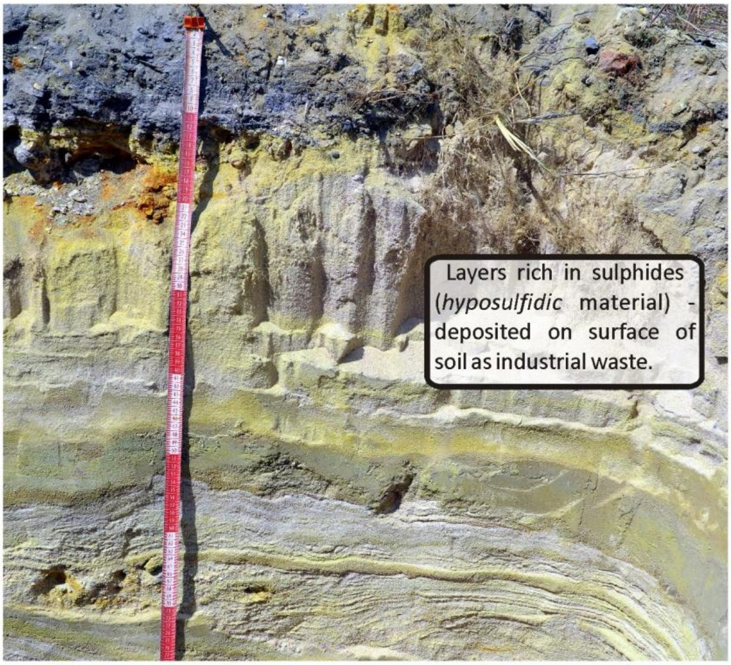
3.2. Soil properties and materials

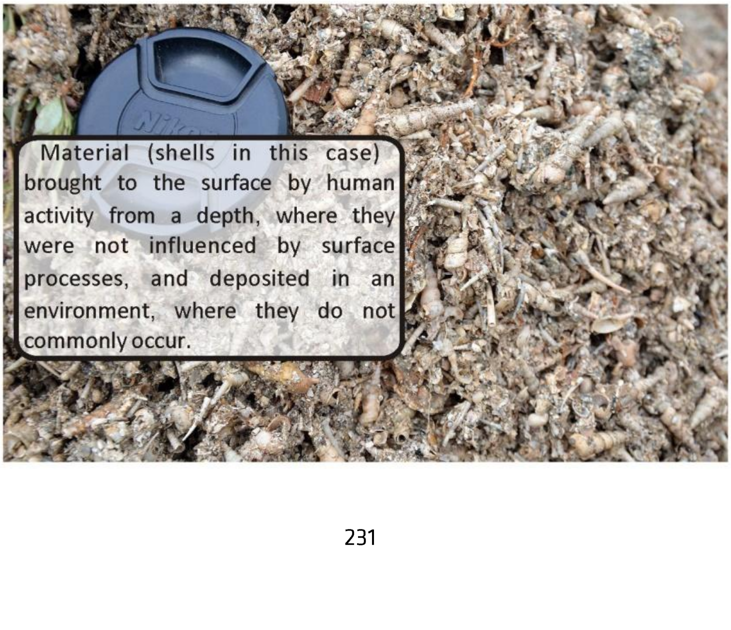
ARTEFACTS


Metal pieces
Cable
Bullet
Pottery
Pottery
Glass pieces
Bone

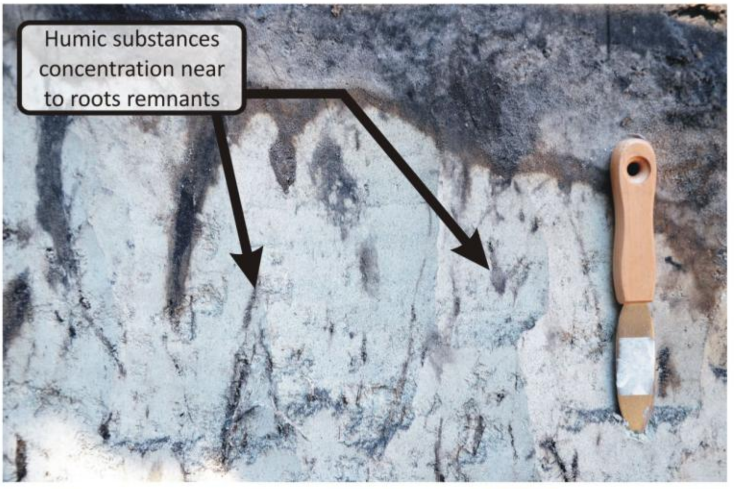

Bricks


Industrial
waste

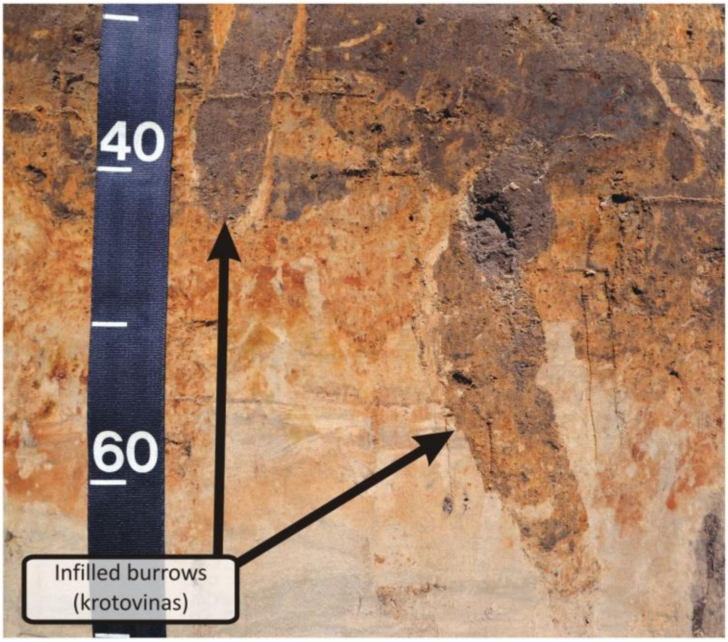

Layers rich in sulphides (*hyposulfidic* material) - deposited on surface of soil as industrial waste.


Material (shells in this case) brought to the surface by human activity from a depth, where they were not influenced by surface processes, and deposited in an environment, where they do not commonly occur.

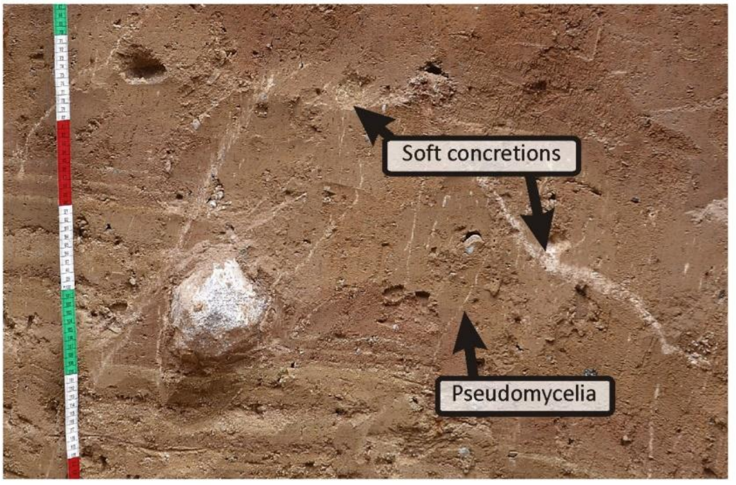
BIOLOGICAL ACTIVITY




Earthworm channels


40
60
Infilled burrows (krotovinas)

CARBONATES


Soft concretions
Pseudomycelia

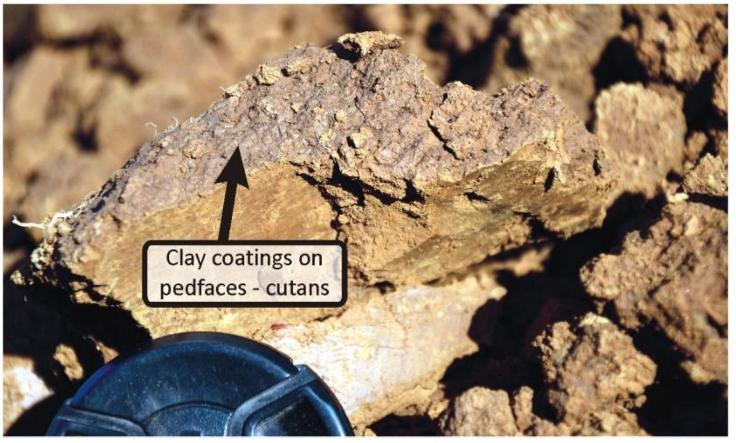

Nikon
Hard concretion
„loess doll"

CARBONATES

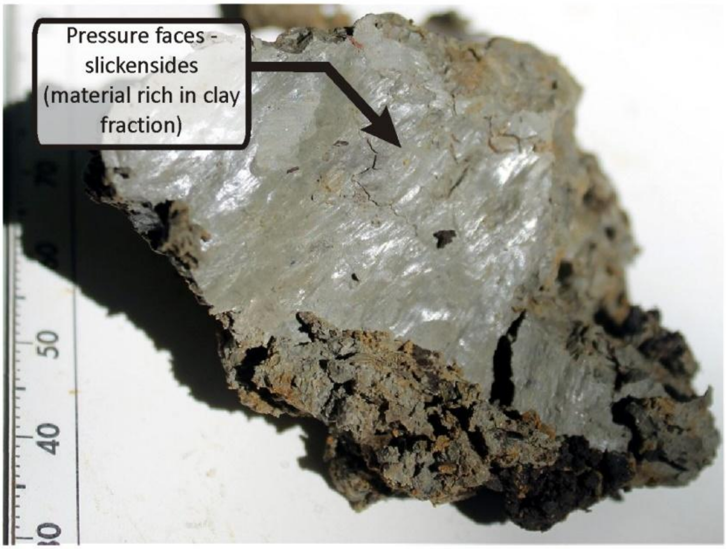

Soft concretions
and disperse
powdery lime

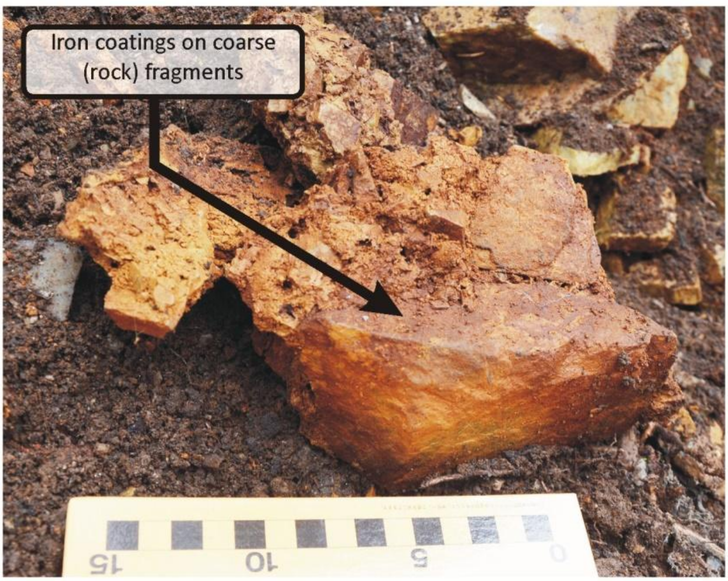

Hard concretions

COATINGS

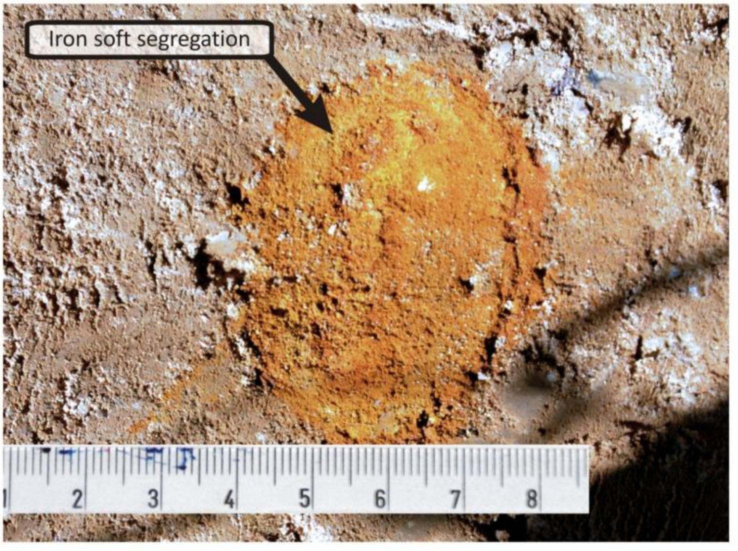

Clay coatings on
pedfaces - cutans

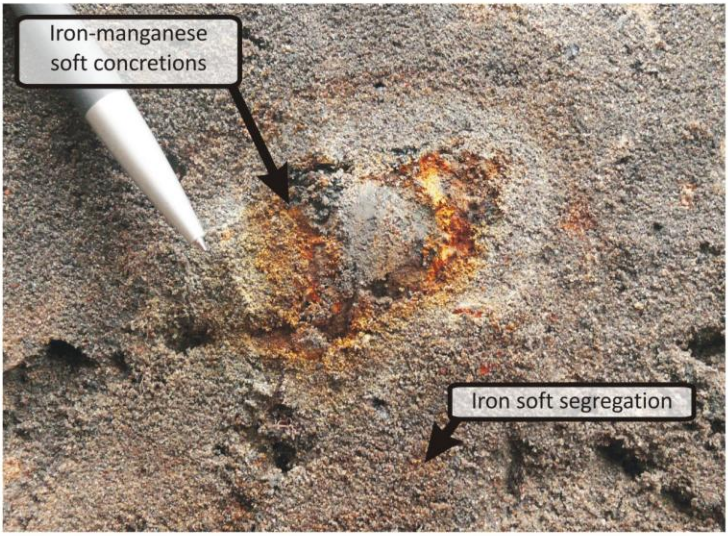

Clay and iron coatings -
cutans, on coarse (rock)
fragments


Pressure faces - slickensides (material rich in clay fraction)
50
40


Iron coatings on coarse (rock) fragments
15
10
5
0

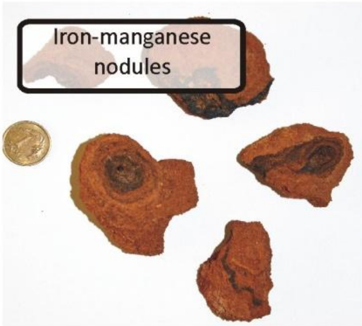
CONCRETIONS

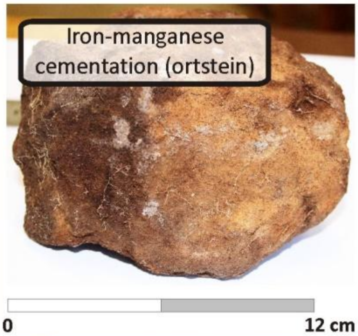


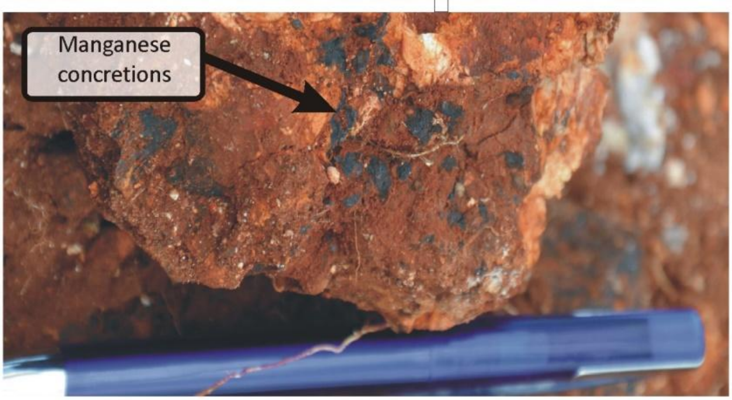

Iron-manganese soft concretions
Iron soft segregation


Iron-manganese concretions

CONCRETIONS



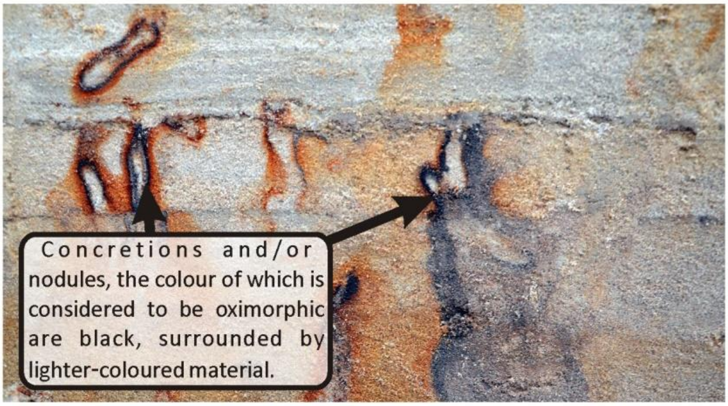




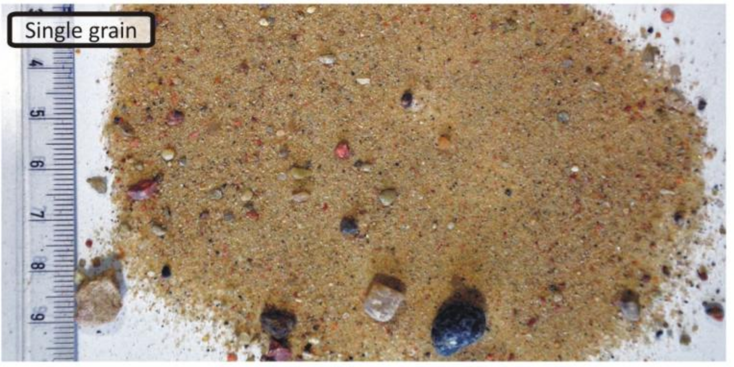
CONCRETIONS

GLEYIC PROPERTIES

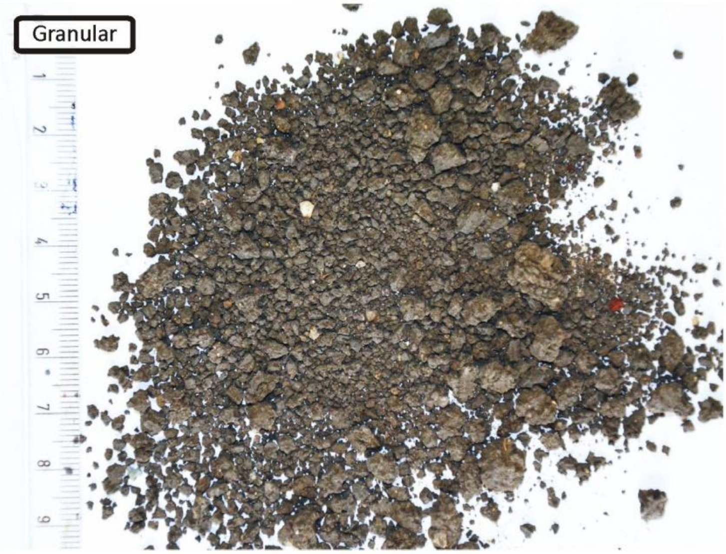
STAGNIC PROPERTIES



STRUCTURES



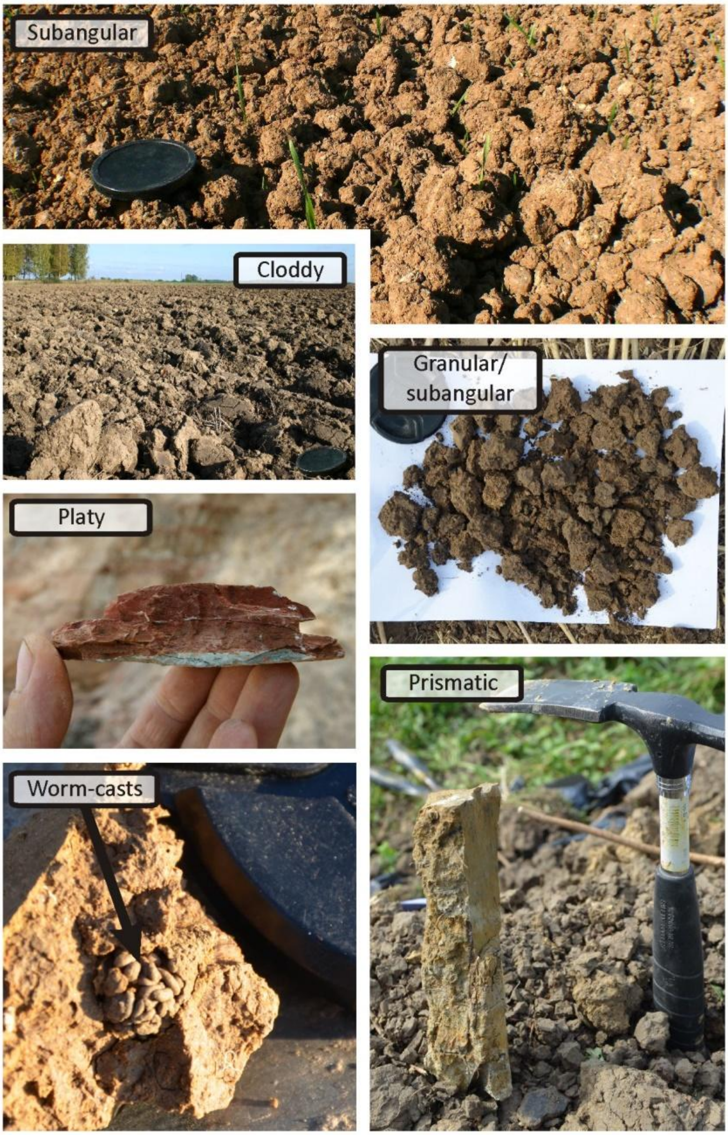
STRUCTURES



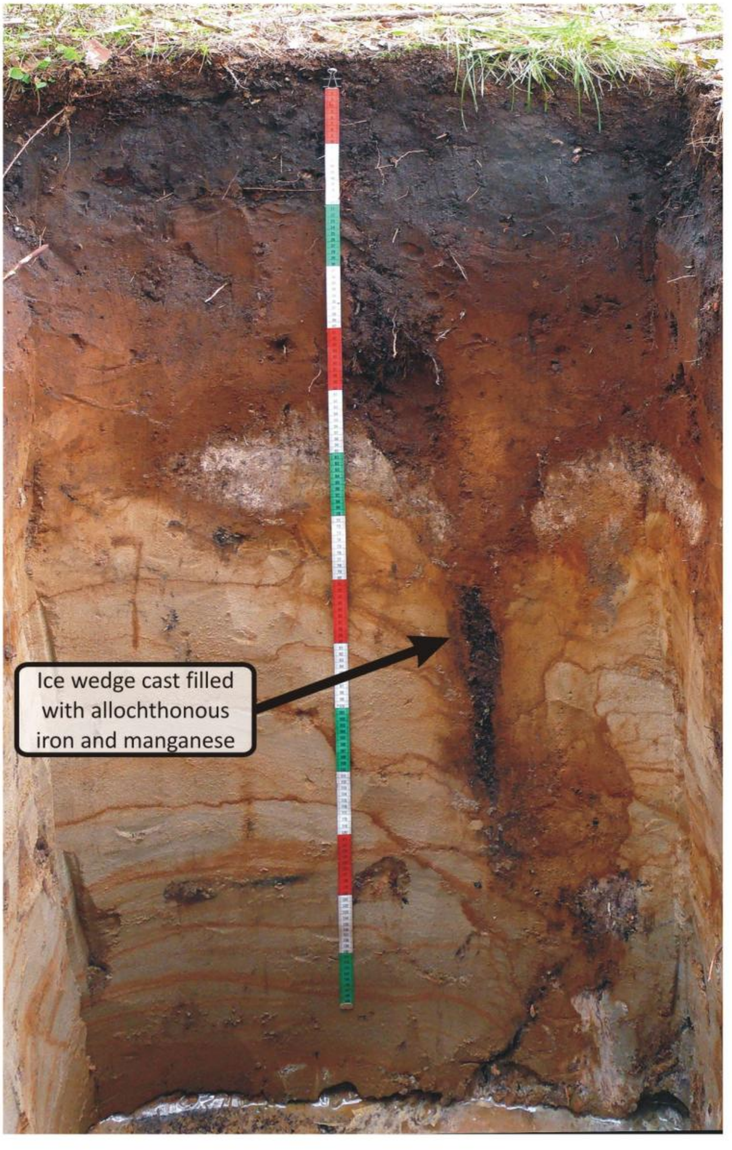

Angular
0
1
2
3
4
5
6
7
8
9
10
11
12
13


Angular/
subangular
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

STRUCTURES

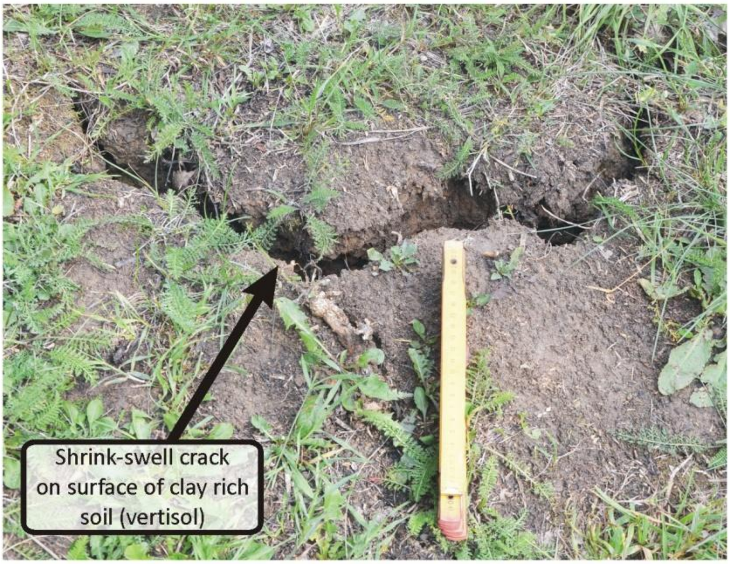

Subangular
Cloddy
Granular/
subangular
Platy
Prismatic
Worm-casts

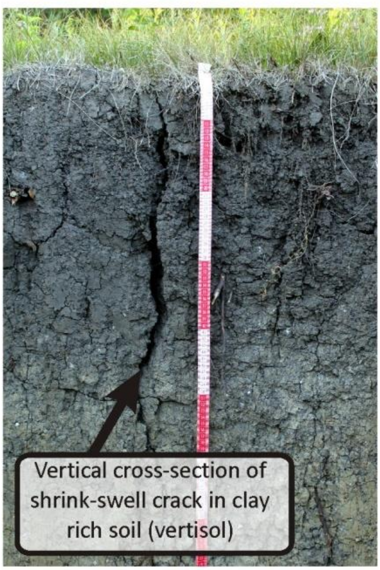
WEDGES AND CRACKS



WEDGES AND CRACKS

WEDGES AND CRACKS





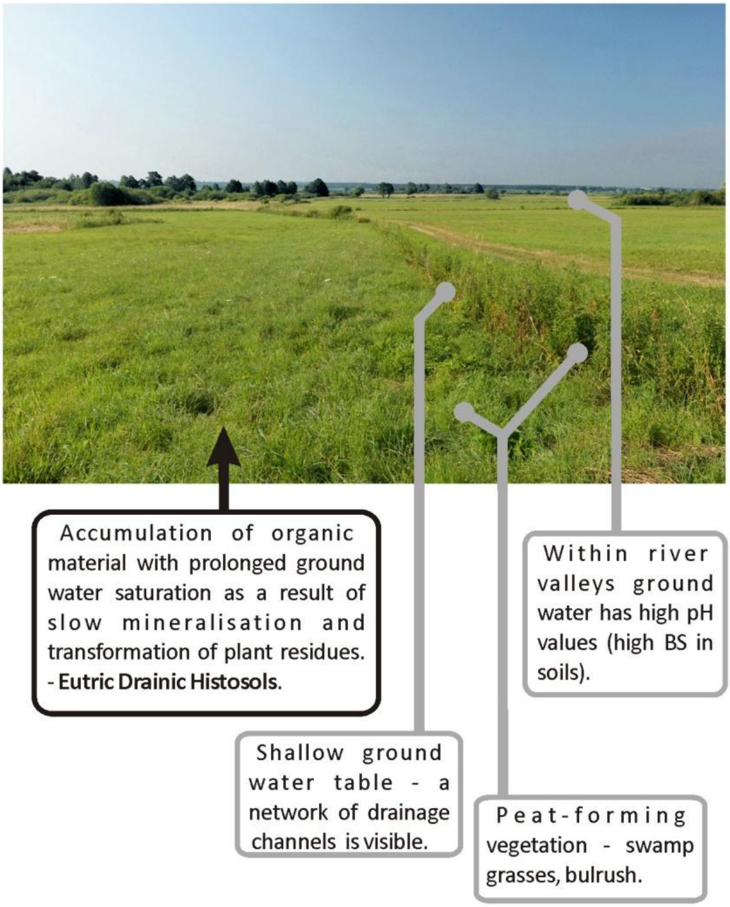
3.3. Soil landscapes

SAND-DUNE SPIT

Climate: snow, fully humid with warm summer
Landform: sand-dune spit
Lithology: aeolian sand
Land use: monoculture plantation - pines and spruces
Location: Northern Lithuania

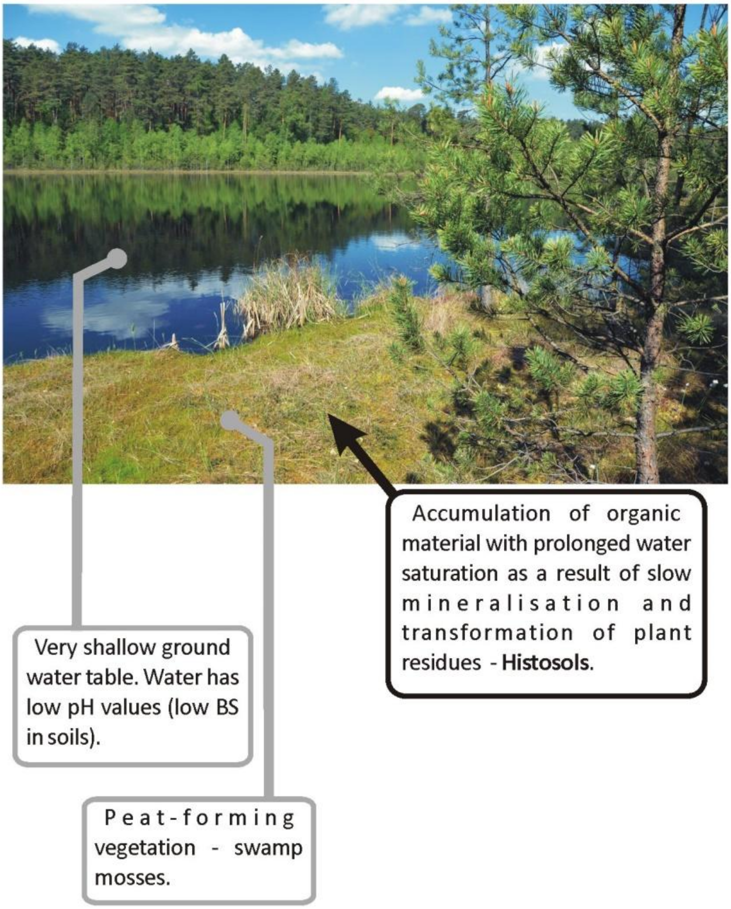
BIOGENIC PLAIN

<u>Climate</u>: warm temperate, fully humid with warm summer
<u>Landform</u>: biogenic plain in river valley
<u>Lithology</u>: organic material
<u>Land use</u>: meadow/pasture
<u>Location</u>: Central Poland



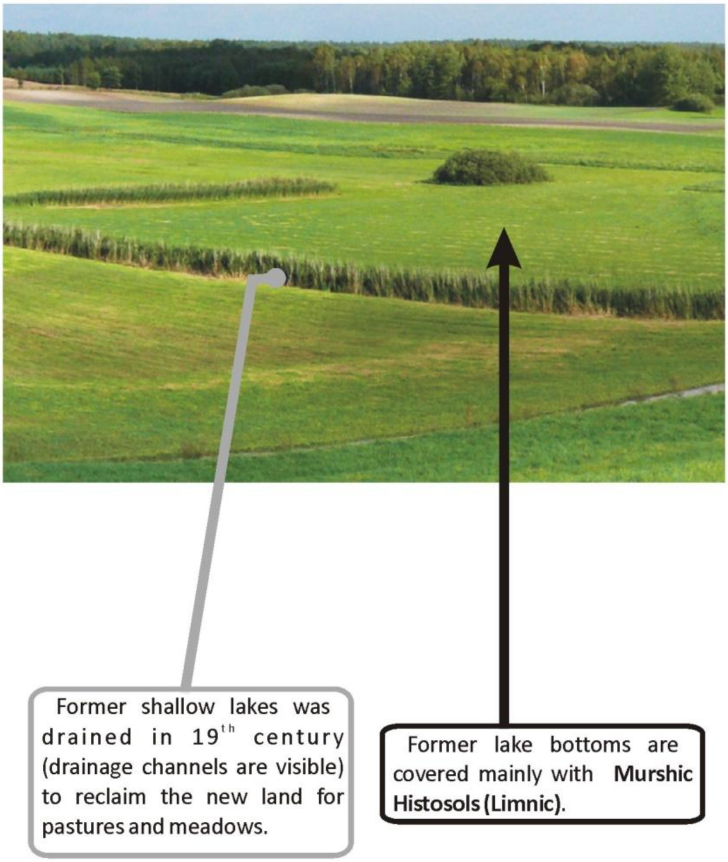
BOTTOM OF KETTLE HOLE

Climate: warm temperate, fully humid with warm summer
Landform: bottom part of kettle hole
Lithology: organic material
Land use: natural reserve with pine stands
Location: Northern Poland



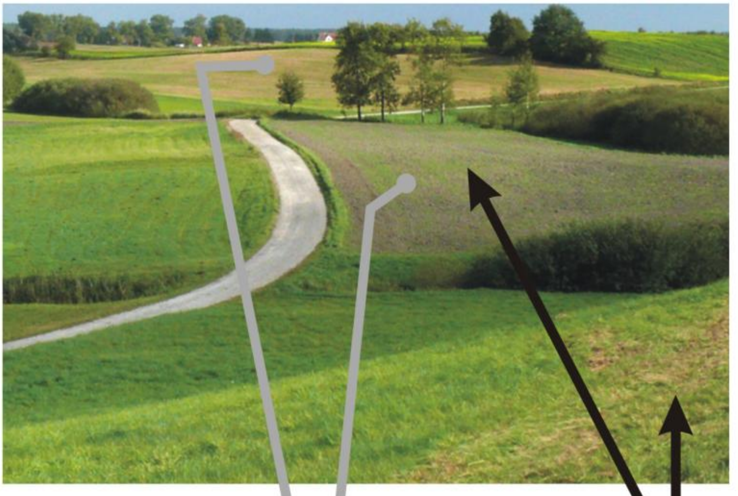
POST-LACUSTRINE PLAIN

Climate: warm temperate, fully humid with warm summer
Landform: post-lacustrine flat depressions bottoms
Lithology: organic lacustrine sediments (gyttja)
Land use: pastures and meadows
Location: Northern Poland



KAME HILLS

Climate: warm temperate, fully humid with warm summer
Landform: kame hills and plateaus
Lithology: glacilimnic sands and loams
Land use: arable field
Location: Northern Poland

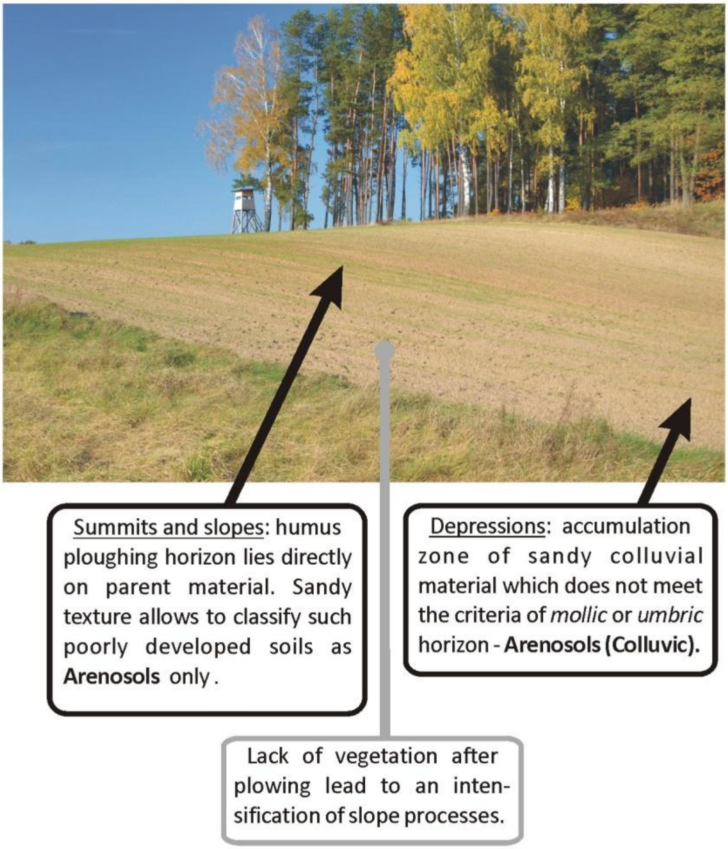


High content of calcium carbonates causes high base saturation. That is why these soils are relatively fertile and being used for cultivation what is leading to strong erosion on the hill slopes.

Soil cover of kame hills and plateaus is very diversified. Due to large variety of texture and local hydrological conditions (due to occurring of strongly cemented, impermeable horizons) they could be classified as different Reference Soil Groups: **Stagnosols**, **Arenosols** or **Regosols**

OUTWASH PLAIN

<u>Climate</u>: warm temperate, fully humid with warm summer
<u>Landform</u>: outwash plain (sandur)
<u>Lithology</u>: glaciofluvial sands
<u>Land use</u>: arable fields
<u>Location</u>: Northern Poland



PLEISTOCENE TERRACE

Climate: warm temperate, fully humid with warm summer
Landform: plain - almost flat (level) Pleistocene terraces
Lithology: fluvial sand and gravel
Land use: plantation forestry, deciduous forest
Location: Northern Poland

Despite of humid climate, acid reaction and high permeability of sandy deposits, decidous forest prevent the development of podzolization.

Biochemical weathering of highly sandy deposits and no influence of ground water lead to development of **Dystric Brunic Arenosols.**

PLEISTOCENE TERRACE

Climate: warm temperate, fully humid with warm summer
Landform: plain - almost flat (level) Pleistocene terraces
Lithology: fluvial sand and gravel
Land use: plantation forestry, pines
Location: Northern Poland

An acidic environment in combination with a high precipitation favors podzolization process and development of **Albic Podzols (Arenic)**.

Species of coniferous forest (pines, bilberries) cause strong acidification of soils.

HUMMOCKY MORAINIC PLATEAU

Climate: warm temperate, fully humid with warm summer
Landform: hummocky moraine plateau
Lithology: ablation sands on glacial tills
Land use: plantation forestry, deciduous forest
Location: Northern Poland

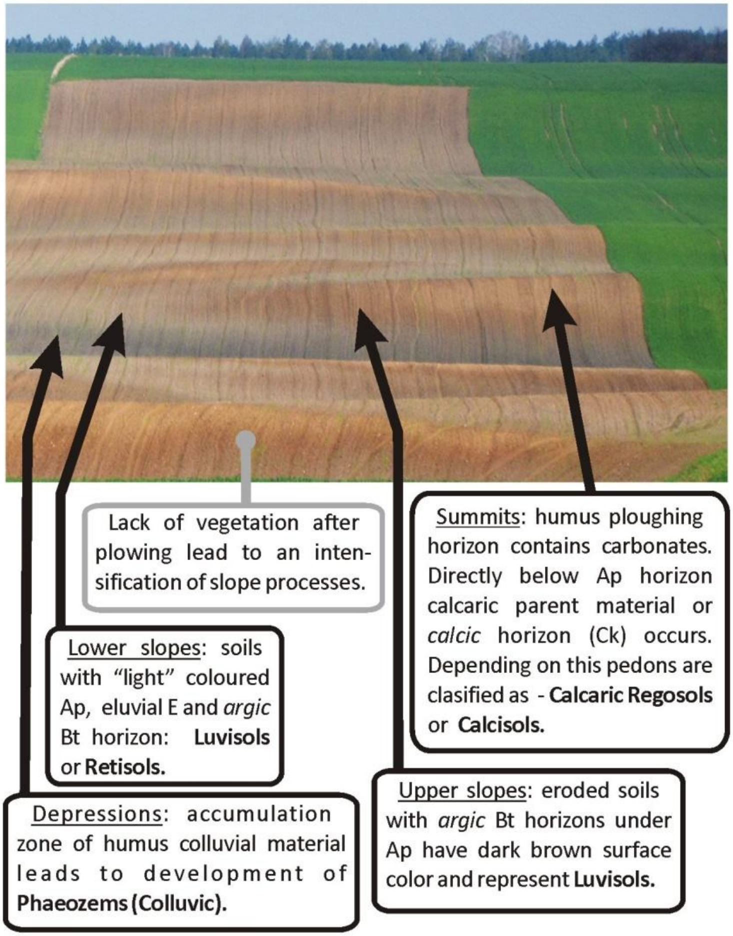
Summits and slopes: pedons developed from glacial deposits with clay-enriched subsoil (argic horizon) as a result of clay translocation in humid climate conditions - **Luvisols** and **Retisols.**

Depressions: mineral soils under influence of ground water and with slow decomposition of organic matter : **Gleyic Umbrisols** or **Umbric Gleysols.**

Dense forest vegetation protect the soil cover against erosional alterations even on steep slopes.

UNDULATING MORAINIC PLATEAU

Climate: warm temperate, fully humid with warm summer
Landform: undulating moraine plateau
Lithology: ablation sands on glacial tills
Land use: arable fields
Location: Northern Poland



FLAT MORAINIC PLATEAU

Climate: warm temperate, fully humid with warm summer
Landform: plain - almost flat (level) morainic plateau
Lithology: glacial tills (sandy loams)
Land use: arable field - wheat
Location: Northern Poland

Despite flat relief moderate or good natural drainage is supported by average permeability of sandy loam material. Leaching water regime prevails (clay translocation).

Soils with *argic* horizons characterized by illuvial accumulation of clay predominate. They are classified as **Retisols** or **Luvisols**.

FLAT MORAINIC PLATEAU

Climate: warm temperate, fully humid with warm summer
Landform: plain - almost flat (level) morainic plateau
Lithology: glacial tills (loams or clay loam)
Land use: arable field - rape, wheat
Location: Northern Poland

Poor natural drainage is caused by humid climate, flat relief and low permeability of loamy material rich in clay fraction. This is evidenced by visible drainage wells and channels.

High moisture of soils lead to development of *mollic* or *chernic* horizons. **Mollic/Chernic Gleysols** or **Gleyic Chernozems.**

FLOODPLAIN

Climate: warm temperate, fully humid with warm summer
Landform: embanked flat plain
Lithology: fluvial sands and silts
Land use: arable land
Location: Northern Poland

Fluvisols or **Fluvic Gleysols/Phaeozems** are common in periodically flooded areas (e.g. floodplains), where both sediments deposition and pedogenesis are active. Many properties of these soils depend on location in landscape and land use or plant cover type.

Alluvial soils, formerly covered with willow bushes (Salix species), are nowadays arable lands.

SALINE STEPPE

Climate: warm temperate, fully humid with hot summer
Landform: plain, level land
Lithology: silty and clayey fluvial sediments
Land use: grazing
Location: Eastern Hungary (Báránd)

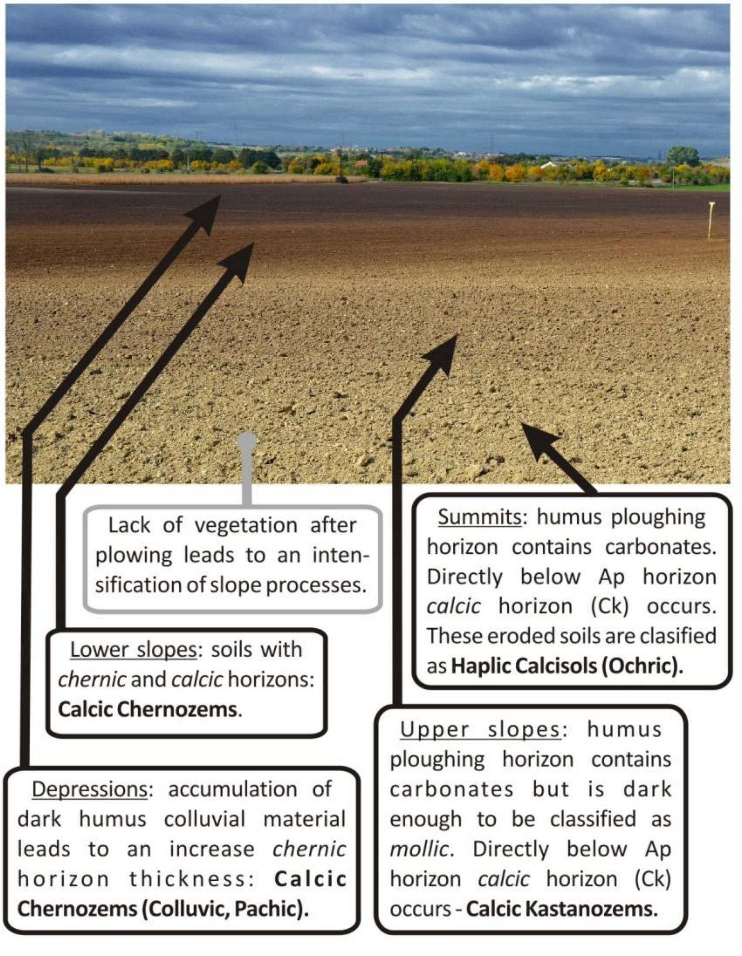
Halophytic plant species (e.g Artemisia santonicum) indicates alkaline reaction and / or presence of water soluble salts in soils.

Sparsely vegetated, or bare plots indicates unfavourable conditions for plant growing.

Albic material covers bare soil plots. Clayey soil soil surface (shrinkage cracks are visible) characterize with low water permeability causes stagnation of water on the surface - **Stagnic Solonetz (Albic)**.

LOESS PLATEAU

Climate: warm temperate, fully humid with hot summer
Landform: undulating plateau
Lithology: loess
Land use: arable land
Location: Central Hungary



DENUDATION PLAIN

Climate: warm temperate, fully humid with warm summer
Landform: denudation plain
Lithology: ablation sand over glacial till
Land use: arable field
Location: South-western Poland

Despite sandy texture of the topsoil, underlying loam material reduce permeability and water supply in soil thus provide favourable conditions for plants cropping.

Deposition of ablation sands on glacial tills in the end of the Pleistocene result in strong differenation in texture as well as water stagnation, therefore these deposits in such configuration decide about **Planosols** formation.

LIMESTONE UPLAND

Climate: warm temperate, fully humid with warm summer
Landform: undulating plateau
Lithology: Jurassic limestone
Land use: arable field
Location: Southern Poland

Agriculture use sustain presence of *mollic* horizon, while shallow occurence of the limestone decide about **Rendzic Phaeozems** presence.

LIMESTONE PLAIN

Climate: warm temperate, fully humid with warm summer
Landform: limestone highlands
Lithology: limestones
Land use: arable fields
Location: Southern Poland

Lack of vegetation after plowing lead to an intensification of slope processes.

Slopes and summits: White rock fragments (limestones) on soil surface. Uppermost horizon fulfill criteria of *mollic* - **Somerirendzic Leptosols**.

LOESS FOOTHILLS

Climate: warm temperate, fully humid with warm summer
Landform: concave slope
Lithology: thick loess deposits
Land use: arable field - wheat
Location: South-western Poland

Recently established meadows protect soils against erosional alterations and provide stable conditions for soil development.

Concave slope worked as a trap for deposited and eroded loess in the Pleistocene/Holocene and result in thick slope sediments formation. Clay translocation and developemnt of clay-rich subsurface dominate in loess deposits, while nowadays we observed decay of argic and formation of **Retisols.**

LOWER MONTANE DECIDUOUS FOREST

Climate: warm temperate, fully humid with warm summer
Landform: very gentle slope below basalt outcrops
Lithology: loess mantles over basalt derived slope sediments
Land use: plantation forestry, deciduous forest
Location: South-western Poland

Despite relatively high precipitation and acidicication affect casused by *Beech* forest litter, still redoximorphic features prevail over clay translocation.

Linear slopes with very low inclination, covered by relatively fine materials reduce permeability and cause water stagnation, intense enough for **Stagnosols** development.

UPPER MONTANE CONIFEROUS FOREST

Climate: snow, fully humid with warm summer
Landform: steep, convex slope below sandstone cliffs
Lithology: Cretaceous sandstones
Land use:plantation forestry, Norway spruce forest
Location: South-western Poland

Structure of slope covers (sandstone blocks covered with nearly pure sand) decide about **Dystric Skeletic Podzols** formation.

High annual precipitiation, sandy texture and acid forest litter favour strong leaching conditions and promotes podzolization.

SUBALPINE ZONE

Climate: snow, fully humid with warm summer
Landform: slope in the subalpine zone
Lithology: metamorphic slope sediments
Land use: grassland/Norway spruce
Location: South-western Poland

Dense forest vegetation protect the soil cover against erosional alterations even on steep slopes.

Relict geomorphological landforms in subalpine zone such solifluction lobes and crioplanation terraces provide extremely coarse parent material for soil development - **Leptosols**.

VINEYARDS

Climate: snow, fully humid with warm summer
Landform: sand-dune spit
Lithology: limestone regolith
Land use: vineyard
Location: Slovenia

Relatively high amount of iron affects the red color of soil material. High precipitation lead to translocation of clay fraction - **Chromic Luvisols (Escalic, Ochric)**. In some cases pedons were „rejuvenated" by anthropogenic destruction of **argic** horizons and altered into **Chromic Cambisols (Escalic, Ochric).**

Terracing and other leveling works led to strong mechanical transformations of soil cover.

Annex - Soil description sheet*

* full resolution version: www.soils.umk.pl

SOIL DESCRIPTION SHEET

FACES Project .

Profile ID (p. 14)	**Date** (p. 14)	**Description author** (p. 14)	**Latitude** (p. 14)	**Longitude** (p. 14)	**Location** (p. 14)	**Elevation m a.s.l.** (p. 14)
Mean air temperature (p. 16)	**Mean precipitation** (p. 16)	**Major landform** (p. 17)	**Landform - 2nd level** (p. 17)	**Profile position** (p. 18)	**Microrelief** (p. 20)	**Slope form** (p. 18)
Slope inclination (p. 19)	**Slope exposition** (p. 20)					
Land use / natural vegetation (p. 21)	**Human influence** (p. 22)	**Parent material(s)** (p. 22)	**Rock outcrops** (p. 23)	**Coarse fragments** (p. 23)		
Erosion: (p. 24) Category Activity	**Surface sealing** (p. 25)	**Cracks** (p. 25)	**Water stagnation** (p. 26)	**Flooding** (p. 26)	**Drainage/Irrigation** (p. 26)	**Groundwater, cm** (p. 26)
Classification WRB (2015)	**Classification**					

VEGETATION / CROPS

No	Species name	%

GRAPHICS AND FIELD COMMENTS

		Samples 1	Samples 2	Samples 3
20				
10				
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
100				
110				
120				
130				
140				
150				
160				
170				
180				

No	Horizons				Texture class (p. 38)	Coarse fragments (p. 43)				Peat decom-position (p. 46)	Soil colour (matrix) (p. 47)		Redox mottling (p. 47)					Reducing condi-tions (p. 48)	Carbonates (p. 49)		Salts (p. 50)	pH (p. 50)
	Symbol (p. 27)	Depth, cm (p. 38)	Boundary (p. 38)			Abun-dance	Size	Shape	Weathe-ring		dry state	moist state	Total abund.	Oximorphic		Reductomorphic			Abun-dance	Form		
			Distinct	Topogr.										Colour	Abund.	Colour	Abund.					
1																						
2																						
3																						
4																						
5																						
6																						
7																						
8																						

No	Structure				Consistency (p. 57)		Soil water status (p. 58)	Coatings (p. 59)			Cementation (p. 60)		Other concentrations (p. 61)			Biological features (p. 62)		Artefacts (p. 63)			Diagnostic horizons, properties and materials
	Grade (p. 52)	Type (p. 54)	Size (p. 56)	Com-pound structure	Dry	Moist		Nature	Abun-dance	Location	Conti-nuity	Nature	Type	Compo-sition	Abun-dance	Root abun-dance	Other activity	Kind	Abun-dance	Trans-formation	
1																					
2																					
3																					
4																					
5																					
6																					
7																					
8																					

Index

The names of Reference Soil Groups and qualifiers are given in capital letters. Next to the names of the qualifiers, their abbreviations are given in brackets. Index does not contain information about qualifier RSG lists (pages 105 – 127).

SOIL

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CENTRAL AND EASTERN EUROPEAN
STUDENTS' VERSION

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