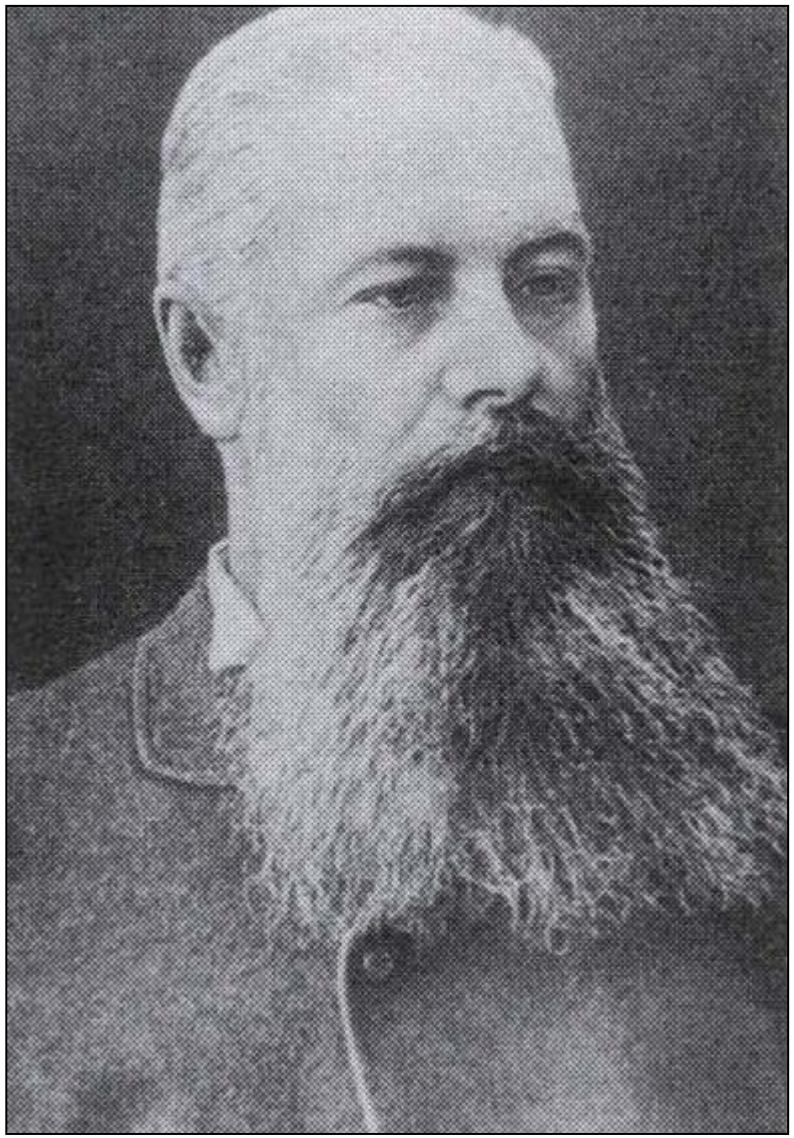
6. Soil observation II.

Soil classification according to the World Reference Base for Soil Resources (WRB)



Vasili Dokuchaev

The Russian School

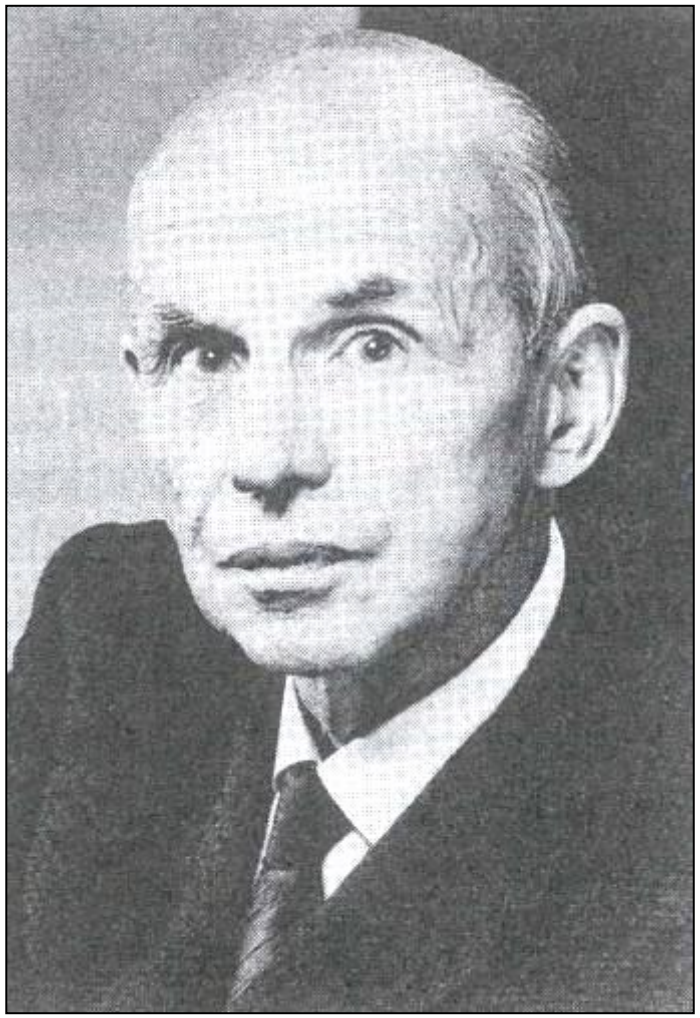
Soil forming factors

⇩

Soil forming processes

⇩

Different Soils



Hans Jenny:

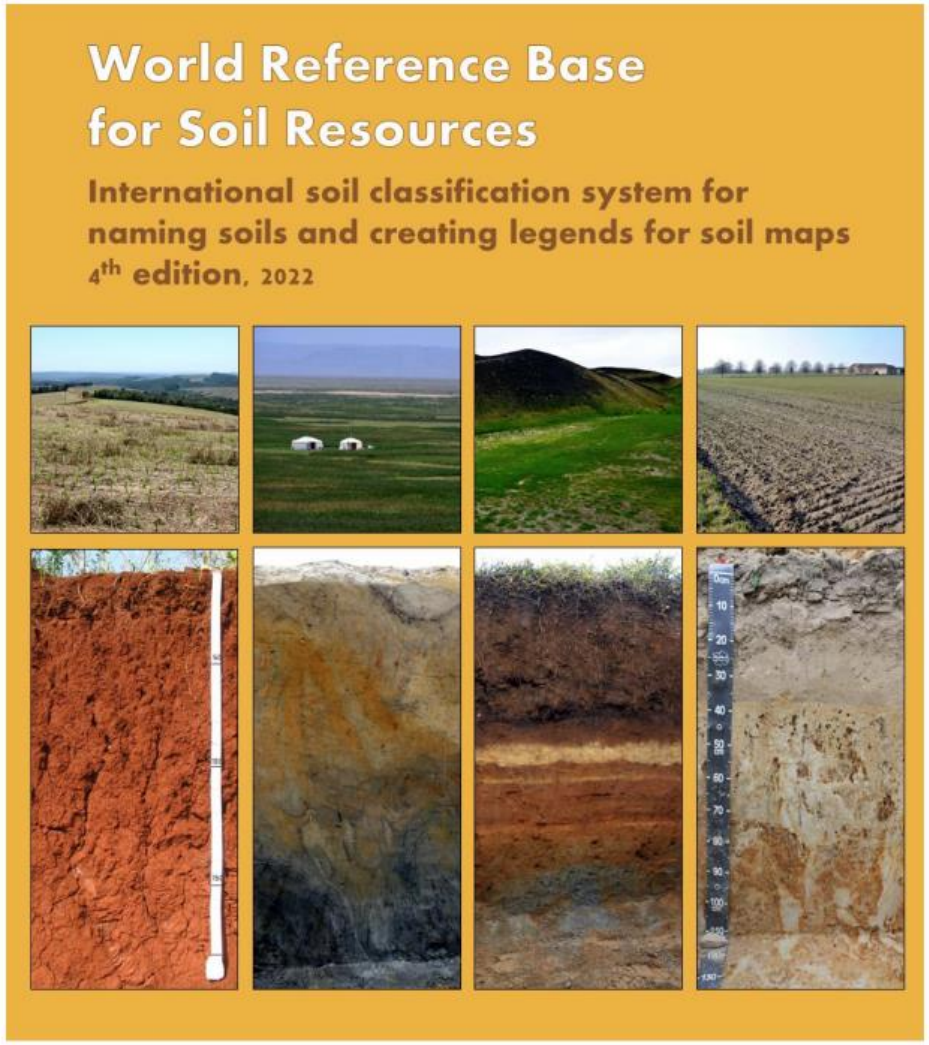
Factors of soil formation (1941)

$S = f(cl, o, r, p, t..)$

(climate, organisms, topography, parent material, time)

Published and helped our understanding of soil forming processes by introducing quantitative approach to the soil forming factors

World Reference Base for Soil Resources



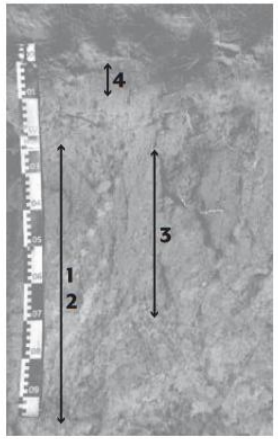
Book and simplified guidelines

Simplified key to the Reference Soil Groups of the World Reference Base for Soil Resources (WRB, 2015). After the definition, the most important diagnostic units (horizons, properties, and materials) are indicated. Diagnostic units separated by "|" should not be present necessarily together in the soil. Each diagnostic unit separated by "," must be present in the soil

Soils with thick organic layers		
1. High amount of undecomposed or partially decomposed organic matter (*organic material*)	No ↓ Yes →	Histosols
Soil with strong human influence		
2. Evidence of long, intensive agricultural use (*hortic* | *irragric* | *plaggic* | *terric* | *hydragric* | *pretic horizons*)	No ↓ Yes →	Anthrosols
3. Containing a significant amount of human-made materials (*artefacts, technic hard material*)	No ↓ Yes →	Technosols
Soil with limitation to root growth		
4. Permafrost affected/frozen soils (*cryic horizon*)	No ↓ Yes →	Cryosols
5. Shallow, thin soils or having many coarse fragments (*continuous rock*)	No ↓ Yes →	Leptosols
6. Containing a high concentration of exchangeable Na (*natric horizon*)	No ↓ Yes →	Solonetz
7. Containing a high amount of shrink-swell clays, alternating wet-dry conditions (*vertic horizon*)	No ↓ Yes →	Vertisols
8. Containing a high concentration of water-soluble salts (*salic horizon*)	No ↓ Yes →	Solonchaks
Soils distinguished by Fe/Al chemistry		
9. Groundwater affected, underwater or tidal areas (*gleyic properties, reducing conditions*)	No ↓ Yes →	Gleysols
10. Allophane or Al-humus complex rich soils of young volcanic areas (*andic* | *vitric properties*)	No ↓ Yes →	Andosols
11. Subsoil accumulation of Al-humus complexes (*spodic horizon*)	No ↓ Yes →	Podzols
12. Accumulation and redistribution of Fe (*plinthic* | *pisoplinthic* | *petroplinthic horizons*)	No ↓ Yes →	Plinthosols
13. Strongly structured soils, low activity clays, P fixation, many Fe oxides (*nitic horizon*)	No ↓ Yes →	Nitisols
14. Deeply weathered, red-yellow soil, with dominance of kaolinite and oxides (*ferralic horizon*)	No ↓ Yes →	Ferralsols
15. Stagnating water (*abrupt textural difference, stagnic properties, reducing conditions*)	No ↓ Yes →	Planosols
16. Stagnating water, structural difference and/or moderate textural difference (*stagnic properties, reducing conditions*)	No ↓ Yes →	Stagnosols
Pronounced accumulation of organic matter in the mineral topsoils		
17. Very dark, very deep, organic matter rich topsoil, high base saturation (*chernic, calcic horizons*)	No ↓ Yes →	Chernozems
18. Dark, deep, organic matter rich topsoil, high base saturation (*mollic, calcic horizons*)	No ↓ Yes →	Kastanozems
19. Dark, deep, organic matter rich topsoil, high base saturation (*mollic horizon*)	No ↓ Yes →	Phaeozems
20. Dark, deep, organic matter rich topsoil, low base saturation (*umbric horizon*)	No ↓ Yes →	Umbrisols
Accumulation of moderately soluble salts or non-saline substance		
21. Accumulation of, and cementation by secondary silica (*duric* | *petroduric horizons*)	No ↓ Yes →	Durisols
22. Accumulation of, and cementation by secondary gypsum (*gypsic* | *petrogypsic horizons*)	No ↓ Yes →	Gypsisols
23. Accumulation of, and cementation by secondary calcium carbonate (*calcic* | *petrocalcic horizons*)	No ↓ Yes →	Calcisols
Soils with clay enriched subsoil		
24. Interfingering of coarse-textured, lighter colored material into a finer-textured, stronger colored layer (*argic horizon* | *retic properties*)	No ↓ Yes →	Retisols
25. Clay accumulation in the subsoil, low-activity clays, low base saturation (*argic horizon*)	No ↓ Yes →	Acrisols
26. Clay accumulation in the subsoil, low-activity clays, high base saturation (*argic horizon*)	No ↓ Yes →	Lixisols
27. Clay accumulation in the subsoil, high-activity clays, low base saturation (*argic horizon*)	No ↓ Yes →	Alisols
28. Clay accumulation in the subsoil, high-activity clays, high base saturation (*argic horizon*)	No ↓ Yes →	Luvisols
Soils with little or no profile development		
29. Moderately developed soils (*cambic horizon*)	No ↓ Yes →	Cambisols
30. Sandy soils (*loamy sand or coarser texture*)	No ↓ Yes →	Arenosols
31. Stratified, fluviatile, marine, and lacustrine sediments (*fluvic material*)	No ↓ Yes →	Fluvisols
32. No significant profile development (*no diagnostic horizons properties materials*)	Yes →	Regosols

ILLUSTRATED HANDBOOK OF WRB SOIL CLASSIFICATION

Acric Rhodic NITISOL (Ochric)



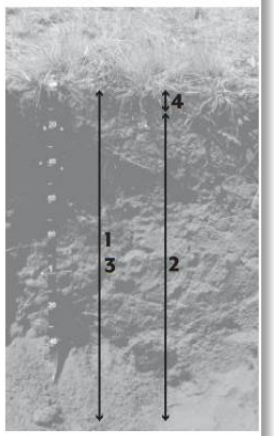
1 – NITISOL
clay-rich (≥30% clay) subsurface *nitic horizon* with moderately to strongly developed blocky structure breaking to polyhedral or flat-edged elements with many shiny pressure faces.

2 – Rhodic
evidence of pedogenesis and very intensively red colour in zone with at least 30 cm.

3 – Acric
argic horizon with evidence of clay illuviation, low-activity clays and low base saturation starting ≤100 cm from the mineral soil surface.

4 – Ochric
weakly developed, thin humus horizon with ≥0.2% *soil organic carbon* (weighted average) in the upper 10 cm of the mineral soil.

Ferritic FERRALSOL (Loamic, Ochric, Eutric)



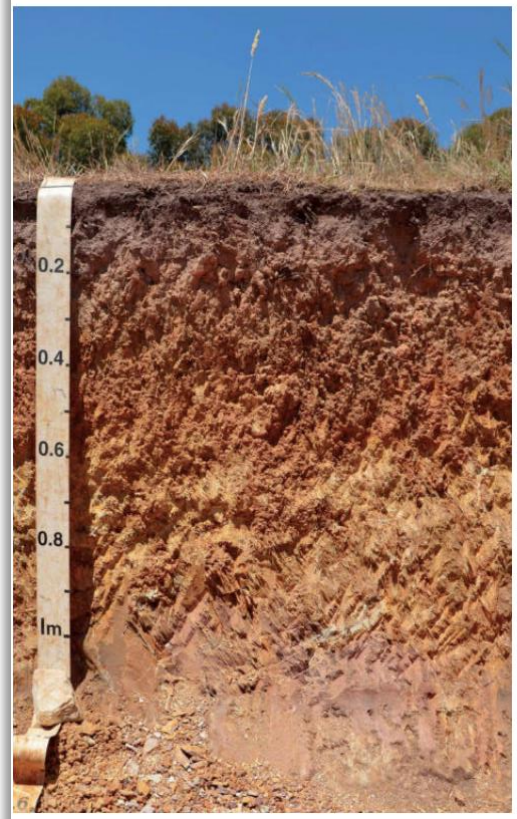
1 – FERRALSOL
ferralic horizon starting ≤150 cm from the mineral soil surface, strongly weathered, dominated by kaolinites and Fe oxides (hematite - red colour).

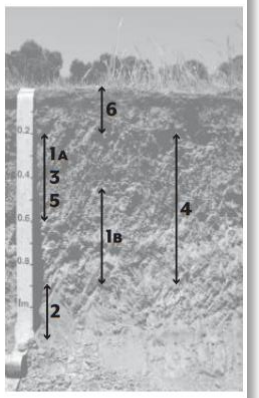
2 – Ferritic
layer, ≥30 cm thick and starting ≤100 cm from the mineral soil surface, with ≥0% Fe_{dith} and not forming part of a *petroplinthic*, *pisoplinthic* or *plinthic horizon*.

3 – Loamic
texture class of loam, sandy loam, clay loam, sandy clay loam or silty clay loam in layer(s) with a combined thickness of ≥30 cm, occurring within 100 cm of the mineral soil surface.

4 – Ochric
weakly developed humus horizon with ≥0.2% *soil organic carbon* (weighted average) in the upper 10 cm of the mineral soil.

Chromic Leptic ACRISOL (Clayic, Cutanic, Ochric)





1 – ACRISOL
1A clay-illuvial *argic horizon* with low-activity clays (developed from highly weathered, old materials).

1B low base saturation (low pH values) in half of more of lower half of the mineral soil above a continuous rock (here at 90 cm).

2 – Leptic
continuous rock starting >25 cm and ≤100 cm from the soil surface.

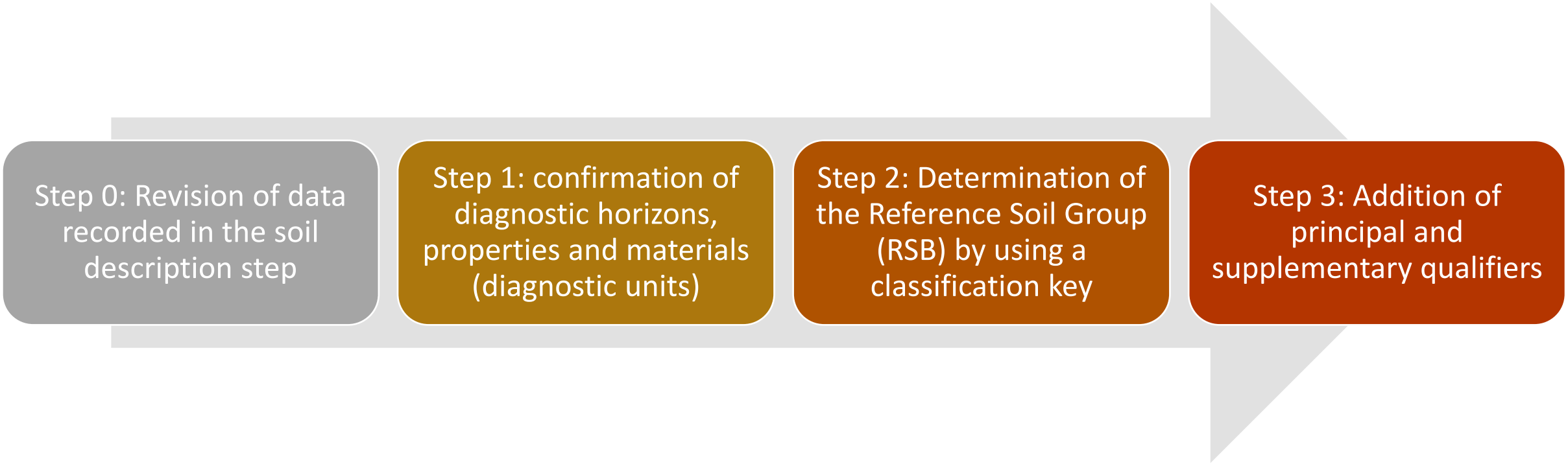
3 – Chromic
evidence of pedogenesis and intensively red colour in zone with at least 30 cm.

4 – Clayic
texture class of clay, sandy clay or silty clay in layer(s) with a combined thickness of ≥30 cm, occurring within 100 cm of the mineral soil surface.

5 – Cutanic
evidence of clay illuviation in form of clay coatings on soil aggregates.

6 – Ochric
weakly developed humus horizon with ≥0.2% *soil organic carbon* (weighted average) in the upper 10 cm of the mineral soil.

Workflow of soil classification



1. Diagnostic horizons, properties and materials (diagnostic units)

Diagnostic horizons
Defined soil layers with specific characteristics, thickness and depth requirements. They usually reflect pedogenic development or long-term human influence.

Example diagnostic horizons
- Argic horizon – subsurface horizon with clay accumulation
- Plinthic horizon – iron-rich horizon that may harden on repeated wetting and drying
- Ferralic horizon – strongly weathered horizon rich in iron and aluminium oxides

Diagnostic properties
Defined soil features or conditions with classificatory value. They may affect part of the profile without forming a separate horizon.

Example diagnostic properties
- Stagnic properties – signs of temporary water stagnation, usually with pale/grey and rusty redox patterns
- Gleyic properties – signs of long-lasting saturation and reduction, typically grey, bluish or greenish colours
- Reducing conditions – oxygen-poor wet conditions that cause chemical reduction in the soil

Diagnostic materials
Defined soil materials or bodies with characteristic composition or origin. They describe what the soil is made of.

Example diagnostic materials
- Mineral material – soil material dominated by mineral particles, not by organic matter
- Artefacts – recognisable human-made fragments or materials such as brick, concrete, glass or metal
- Organotechnic material – organic material strongly mixed with technic/man-made material

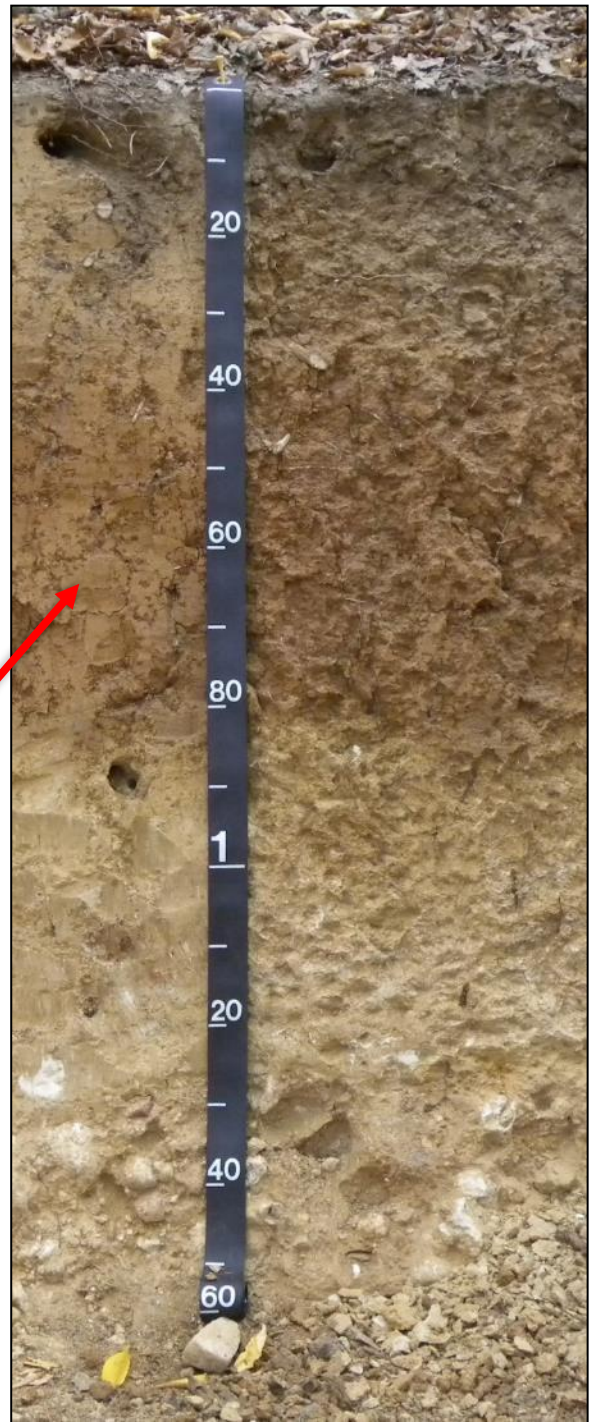
Their role in WRB
They turn field observations into classification evidence. Together, they are used to identify the Reference Soil Group and to assign qualifiers.

Argic horizon

Diagnostic criteria

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 layer with all of the following:
      i. the coarser-textured layer is not separated from the argic horizon by a *lithic discontinuity*; ***and***
      ii. if the coarser-textured layer directly overlies the argic horizon, its lowermost sublayer does not form part of a plough layer; ***and***
      iii. if the coarser-textured layer does not directly overlie the argic horizon, the transitional horizon between the coarser-textured layer and the argic horizon has a thickness of ≤ 15 cm; ***and***
      iv. if the coarser-textured layer has < 15% clay, the argic horizon has ≥ 6% (absolute) more clay; ***and***
      v. if the coarser-textured layer has ≥ 15 and < 50% clay, the ratio of clay in the argic horizon to that of the coarser-textured layer is ≥ 1.4; ***and***
      vi. if the coarser-textured layer has ≥ 50% clay, the argic horizon has ≥ 20% (absolute) more clay;
      or
   b. has evidence of illuvial clay in one or more of the following forms:
      i. clay bridges connecting ≥ 15% of the sand grains; ***or***
      ii. clay coatings covering ≥ 15% of the surfaces of soil aggregates, coarse fragments and/or biopore walls; ***or***
      iii. in thin sections, oriented clay bodies that constitute ≥ 1% of the section and that have not been transported laterally after they had been formed; ***or***
      iv. 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 layer;
   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 (if composed of lamellae: combined thickness within 50 cm of the upper limit of the uppermost lamella) if the argic horizon has a texture class of sandy loam or finer; ***or***
   b. ≥ 15 cm (if composed of lamellae: combined thickness within 50 cm of the upper limit of the uppermost lamella).



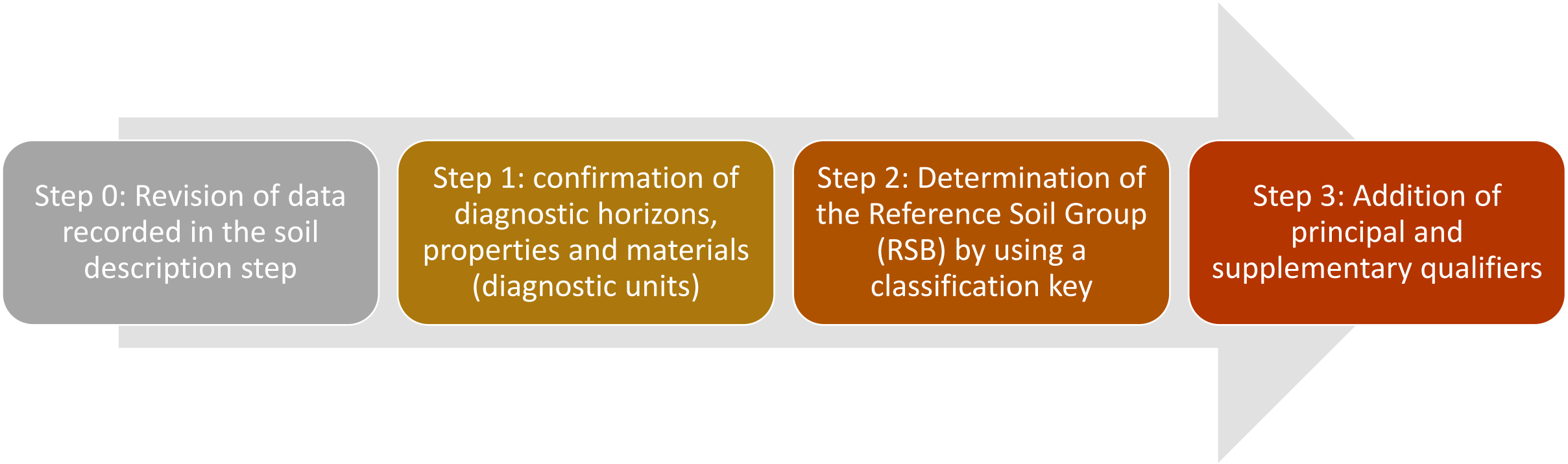
GATEWAY QUESTION 1:Is there a clay-enriched subsurface horizon at least 15 cm thick, with a clear increase in clay content compared with the overlying horizon?

GATEWAY QUESTION 2: Are clay coatings (shiny clay films) visible on ped faces or in pores in a subsurface horizon at least 15 cm thick?

QUESTION 1: Are prismatic (vertically elongated) structural elements present in the clay-enriched horizon?

Possible Argic horizon

Workflow of soil classification



2. Reference Soil Groups (RSGs)

Reference Soil Groups are the main soil groups in the World Reference Base for Soil Resources.

- They are the **highest level** of WRB soil classification.
- Each RSG represents a **characteristic kind of soil**, defined by a specific combination of **diagnostic horizons, properties, and materials**.
- In WRB, the profile is assigned to the **first RSG that fits in the key**.
- After the RSG is identified, the name is made more precise by adding **qualifiers**.

Examples of RSGs

- **Histosols** – soils dominated by organic material
- **Technosols** – soils strongly influenced by human-made material
- **Nitisols** – clay-rich, well-structured soils with a nitic horizon
- **Fluvisols** – soils with young river-deposited material
- **Arenosols** – soils that are sandy through most of the profile

Their role

- RSGs provide the **main identity** of the soil.
- They group soils according to their **dominant pedological characteristics**.
- They are the starting point for the **full WRB name**.

Reference Soil Groups (RSGs)

RSG most probably **PRESENT** in Liberia due to the geographical, geological and climatological setting

RSG **MOST PROBABLY PRESENT** due to local conditions

RSG most probably **NOT PRESENT** in Liberia due to the geographical, geological and climatological setting

Soils with thick organic layers		
1. High amount of undecomposed or partially decomposed organic matter (*organic material*)	No ↓ Yes →	Histosols
Soil with strong human influence		
2. Evidence of long, intensive agricultural use (*hortic* | *irragric* | *plaggic* | *terric* | *hydragric* | *pretic horizons*)	No ↓ Yes →	Anthrosols
3. Containing a significant amount of human-made materials (artefacts | technic hard material)	No ↓ Yes →	Technosols
Soil with limitation to root growth		
4. Permafrost affected/frozen soils (*cryic horizon*)	No ↓ Yes →	Cryosols
5. Shallow, thin soils or having many coarse fragments (*continuous rock* | *< 20 % fine earh (hyperskeletic)*)	No ↓ Yes →	Leptosols
6. Containing a high concentration of exchangeable Na (*natric horizon*)	No ↓ Yes →	Solonetz
7. Containing a high amount of shrink-swell clays, alternating wet-dry conditions (*vertic horizon*)	No ↓ Yes →	Vertisols
8. Containing a high concentration of water-soluble salts (*salic horizon*)	No ↓ Yes →	Solonchaks

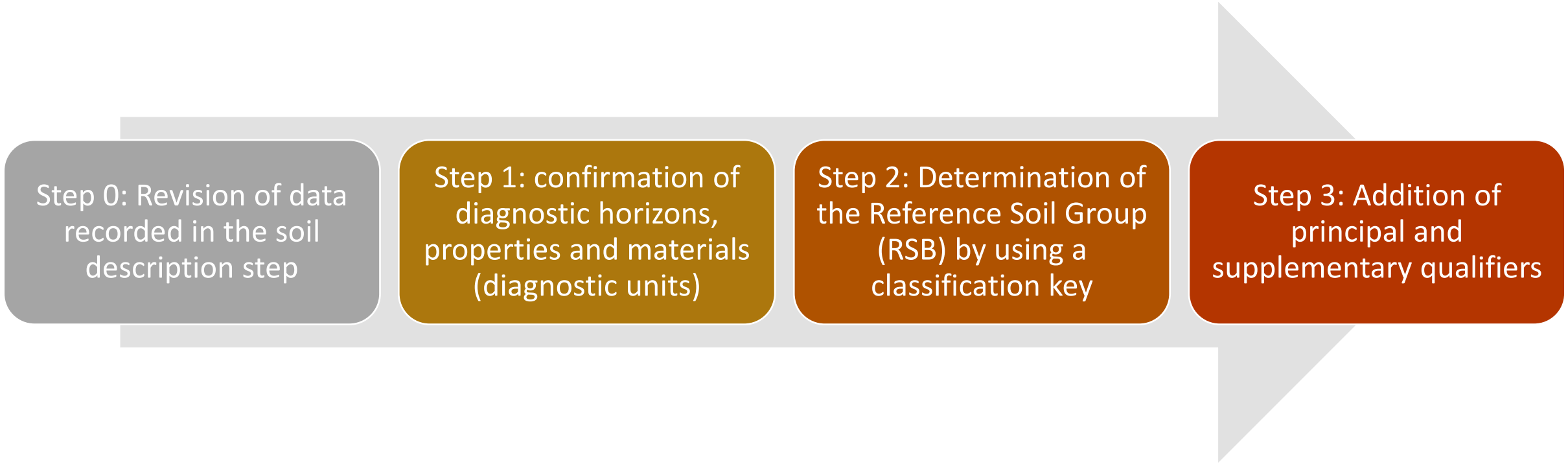
Reference Soil Groups (RSGs)

Soils distinguished by Fe/Al chemistry		
9. Groundwater affected, underwater or tidal areas (*gleyic properties, reducing conditions*)	No ↓ Yes →	Gleysols
10. Allophane or Al-humus complex rich soils of young volcanic areas (*andic* | *vitric properties*)	No ↓ Yes →	Andosols
11. Subsoil accumulation of Al-humus complexes (*spodic horizon*)	No ↓ Yes →	Podzols
12. Accumulation and redistribution of Fe (*plinthic* | *pisoplinthic* | *petroplinthic horizons*)	No ↓ Yes →	Plinthosols
13. Stagnating water (*abrupt textural difference, stagnic properties, reducing conditions*)	No ↓ Yes →	Planosols
14. Stagnating water, structural difference and/or moderate textural difference (*stagnic properties, reducing conditions*)	No ↓ Yes →	Stagnosols
15. Strongly structured soils, low activity clays, P fixation, many Fe oxides (*nitic horizon*)	No ↓ Yes →	Nitisols
16. Deeply weathered, red-yellow soil, with dominance of kaolinite and oxides (*ferralic horizon*)	No ↓ Yes →	Ferralsols
Pronounced accumulation of organic matter in the mineral topsoils		
17. Very dark, very deep, organic matter rich topsoil, high base saturation (*chernic, calcic horizons*)	No ↓ Yes →	Chernozems
18. Dark, deep, organic matter rich topsoil, high base saturation (*mollic, calcic horizons*)	No ↓ Yes →	Kastanozems
19. Dark, deep, organic matter rich topsoil, high base saturation (*mollic horizon*)	No ↓ Yes →	Phaeozems
20. Dark, deep, organic matter rich topsoil, low base saturation (*umbric horizon*)	No ↓ Yes →	Umbrisols

Reference Soil Groups (RSGs)

Accumulation of moderately soluble salts or non-saline substance		
21. Accumulation of, and cementation by secondary silica (*duric* | *petroduric horizons*)	No ↓ Yes →	Durisols
22. Accumulation of, and cementation by secondary gypsum (*gypsic* | *petrogypsic horizons*)	No ↓ Yes →	Gypsisols
23. Accumulation of, and cementation by secondary calcium carbonate (*calcic* | *petrocalcic horizons*)	No ↓ Yes →	Calcisols
Soils with clay enriched subsoil		
24. Interfingering of coarse-textured, lighter colored material into a finer-textured, stronger colored layer (*argic horizon, retic properties*)	No ↓ Yes →	Retisols
25. Clay accumulation in the subsoil, low-activity clays, low base saturation (*argic horizon*)	No ↓ Yes →	Acrisols
26. Clay accumulation in the subsoil, low-activity clays, high base saturation (*argic horizon*)	No ↓ Yes →	Lixisols
27. Clay accumulation in the subsoil, high-activity clays, low base saturation (*argic horizon*)	No ↓ Yes →	Alisols
28. Clay accumulation in the subsoil, high-activity clays, high base saturation (*argic horizon*)	No ↓ Yes →	Luvisols
Soils with little or no profile development		
29. Moderately developed soils (*cambic horizon*)	No ↓ Yes →	Cambisols
30 Stratified, fluviatile, marine, and lacustrine sediments (*fluvic material*)	No ↓ Yes →	Fluvisols
31. Sandy soils (*loamy sand or coarser texture (arenic)*)	No ↓ Yes →	Arenosols
32. No significant profile development (*no diagnostic horizons properties materials*)	Yes →	Regosols

Workflow of soil classification



3. Principal and supplementary **qualifiers**

After the Reference Soil Group is identified, qualifiers are used to make the soil name more precise.

Principal qualifiers

- express the **most important subordinate characteristics** of the soil
- are placed **before** the Reference Soil Group name
- are selected according to the **WRB priority order**
- help define the **main variant** of the RSG

Supplementary qualifiers

- add **further detail** about the soil
- are placed **after** the Reference Soil Group name
- describe additional horizons, properties, materials, depth relations, texture, chemistry, or human influence
- do **not** replace the main identity of the soil, but refine it

Their role

- **RSG** = the main soil group
- **principal qualifiers** = the most important modifiers of that group
- **supplementary qualifiers** = additional descriptors

Principal qualifiers say what kind of RSG it mainly is; supplementary qualifiers say what else is important about it.

Reference Soil Group **Qualifiers**

Key to the Reference Soil Groups	**Principal qualifiers**	**Supplementary qualifiers**
Other soils having a *plinthic*, *pisoplinthic* or *petroplinthic horizon* starting ≤ 100 cm from the mineral soil surface. **PLINTHOSOLS**	Petric Pisoplinthic Gibbsic Stagnic Geric Nitic Histic Mollic/ Umbric Albic Leptic Coarsic Skeletic Haplic	Arenic/ Clayic/ Loamic/ Siltic Abruptic Acric/ Lixic Aric Cohesic Drainic Duric Dystric/ Eutric Epic/ Endic Folic Humic/ Ochric Isopteric Magnesic Novic Oxyaquic Posic Pyric Raptic Saprolithic Technic/ Kalaic Toxic Transportic

WRB Reference Soil Groups most likely to occur in Liberia

Soils having one or more of the following:

1. *organic material* starting ≤ 40 cm from the soil surface and having within 100 cm of the soil surface a combined thickness of:
   a. ≥ 40 cm if < 75% (by volume, related to the fine earth plus all dead plant residues) consists of moss fibres; *or*
   b. ≥ 60 cm;

   or
2. *organic material* starting at the soil surface, having a thickness of ≥ 10 cm and directly overlying ice, *continuous rock* or *technic hard material*;

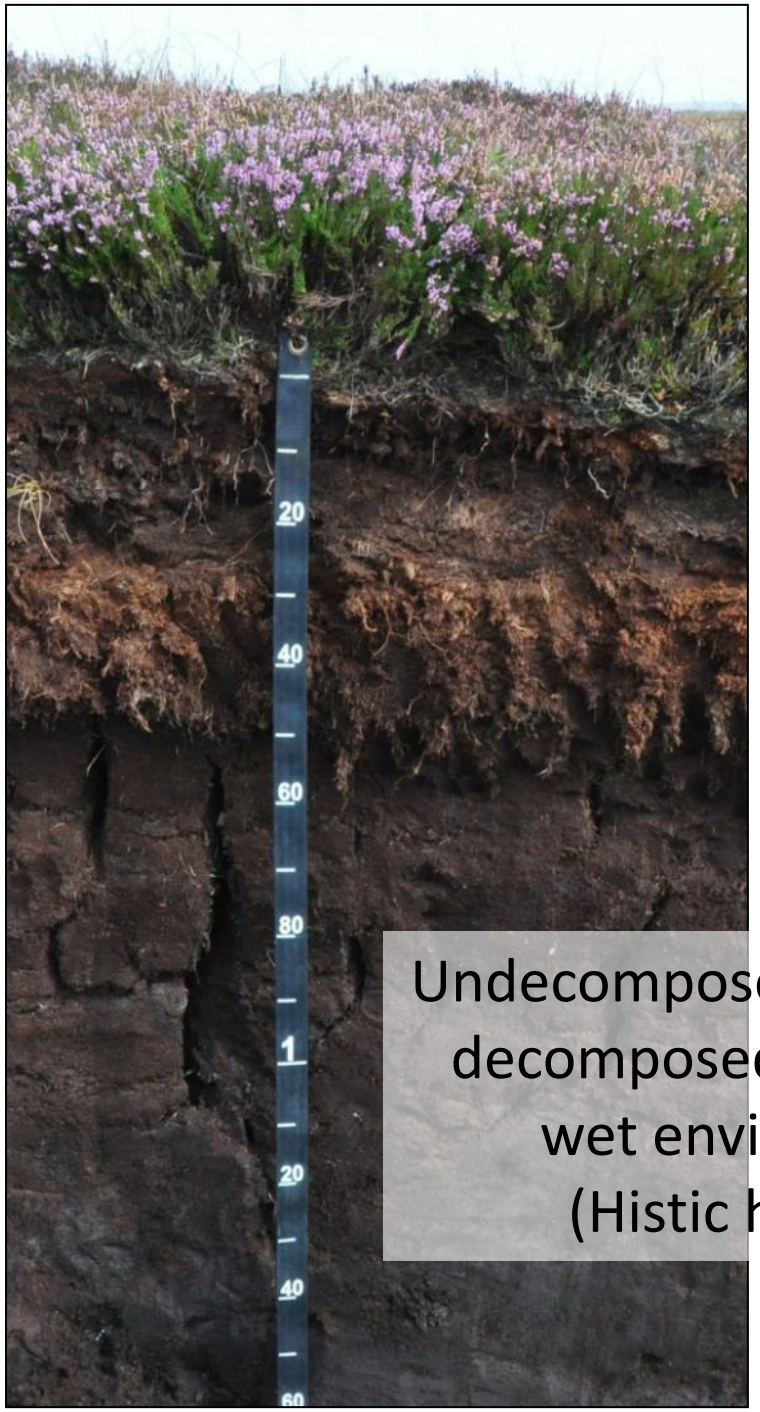
   or
3. a layer of coarse fragments that, together with overlying *organic material*, if present, starts at the soil surface and has a thickness of
   a. ≥ 10 cm if overlying *continuous rock* or *technic hard material*; *or*
   b. ≥ 40 cm;

   and the major part of the interstices between the coarse fragments is filled with *organic material* and the remaining interstices, if present, are void.

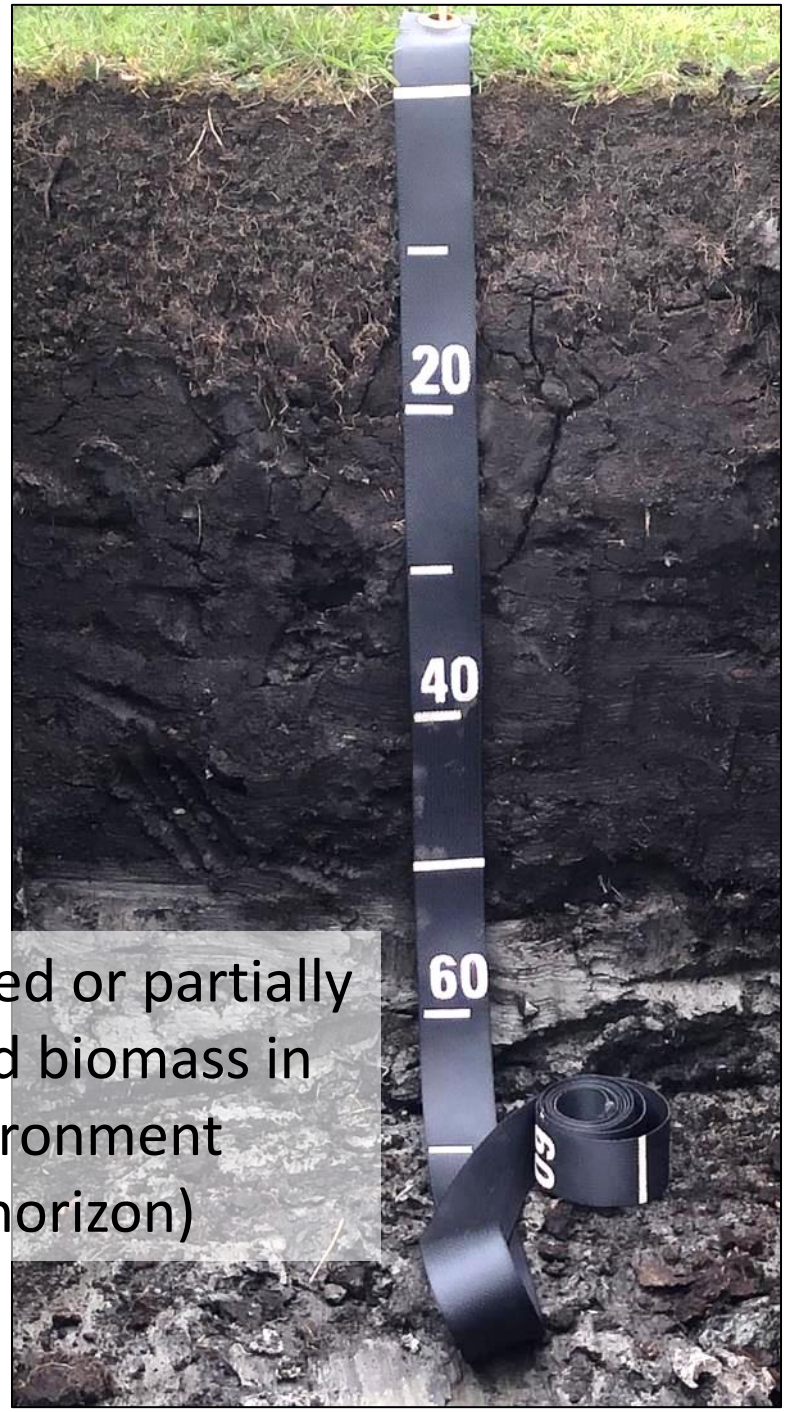
HISTOSOLS

Histosol = soil dominated by thick organic material near the surface.

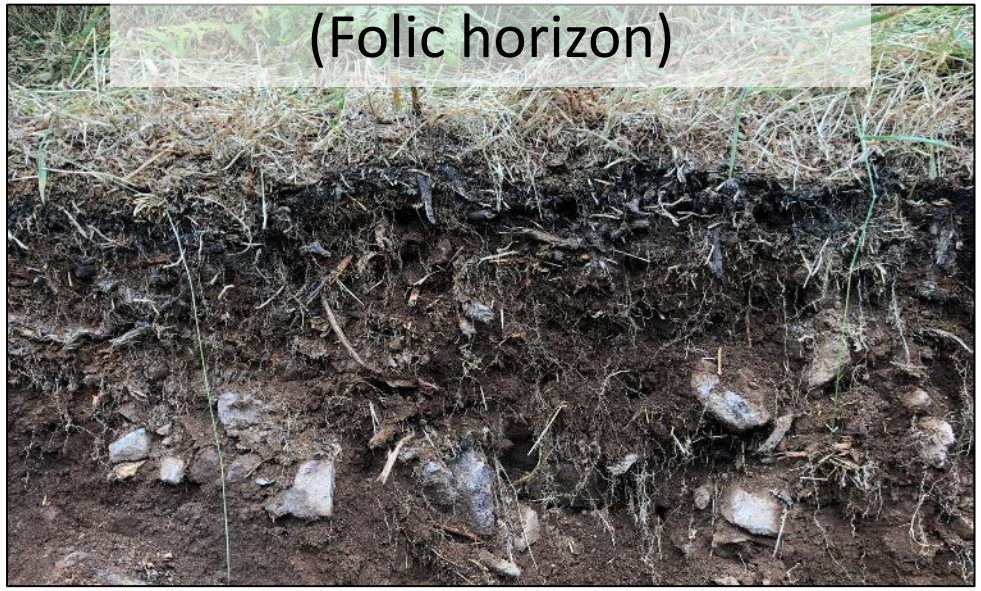
In this key, Histosol is likely when organic material begins within 40 cm of the surface and is at least 40 cm thick, or when a surface organic layer overlies continuous rock or technic hard material.



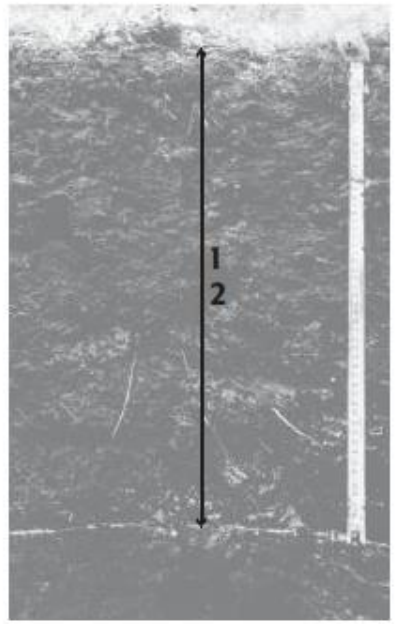
Undecomposed or partially decomposed biomass in wet environment (Histic horizon)



Undecomposed or partially decomposed biomass in well aerated environment (Folic horizon)



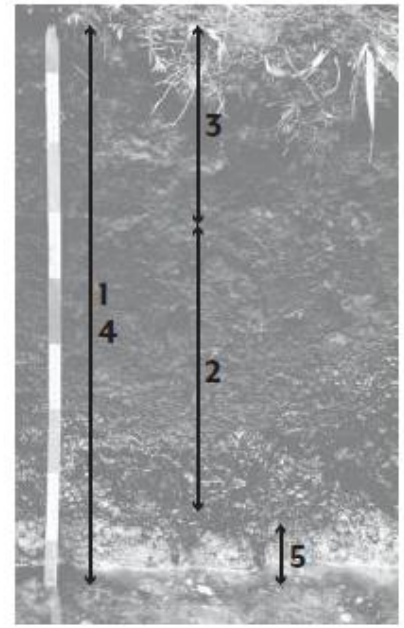
Hemic HISTOSOL



1 – HISTOSOL

organic material starting at the soil surface, having a thickness of ≥40 cm.

Murshic Sapric HISTOSOL (Hypereutric, Limnic)



1 – HISTOSOL

organic material starting at the soil surface, having a thickness of ≥40 cm.

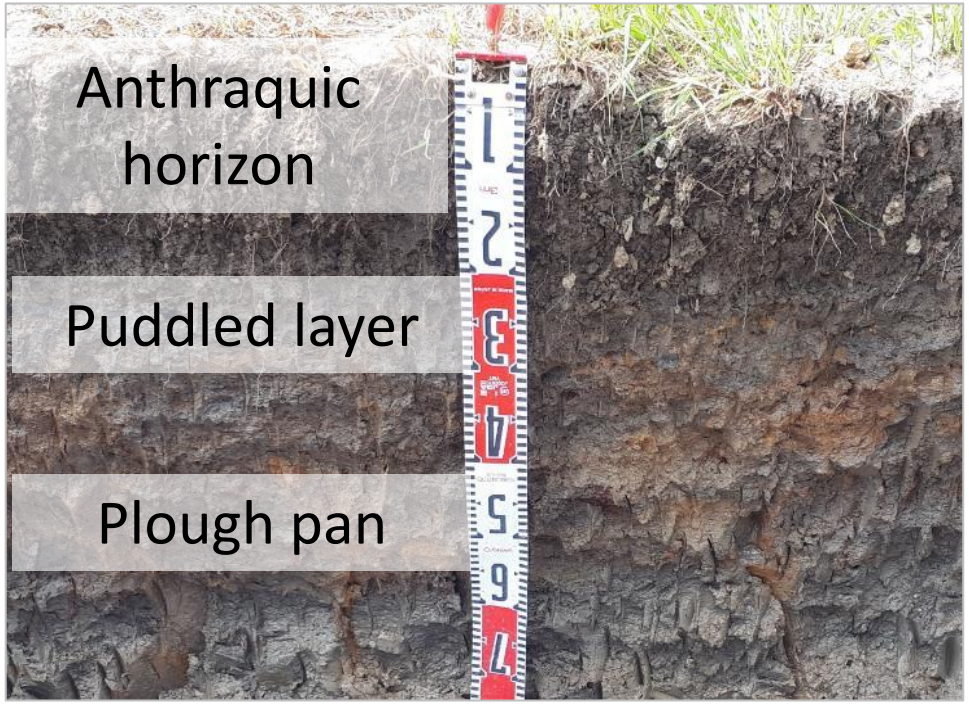
Other soils having:

1. a *hortic*, *irragric*, *plaggic* or *terric horizon*, ≥ 50 cm thick; *or*
2. an *anthraquic horizon* and an underlying *hydragric horizon* with a combined thickness of ≥ 50 cm; *or*
3. a *pretic horizon*, the layers of which have a combined thickness of ≥ 50 cm, within 100 cm of the mineral soil surface.

ANTHROSOLS

Anthrosols are soils that have been **strongly modified by long-term human activity**.
In WRB, they include soils with one or more of the following:

- a **hortic, irragric, plaggic, or terric horizon** that is **at least 50 cm thick**; or
- an **anthraquic horizon** together with an **underlying hydragric horizon**, with a **combined thickness of at least 50 cm**; or
- **pretic horizon layers** with a **combined thickness of at least 50 cm within 100 cm of the mineral soil surface**.


Anthraquic horizon
Puddled layer
Plough pan


Pretic horizon

Other soils:

1. with all of the following:
   a. one or both of the following:
      i. having ≥ 20% (by volume, weighted average, related to the whole soil) *artefacts* in the upper 100 cm from the soil surface or to a limiting layer, whichever is shallower; *or*
      ii. having a layer, ≥ 10 cm thick and starting ≤ 50 cm from the soil surface, with ≥ 80% (by volume, weighted average, related to the whole soil) *artefacts*;

   and

   b. not having a layer containing *artefacts* that qualifies as an *argic, duric, ferralic, ferric, fragic, hydragric, natric, nitic, petrocalcic, petroduric, petrogypsic, petroplinthic, pisoplinthic, plinthic, spodic* or *vertic horizon* starting ≤ 100 cm from the soil surface, unless buried;

   and

   c. not having a limiting layer, unless consisting of *artefacts*, starting ≤ 10 cm from the soil surface;

or

2. having a continuous, very slowly permeable to impermeable, constructed geomembrane of any thickness or *technic hard material* starting ≤ 100 cm from the soil surface.

TECHNOSOLS[1]

Technosol = soil strongly influenced by human-made material or construction.

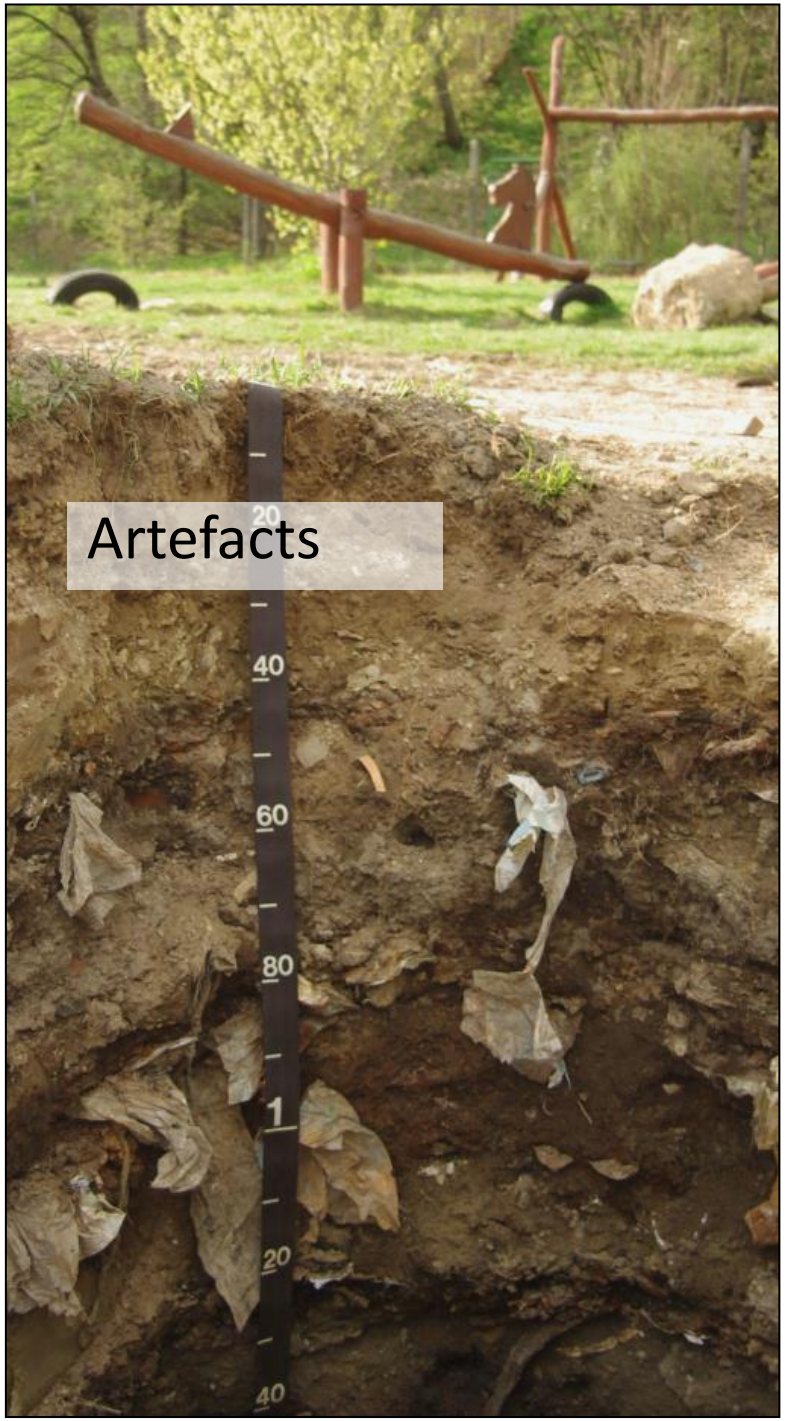
- the upper **100 cm** contains many artefacts such as brick, concrete, metal, plastic, glass, ash, or rubble
- or a layer starts within **50 cm**, is at least **10 cm** thick, and is made **mostly of artefacts**
- or **technic hard material** or a **constructed barrier** occurs within **100 cm**

But artefacts alone are not enough.

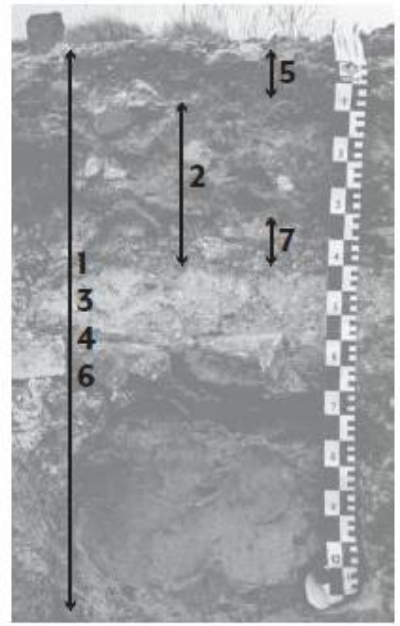
- if the same layer already qualifies as a **stronger diagnostic horizon**, that other feature has priority
- a **very shallow limiting layer** can also prevent classification as Technosol, unless that layer itself is made of artefacts

Technic hard material

Technic hard material + artefacts



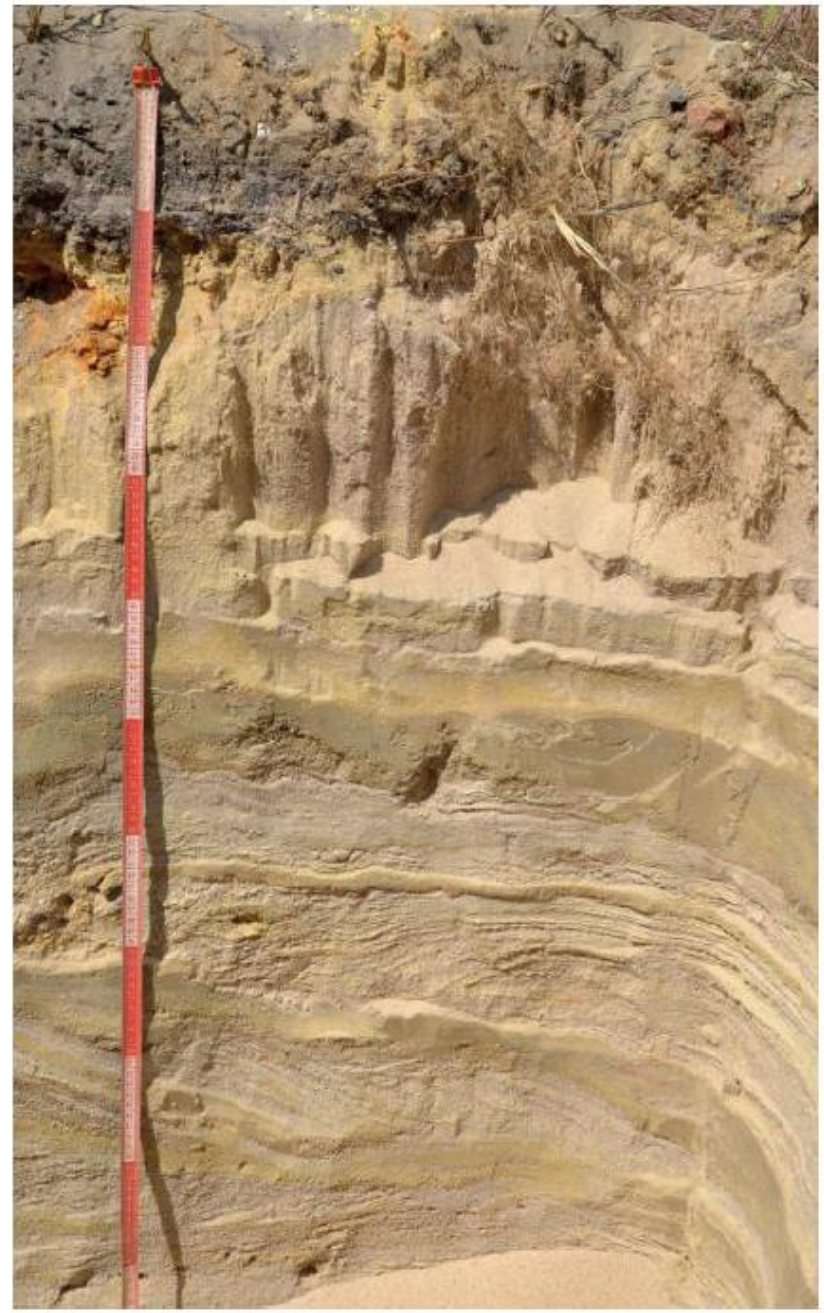
Spolic TECHNOSOL (Arenic, Hyperartefactic, Ochric, Skeletic, Toxic)

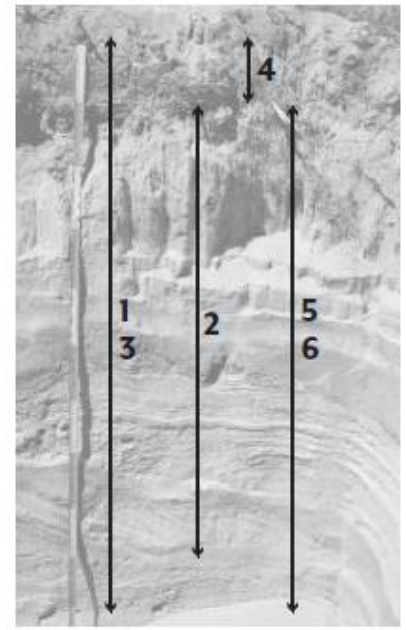


1 – TECHNOSOL

≥20% (by volume, weighted average, related to the whole soil) *artefacts* in the upper 100 cm from the soil surface.

Spolic TECHNOSOL (Arenic, Ochric, Hypersulfidic, Toxic)





1 – TECHNOSOL

≥20% (by volume, weighted average, related to the whole soil) *artefacts* and *technic hard material* in the upper 100 cm from the soil surface.

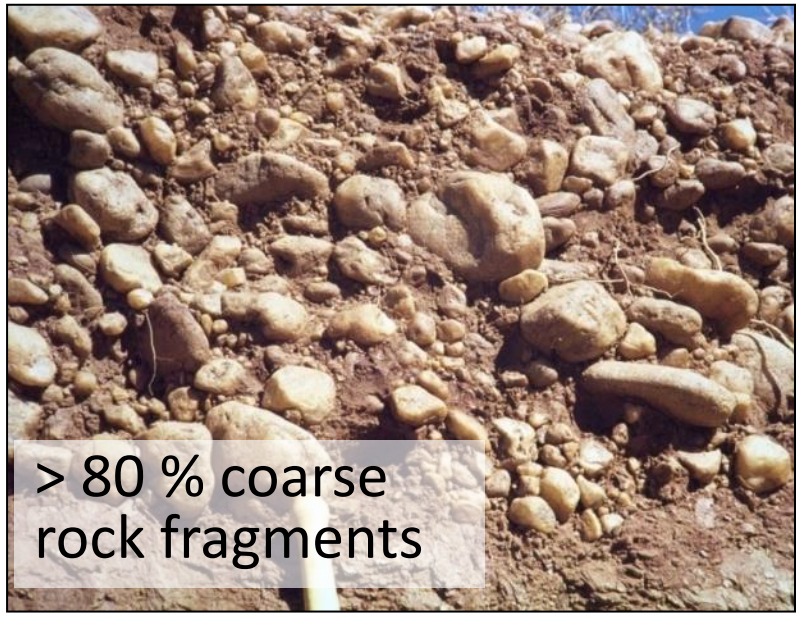
Leptosols

Other soils having:

1. one of the following:
   a. *continuous rock* starting ≤ 25 cm from the soil surface; *or*
   b. < 20% (by volume, related to the whole soil) fine earth plus dead plant residues of any size[2], averaged over a depth of 75 cm from the soil surface or to *continuous rock*, whichever is shallower;

   and
2. no *duric, petrocalcic, petroduric, petrogypsic, pisoplinthic* or *spodic horizon*.

LEPTOSOLS



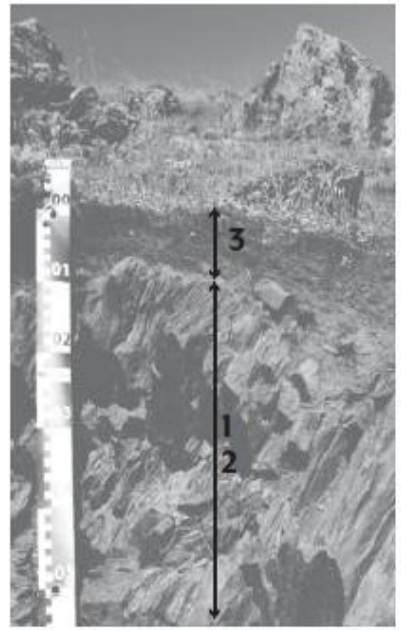
> 80 % coarse rock fragments

Continuous rock

Leptosol = very shallow or extremely stony soil.

- rock starts within **25 cm** of the surface
- or the soil has **very little fine earth** because it is dominated by coarse fragments
- and no stronger competing horizon such as **duric, petrocalcic, petroduric, petrogypsic, pisoplinthic, or spodic** is present

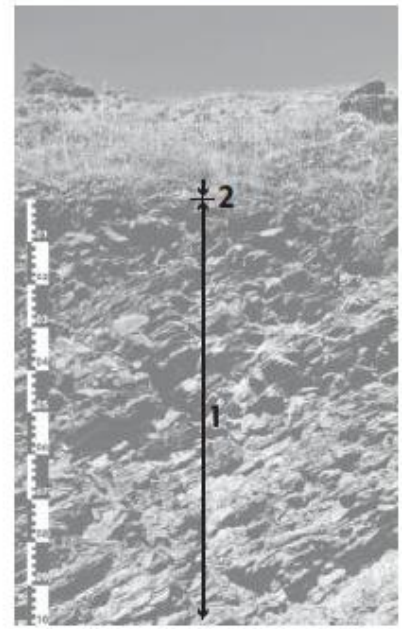
Lithic LEPTOSOL (Ochric)



1 – LEPTOSOL

continuous rock starting ≤25 cm from the soil surface.

Nudilithic LEPTOSOL



1 – LEPTOSOL

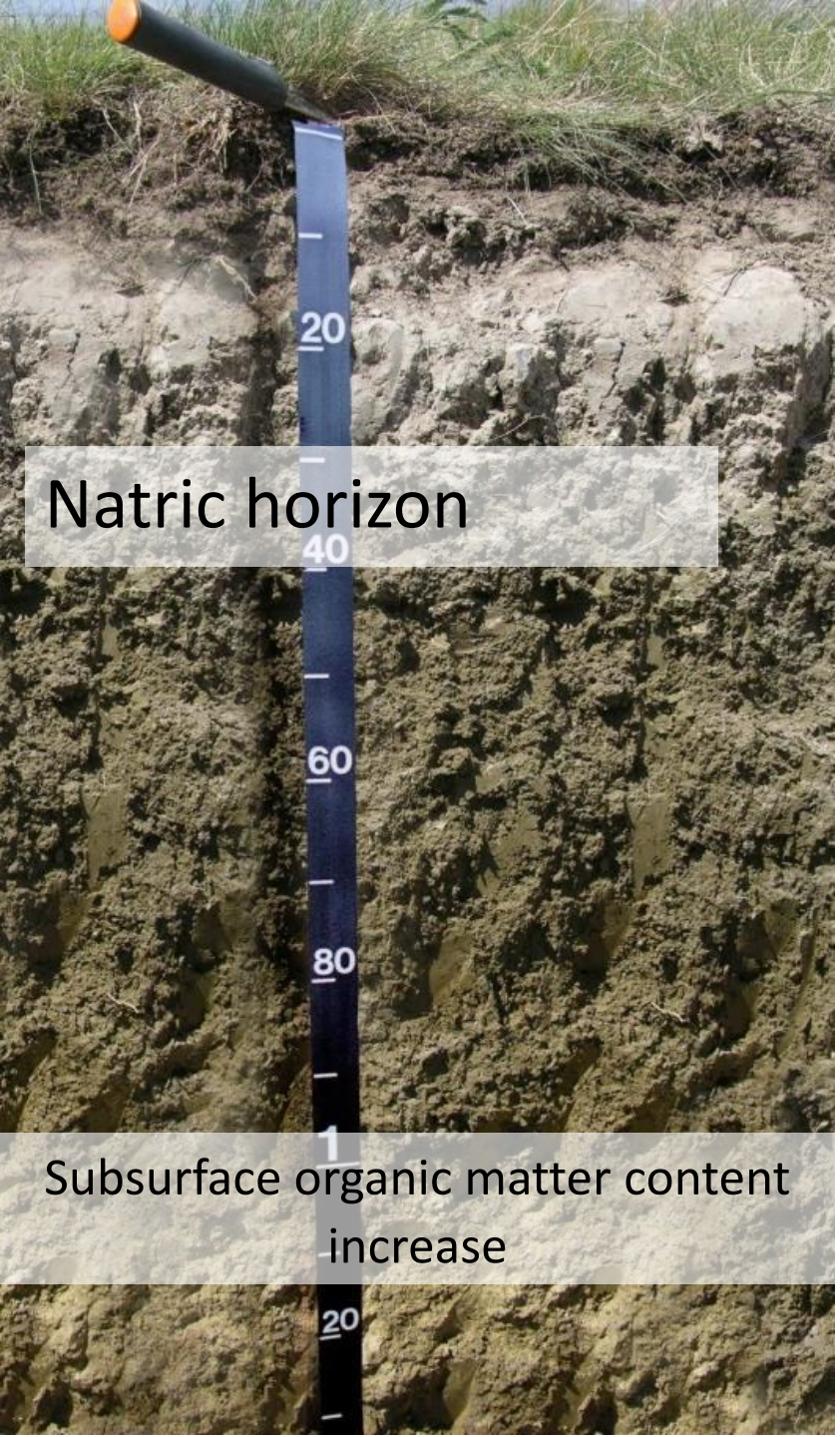
continuous rock starting ≤25 cm from the soil surface.

Other soils having a *natric horizon* starting ≤ 100 cm from the mineral soil surface.

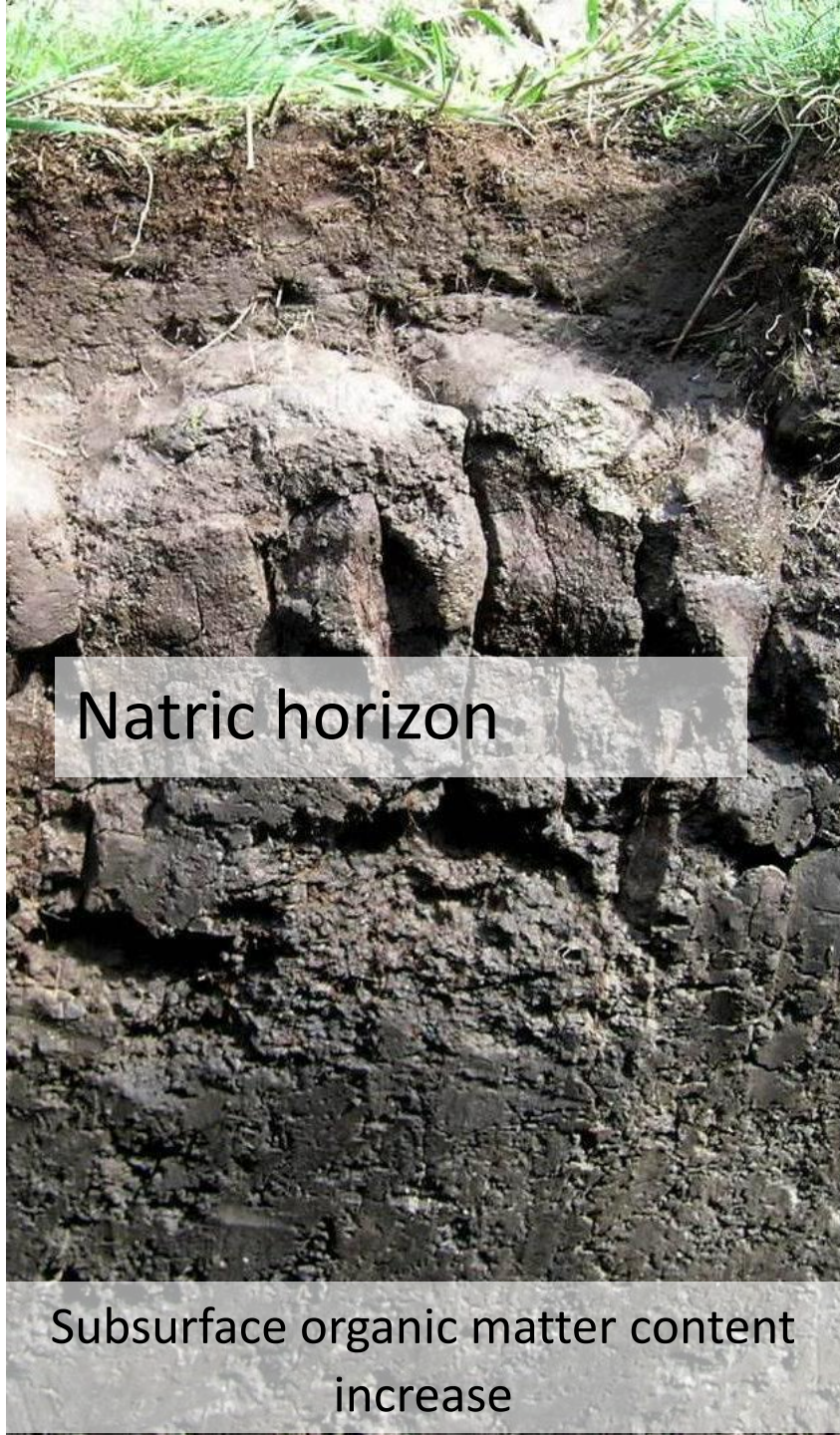
SOLONETZ

Solonetz = soil with a natric horizon near the surface.

- more clay than the layer above
- high exchangeable sodium
- dense and hard
- slow water movement when wet
- often prismatic or columnar
- Solonetz if it starts within 100 cm of the mineral soil surface


Natric horizon
Subsurface organic matter content increase


Natric horizon


Natric horizon
Subsurface organic matter content increase

Other soils having:

1. a *vertic horizon* starting ≤ 100 cm from the mineral soil surface;
   and
2. ≥ 30% clay between the mineral soil surface and the *vertic horizon* throughout;
   and
3. *shrink-swell cracks* that start:
   a. at the mineral soil surface; *or*
   b. at the base of a plough layer; *or*
   c. directly below a layer with strong granular structure or strong angular or subangular blocky structure with an aggregate size of ≤ 1 cm (self-mulching surface); *or*
   d. directly below a surface crust;
   and extend to the *vertic horizon*.

VERTISOLS

Vertisol = heavy clay soil that swells when wet and cracks when dry.

- a **vertic horizon** starts within **100 cm**
- the soil above it is **clay-rich throughout**
- **shrink–swell cracks** start from the surface zone and continue down to the vertic horizon


Slickensides

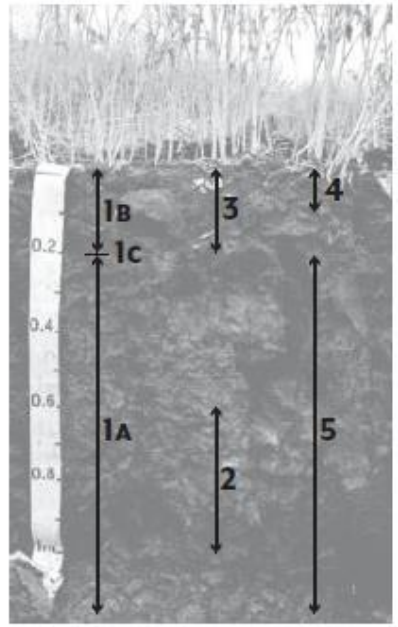

Shrink-swell cracks


Shrink-swell cracks


Shrink-swell cracks


Wedge-shaped aggregates

Calcic VERTISOL (Aric, Grumic, Stagnic)



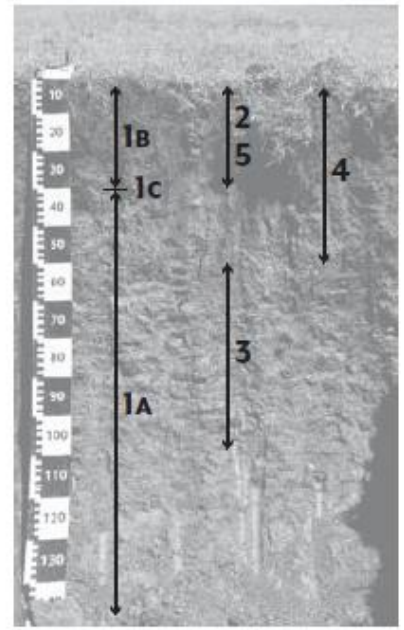
1 – VERTISOL

1A clay-rich (≥30% clay) subsurface *vertic horizon* with thickness ≥25 cm, that, as a result of shrinking and swelling, has slickensides and wedge-shaped soil aggregates. Starting ≤100 cm from the mineral soil surface.

1B ≥30% clay between the mineral soil surface and the *vertic horizon* throughout.

1C *shrink-swell cracks* that start at the base of a plough layer.

Calcic Pellic VERTISOL (Humic, Mollic)



1 – VERTISOL

1A clay-rich (≥30% clay) subsurface *vertic horizon* with thickness ≥25 cm, that, as a result of shrinking and swelling, has slickensides and wedge-shaped soil aggregates. Starting ≤100 cm from the mineral soil surface.

1B ≥30% clay between the mineral soil surface and the *vertic horizon* throughout.

1C *shrink-swell cracks* that start at the base of a plough layer.

Solonchaks

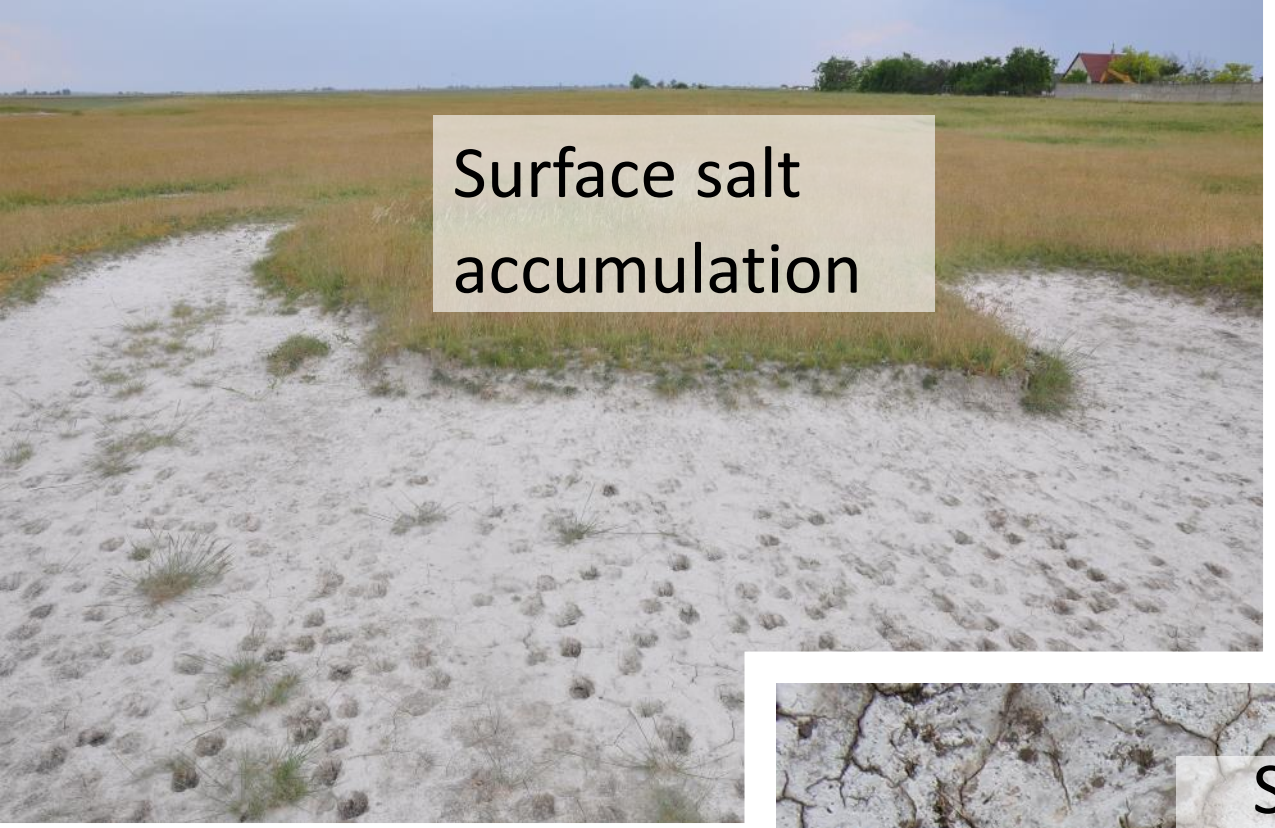
Other soils:

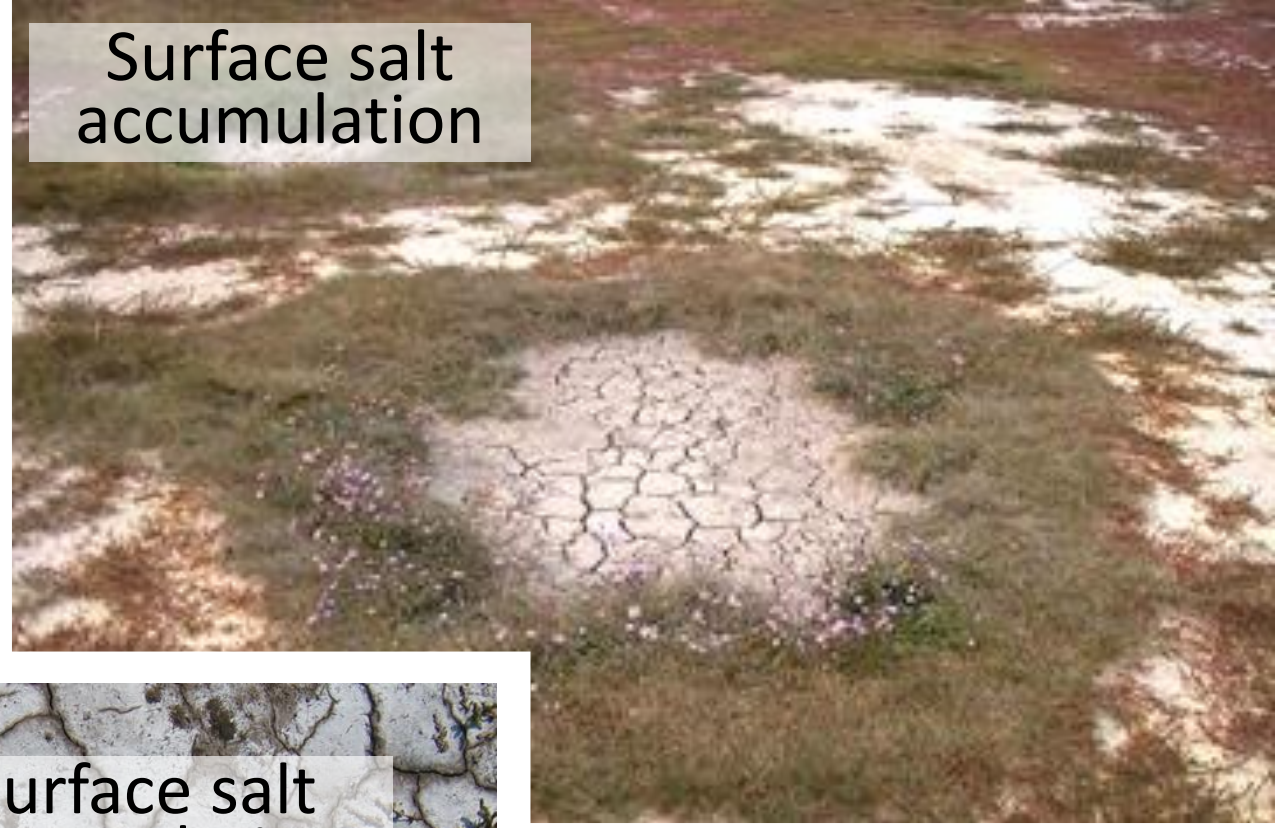
1. having a *salic horizon* starting ≤ 50 cm from the soil surface; *and*
2. not having a *thionic horizon* starting ≤ 50 cm from the soil surface; *and*
3. not being permanently submerged by water and not located below the line affected by tidal water (i.e. not located below the line of mean high water springs).

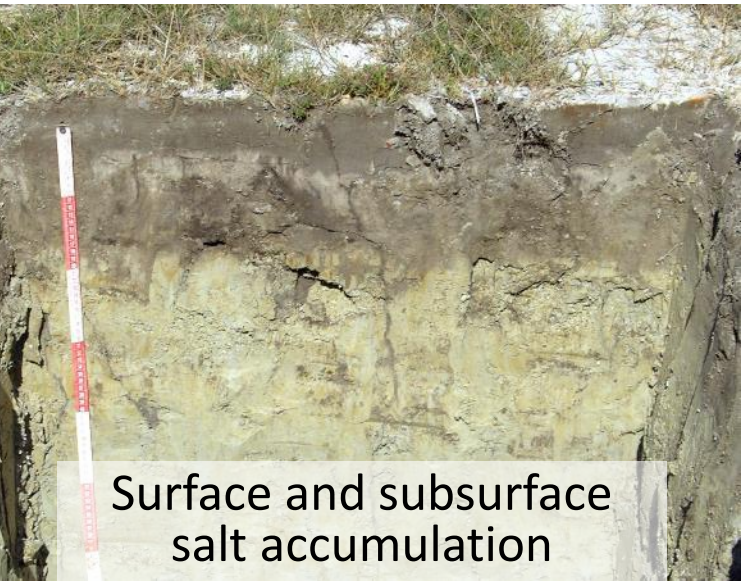
SOLONCHAKS

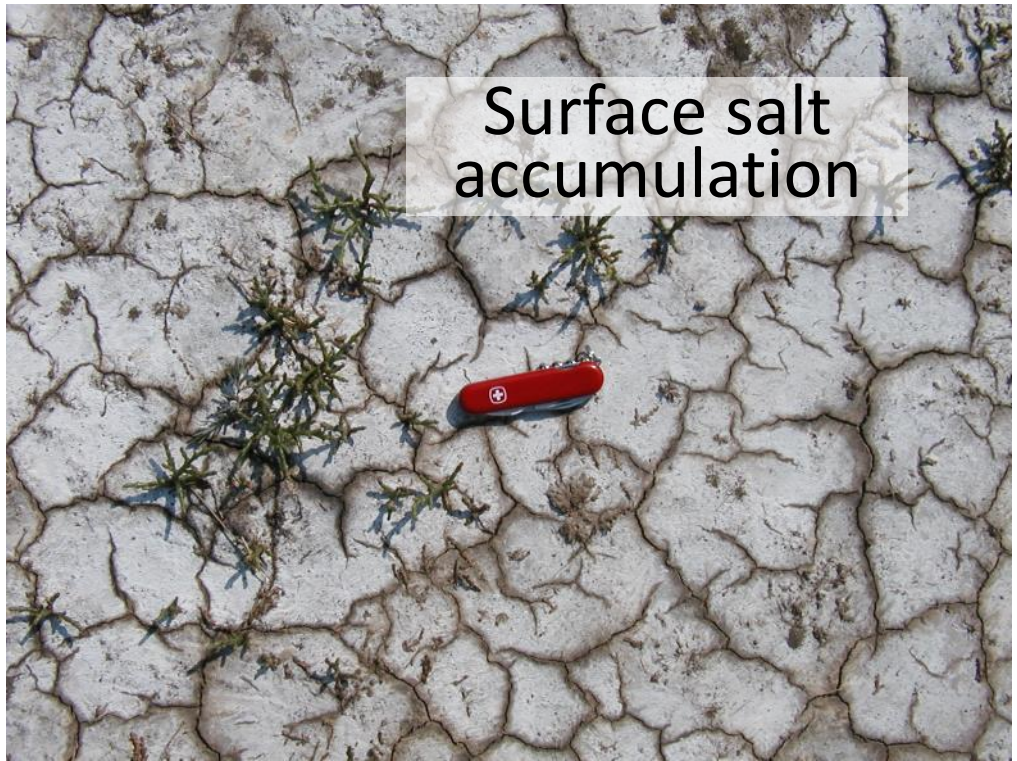
Solonchak = salt-affected soil with a salt-rich layer near the surface.

- a **salic horizon** starts within **50 cm**
- this means a layer with a strong accumulation of **soluble salts**
- there is **no thionic horizon** within **50 cm**
- the soil is **not permanently under water** and **not below the tidal water line**


Surface salt accumulation

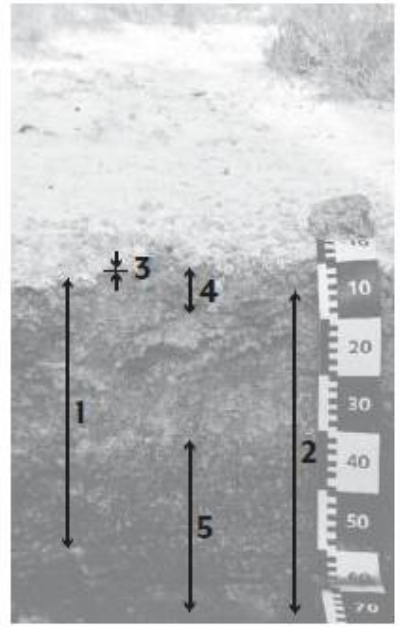

Surface salt accumulation


Surface and subsurface salt accumulation


Surface salt accumulation


Halophyte vegetation

Gypsic SOLONCHAK (Evapocrustic, Ochric, Oxyaquic)



1 – SOLONCHAK

salic horizon with high amounts of readily soluble salts (more soluble than gypsum) starting ≤50 cm from the soil surface.

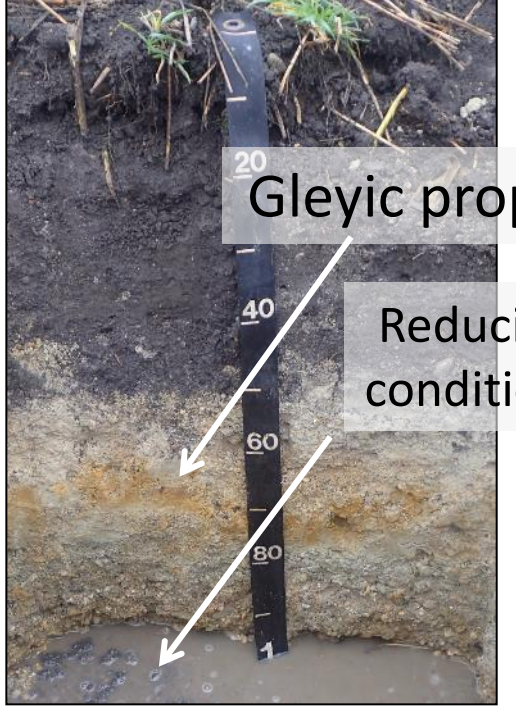
Other soils having one or more of the following:

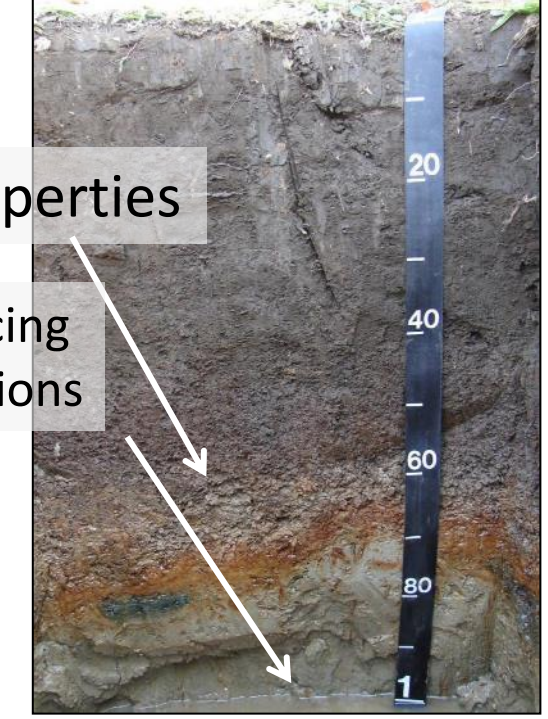
1. a layer, ≥ 25 cm thick and starting ≤ 40 cm from the mineral soil surface, that has
   a. *gleyic properties* throughout; *and*
   b. *reducing conditions* in some parts of every sublayer;
   or
2. both of the following:
   a. a *mollic* or *umbric horizon*, > 40 cm thick, that has *reducing conditions* in some parts of every sublayer, 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;
   or
3. permanent saturation by water starting ≤ 40 cm from the mineral soil surface.

GLEYSOLS

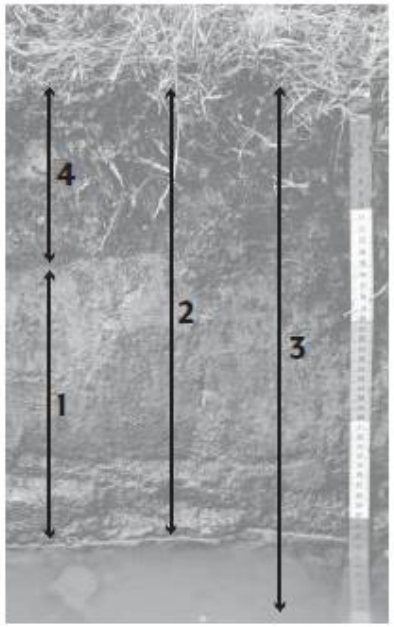
Gleysol = wet soil affected by groundwater near the surface.

- the soil shows **gleyic properties**, meaning mainly **grey, bluish, or greenish colours** caused by long wetness and reduction
- it also shows **reducing conditions**, meaning the soil is **oxygen-poor for long periods**
- in WRB, think Gleysol when a wet, gleyic layer begins within **40 cm** and is thick enough, or when the soil is **permanently saturated** near the surface





Eutric GLEYSOL (Siltic, Ochric)



1 – GLEYSOL

a layer, ≥25 cm thick and starting ≤40 cm from the mineral soil surface, that has *gleyic properties* throughout; and *reducing conditions* in some parts of every sublayer.

Other soils having a *plinthic*, *pisoplinthic* or *petroplinthic horizon* starting ≤ 100 cm from the mineral soil surface.

PLINTHOSOLS

Plinthosol = soil with an iron-rich plinthic horizon near the surface.

- a **plinthic horizon** is an iron-rich layer that may harden
- a **pisoplinthic horizon** contains many rounded hard iron nodules
- a **petroplinthic horizon** is a hard, cemented ironstone layer
- in WRB, think Plinthosol when one of these starts within **100 cm** of the mineral soil surface

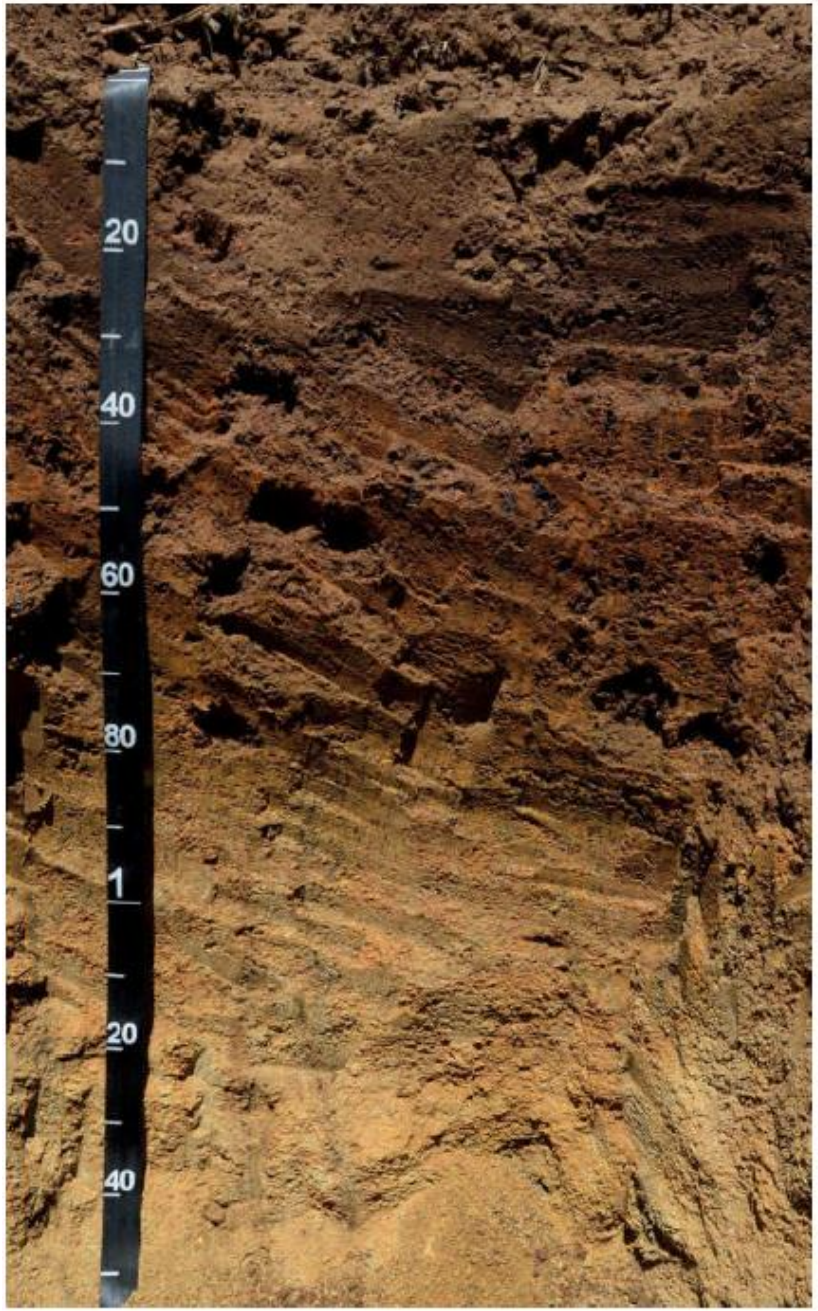

Ferric horizon

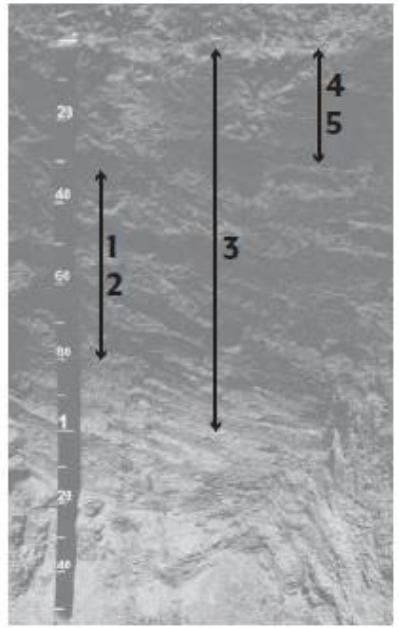

Pisoplinthic horizon


Petroplinthic horizon


Plinthic horizon

Pisoplinthic PLINTHOSOL (Loamic, Aric, Ochric)

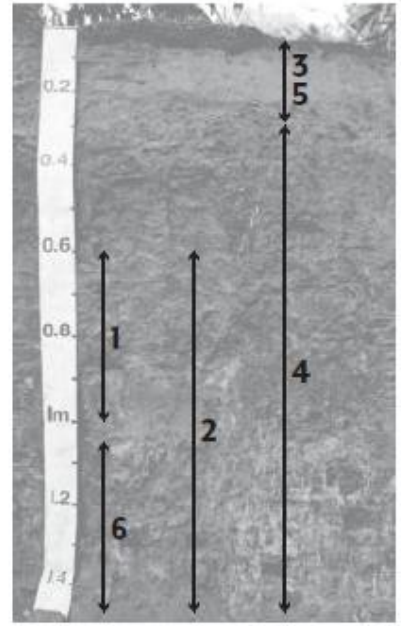




1 – PLINTHOSOL

pisoplinthic horizon with large amount of concretions and nodules that are at least moderately cemented by Fe and Mn (hydr-)oxides.

Stagnic PLINTHOSOL (Epiloamic, Katoclayic, Ochric, Bathypetric)



1 – PLINTHOSOL

plinthic horizon rich in Fe (hydr-) oxides and poor in humus, shows redoximorphic features. The clay fraction is dominated by kaolinite.

Other soils having an *abrupt textural difference* ≤ 75 cm from the mineral soil surface and having within the range of 5 cm directly above or below the *abrupt textural difference*:

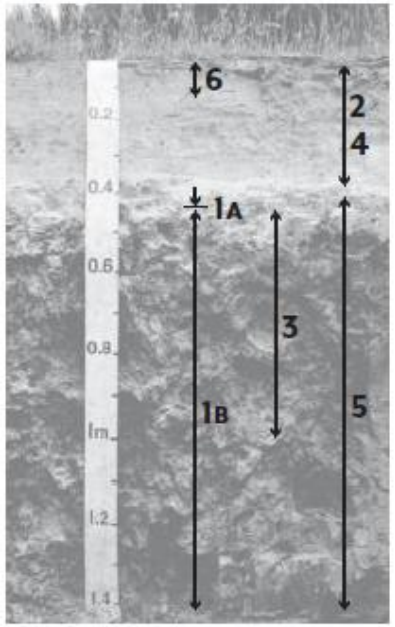
1. *stagnic properties*, in which the area of reductimorphic features plus the area of oximorphic features is ≥ 50% (weighted average, related to the fine earth plus oximorphic features of any size and any cementation class) of the total area; *and*
2. *reducing conditions* for some time during the year in some parts of the soil volume that has the reductimorphic features.

PLANOSOLS

Planosol = soil with a sudden change to a denser, more clayey subsoil that causes water stagnation.

- an **abrupt textural difference** occurs within **75 cm**
- this means the soil suddenly changes to a **much more clay-rich, denser layer**
- around this boundary, the soil shows **stagnic properties**: many **pale/grey** and **rusty** redox features together

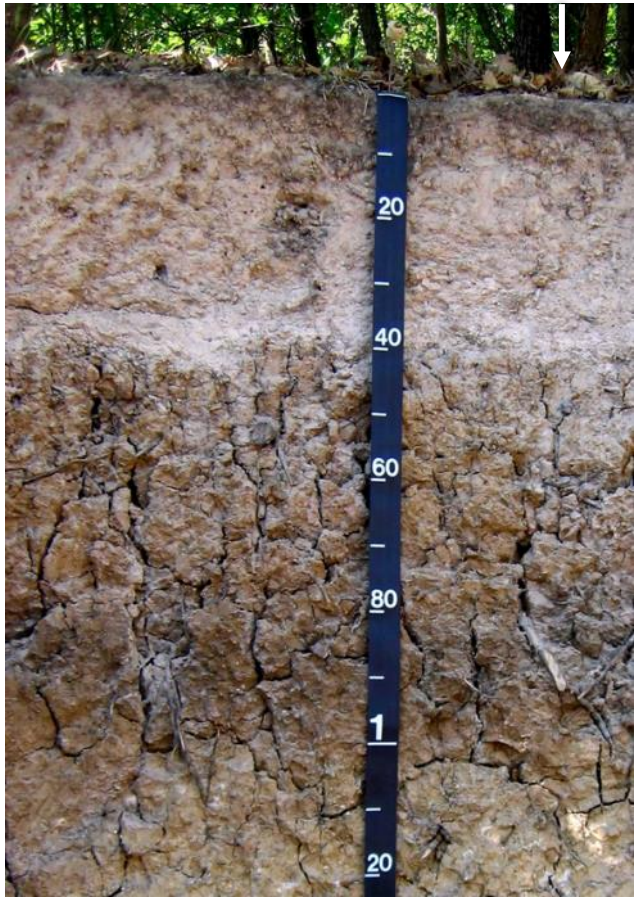
Alic Albic PLANOSOL (Epiloamic, Katoclayic, Ochric)



1 – PLANOSOL

1A *abrupt textural difference* ≤75 cm from the mineral soil surface and having within the range of 5 cm from it (above or below) *stagnic properties* in which the area of reductimorphic and oximorphic features is ≥50% of the total area.

1B *reducing conditions* for some time during the year in some parts of the soil volume that has the reductimorphic features.



Abrupt increase of clay content

Other soils having:

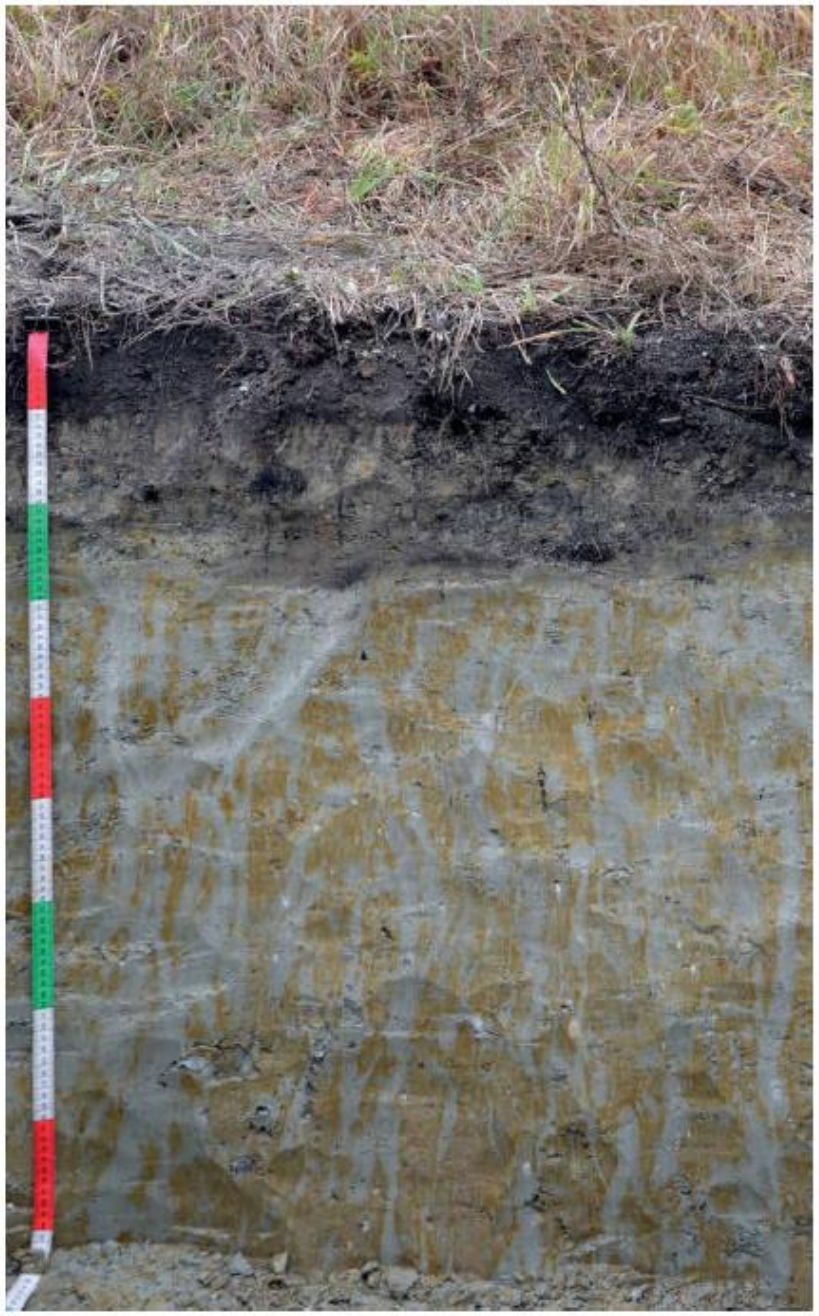
1. *stagnic properties*, in which the area of reductimorphic features plus the area of oximorphic features is ≥ one third (weighted average, related to the fine earth plus oximorphic features of any size and any cementation class) of the area from the mineral soil surface to a depth of 60 cm or to *continuous rock*, whichever is shallower; *and*
2. *reducing conditions* for some time during the year in some parts of the soil volume that has the reductimorphic features within 60 cm from the mineral soil surface or to *continuous rock*, whichever is shallower.

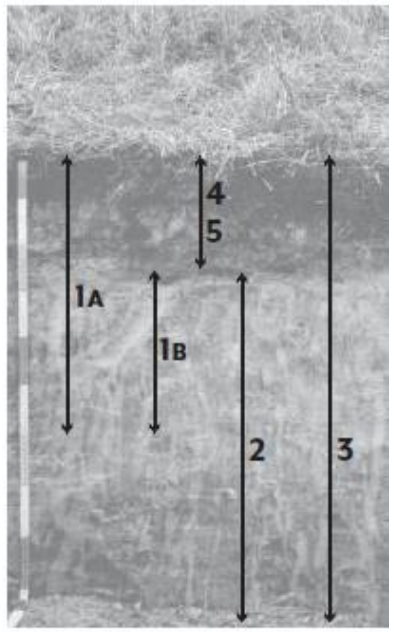
STAGNOSOLS

Stagnosol = soil with stagnant water near the surface.

- water stays in the upper soil for part of the year
- the soil shows **stagnic properties**: many **pale/grey** and **rusty** wetness features together
- it also shows **reducing conditions** in that upper zone
- in WRB, think Stagnosol when these wetness features occur within the upper **60 cm**

Calcaric STAGNOSOL (Loamic, Aric, Ochric)

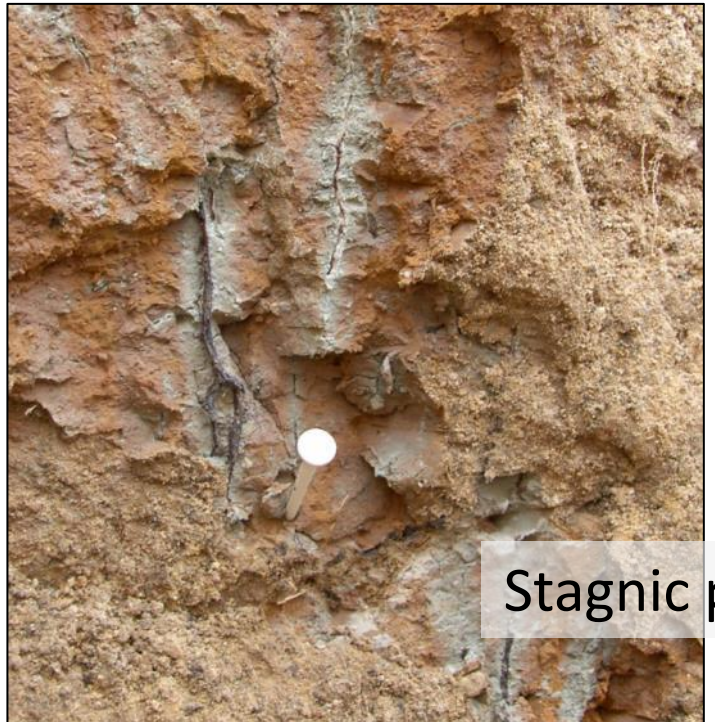




1 – STAGNOSOL

1A *stagnic properties*, with reductimorphic and oximorphic features covering ≥ one third (weighted average) of the area from the mineral soil surface to a depth of 60 cm.

1B *reducing conditions* for some time during the year in some parts of the soil volume that has the reductimorphic features within 60 cm from the mineral soil surface.



Nitisols

Other soils having:

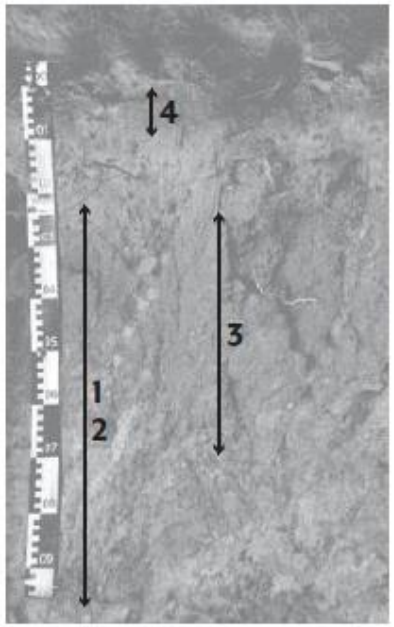
1. a *nitic horizon* starting ≤ 100 cm from the mineral soil surface; *and*
2. from the mineral soil surface to the *nitic horizon*, a clay content that is at least half of the weighted average clay content of the *nitic horizon*; *and*
3. no *vertic horizon* starting above or at the upper limit of the *nitic horizon*.

NITISOLS

Nitisol = deep, clay-rich, well-structured soil with a nitic horizon near the surface.

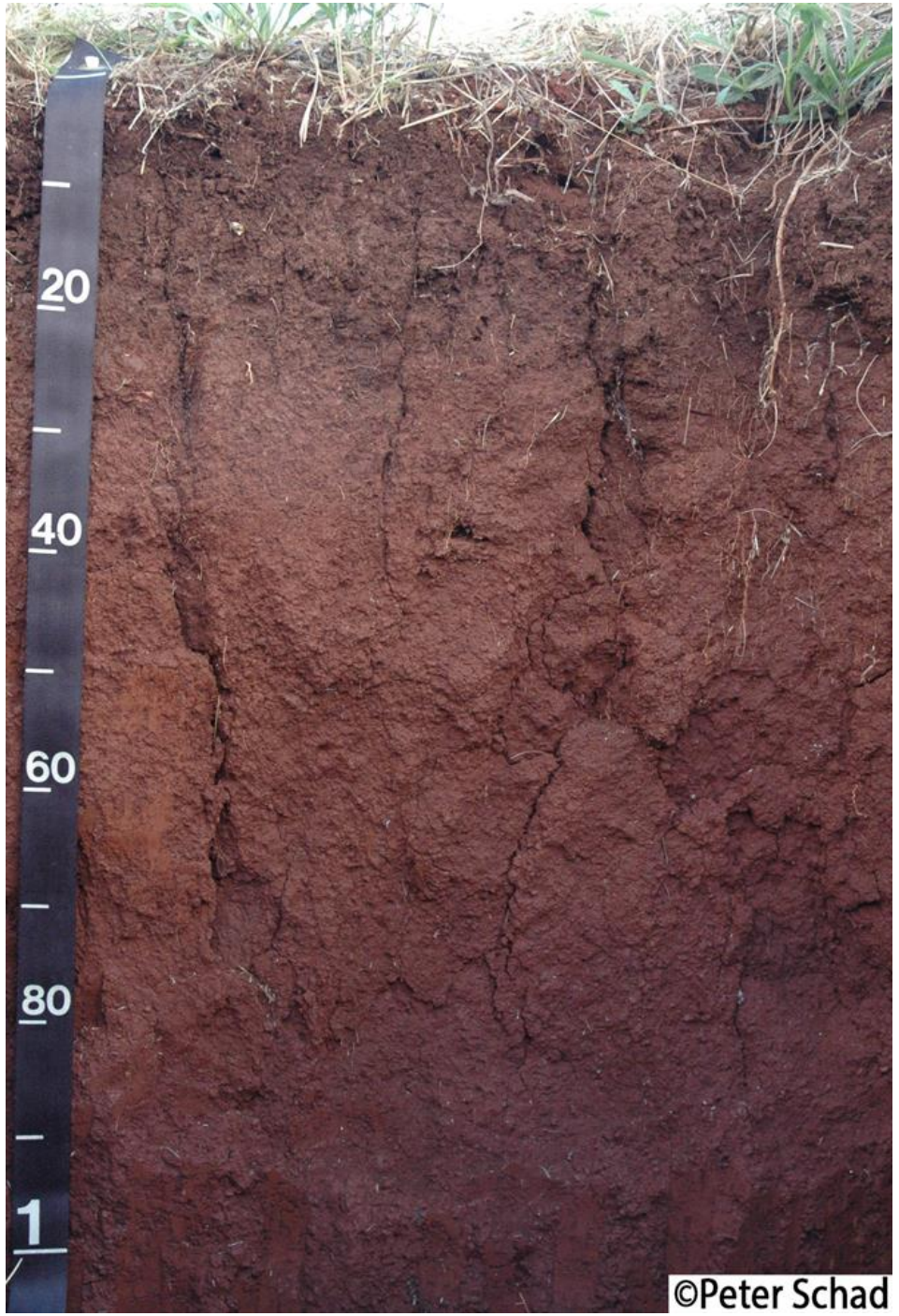
- a **nitic horizon** starts within **100 cm**
- a nitic horizon is a **clay-rich subsoil with strong structure and many shiny ped faces**
- the soil from the surface down to that horizon is **already fairly clayey**
- there is **no vertic horizon above it or at its top**

Acric Rhodic NITISOL (Ochric)



1 – NITISOL

clay-rich (≥30% clay) subsurface *nitic horizon* with moderately to strongly developed blocky structure breaking to polyhedral or flat-edged elements with many shiny pressure faces.



Other soils having:

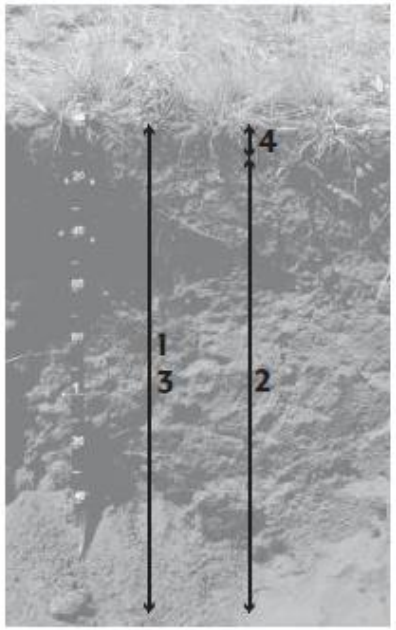
1. a *ferralic horizon* starting ≤ 150 cm from the mineral soil surface;
   and
2. no *argic horizon* starting above or at the upper limit of the *ferralic horizon*, unless the *argic horizon* has, in its upper 30 cm or throughout, whichever is shallower, one or more of the following:
   a. < 10% water-dispersible clay; *or*
   b. a ΔpH (pH_{KCl} - pH_{water}) ≥ 0 (both in 1:1 solution); *or*
   c. ≥ 1.4% *soil organic carbon*.

FERRALSOLS

Ferralsol = very strongly weathered soil with a ferralic horizon near the surface.

- a **ferralic horizon** starts within **150 cm**
- usually there is **no argic horizon above it**
- if an argic horizon is present above it, Ferralsol is still possible only if the upper part of that argic horizon still shows **ferralsol-like properties**

Ferritic FERRALSOL (Loamic, Ochric, Eutric)



1 – FERRALSOL

ferralic horizon starting ≤150 cm from the mineral soil surface, strongly weathered, dominated by kaolinites and Fe oxides (hematite - red colour).

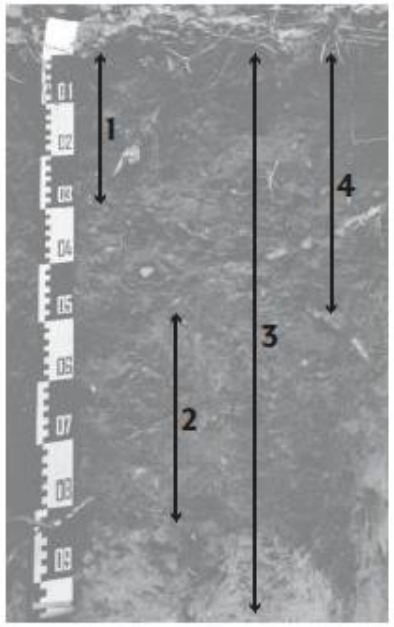
1. Other soils havingan *umbric* or *mollic* or *hortic* horizon

UMBRISOLS

Umbrisol = soil with a dark, humus-rich surface horizon.

- an **umbric horizon** = dark, humus-rich, usually more acidic topsoil
- a **hortic horizon** = dark cultivated topsoil enriched by long-term management

Luvic UMBRISOL (Loamic, Humic)



1 – UMBRISOL

umbric horizon – thick, dark (≥0.6% *soil organic carbon*) humus horizon with well developed structure and low base saturation.

Dark surface – low base (Umbric horizon) Umbrisols

Other soils having:

1. an *argic horizon* starting ≤ 100 cm from the mineral soil surface;
   and
2. a CEC (by 1 *M* NH_4OAc, pH 7) of < 24 $cmol_c\ kg^{-1}$ clay in some subhorizon of the *argic horizon* within 150 cm of the mineral soil surface;
   and
3. exchangeable Al > exchangeable $(Ca+Mg+K+Na)^8$ in half or more of:
   a. the depth range between 50 and 100 cm of the mineral soil surface; *or*
   b. the lower half of the mineral soil above a limiting layer starting ≤ 100 cm from the mineral soil surface,

   whichever is shallower.

ACRISOLS

Acrisol = strongly leached, acidic soil with a clay-enriched subsoil.

- an **argic horizon** starts within **100 cm**
- this means the subsoil has **more clay than the layer above**
- the clay has **low nutrient-holding capacity**
- in much of the subsoil, **acidic aluminium** is more abundant than the main nutrient base cations (**Ca, Mg, K, Na**)

Other soils having:

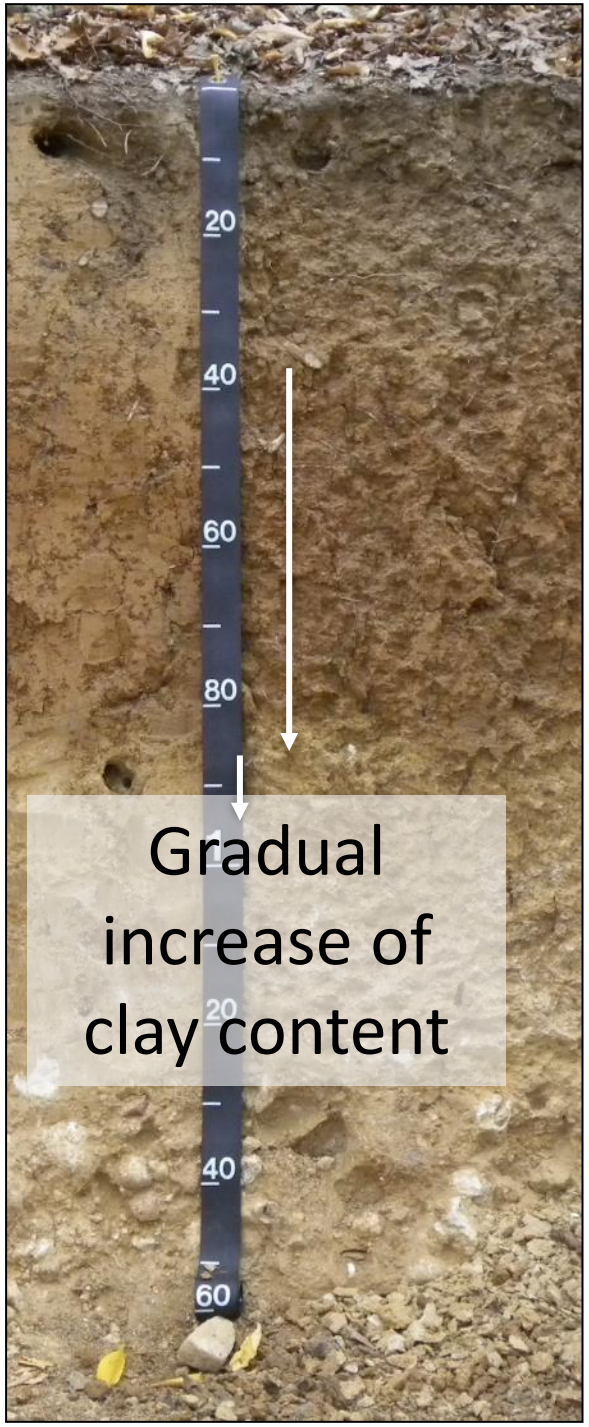
1. an *argic horizon* starting ≤ 100 cm from the mineral soil surface; *and*
2. a CEC (by 1 *M* NH_4OAc, pH 7) of < 24 $cmol_c\ kg^{-1}$ clay in some subhorizon of the *argic horizon* within 150 cm of the mineral soil surface.

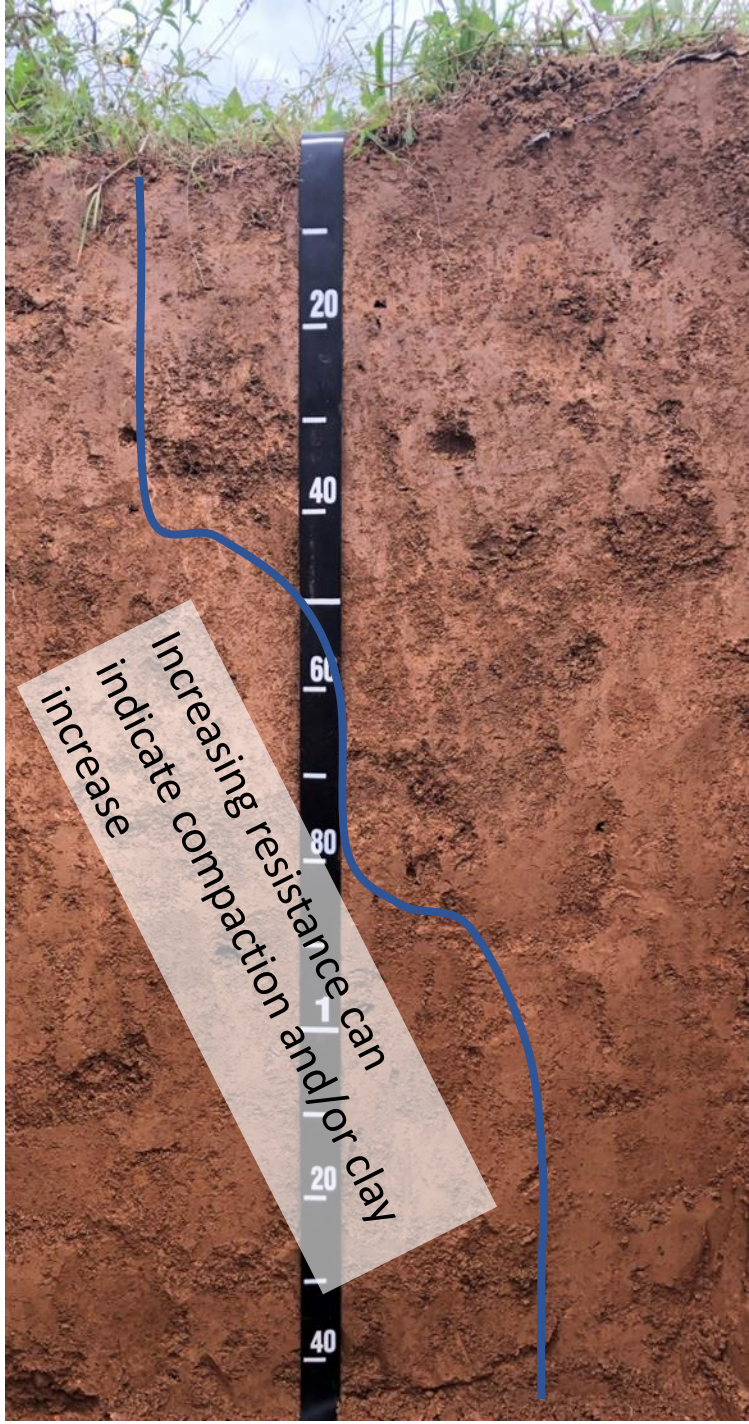
LIXISOLS

Lixisol = soil with a clay-enriched subsoil near the surface.

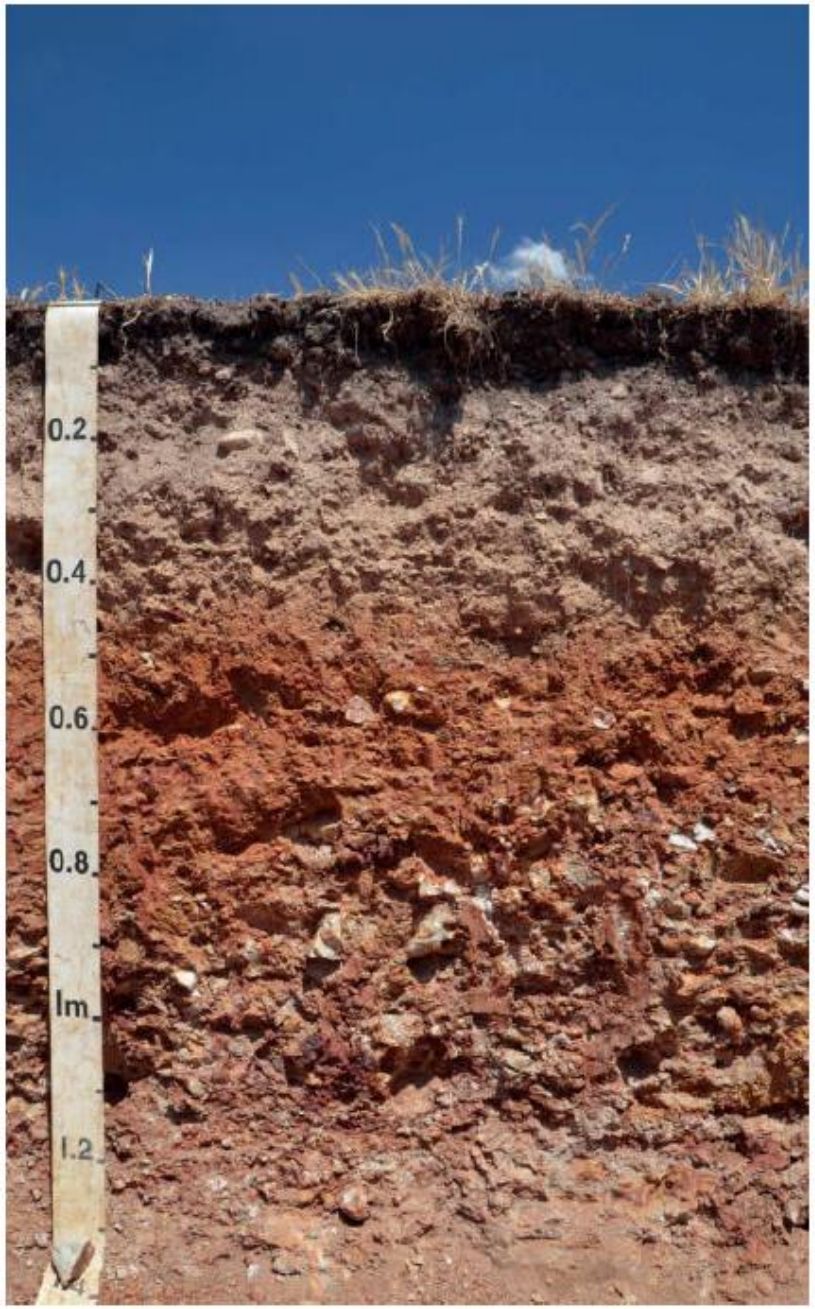
- an **argic horizon** starts within **100 cm**
- this means the subsoil has **more clay than the layer above**
- in part of that argic horizon, the clay has **low activity** (**low CEC**)

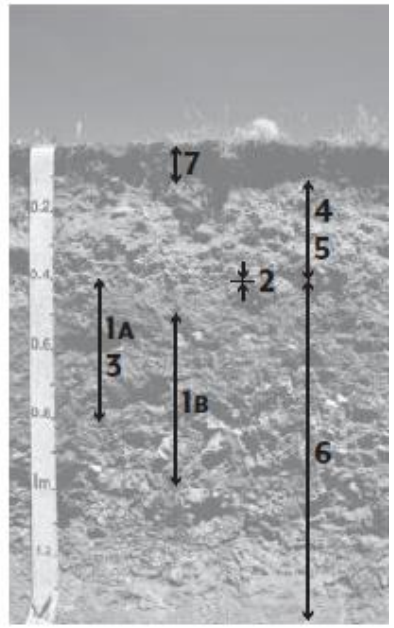

Clay skins


Gradual increase of clay content


Increasing resistance can indicate compaction and/or clay increase

Albic Chromic Abruptic ACRISOL (Epiloamic, Katoclayic, Ochric)



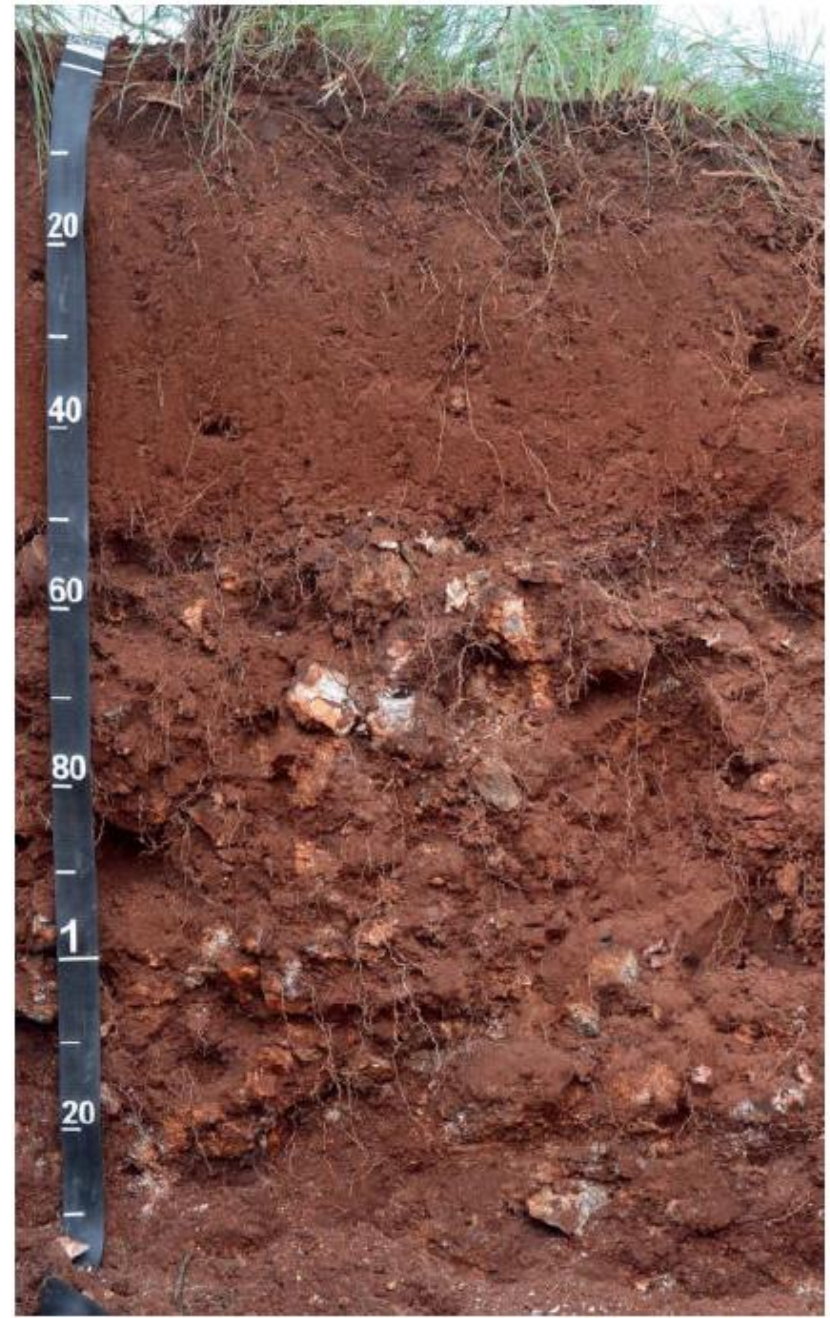


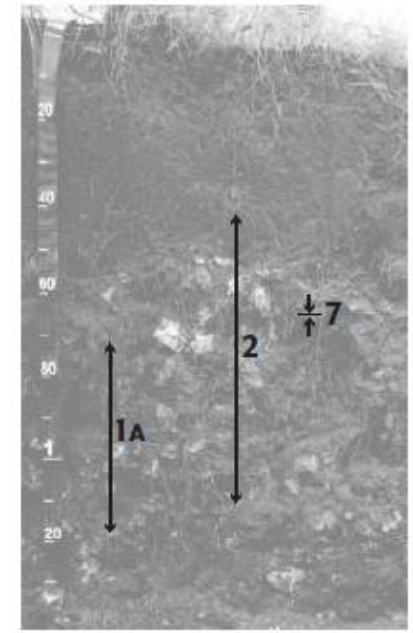
1 – ACRISOL

1A clay-illuvial *argic horizon* with low-activity clays (developed from highly weathered, old materials).

1B low base saturation (low pH values) in half of more of the depth of 50-100 cm.

Endoskeletic Chromic LIXISOL (Loamic, Humic, Raptic)





1 – LIXISOL

1A clay-illuvial *argic horizon* with low-activity clays (developed from highly weathered, old materials).

1B high base saturation (relatively high pH values) in half of more of the depth range between 50 and 100 cm of the mineral soil surface.

Other soils having:

1. a *cambic horizon*
   a. starting ≤ 50 cm from the mineral soil surface; *and*
   b. having its lower limit ≥ 25 cm from the mineral soil surface;

   or
2. an *anthraquic*, *hydragric*, *irragric*, *plaggic*, *pretic* or *terric horizon*;

   or
3. a *fragic*, *thionic* or *vertic horizon* starting ≤ 100 cm from the mineral soil surface;

   or
4. a *tsitelic horizon* with a texture class of sandy loam or finer, starting ≤ 50 cm from the mineral soil surface;

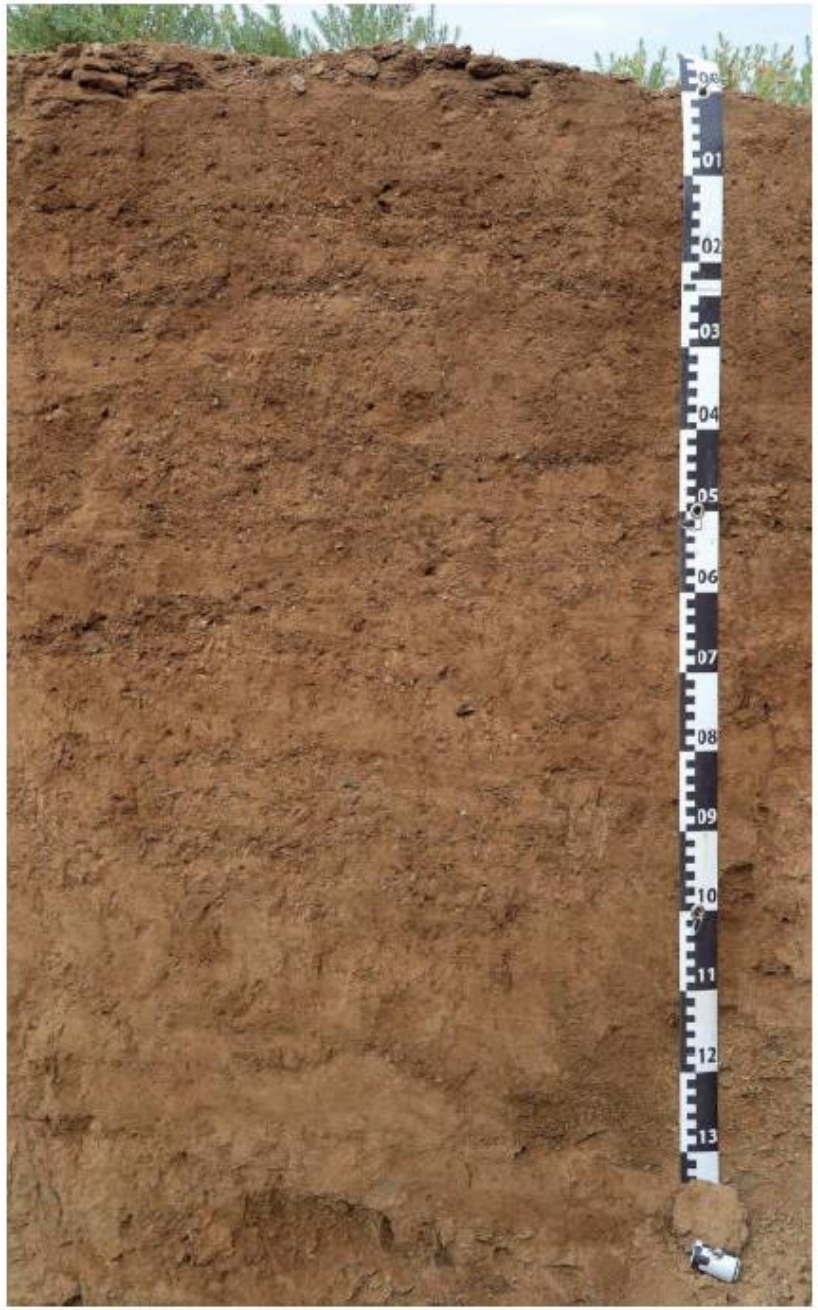
   or
5. one or more layers with *andic* or *vitric properties* with a combined thickness of ≥ 15 cm within 100 cm of the soil surface.

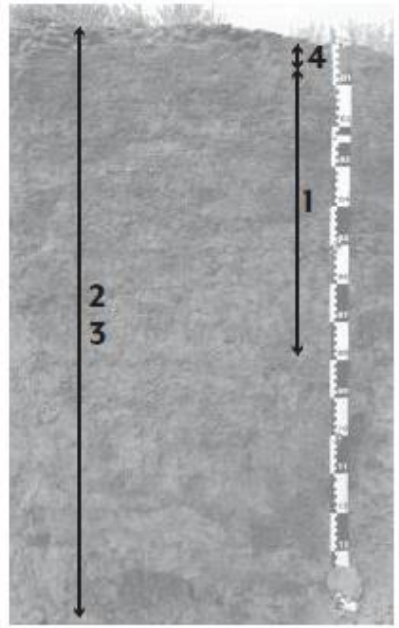
CAMBISOLS

Cambisol = soil with a clearly developed subsoil, but without the stronger specialized features of many other WRB groups.

- most commonly, it has a **cambic horizon** near the surface
- this means the subsoil is **visibly altered or developed** compared with the parent material
- WRB also places some soils here when they have certain other horizons or properties, such as **anthraquic, hydragric, irragric, plaggic, pretic, terric, fragic, thionic, vertic, tsitelic, or enough andic/vitric material**

Eutric CAMBISOL (Loamic, Ochric)

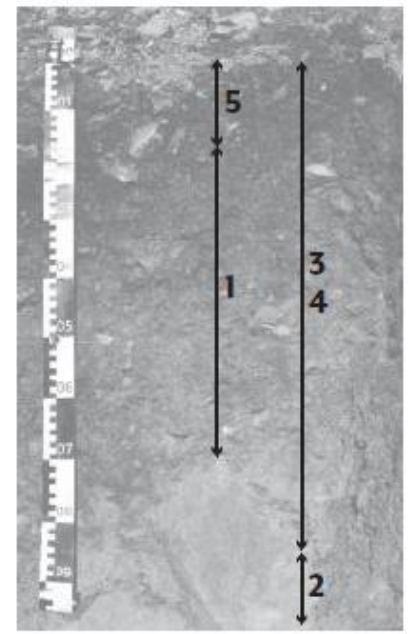




1 – CAMBISOL

cambic horizon starting ≤50 cm and having its lower limit ≥25 cm from the mineral soil surface. In this case it has higher oxide and/or clay contents visible by more intensive colour than this underlying layer and soil aggregate structure at least in half of the volume of the fine earth.

Skeletic Leptic CAMBISOL (Loamic, Ochric)



1 – CAMBISOL

cambic horizon starting ≤50 cm and having its lower limit ≥25 cm from the mineral soil surface. In this case it has higher oxide and/or clay contents visible by more intensive colour than this underlying layer and soil aggregate structure at least in half of the volume of the fine earth.

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, ≤ 40 cm thick, to a depth of ≥ 50 cm from the mineral soil surface.

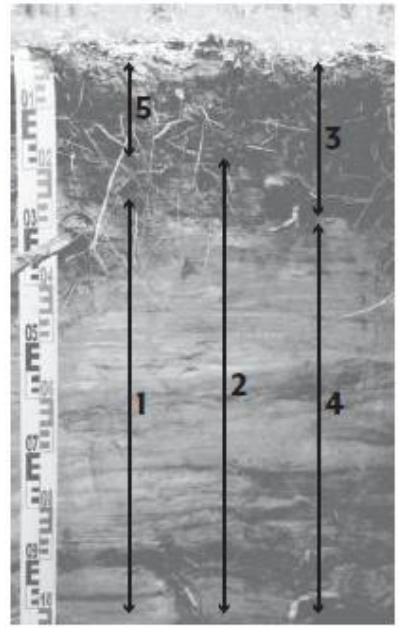
FLUVISOLS[10]

Fluvisol = soil with young river-deposited material near the surface.

- the soil contains **fluvic material**, meaning **young alluvial sediment laid down by water**
- this material usually starts **close to the surface** and is **thick enough to dominate the upper profile**
- if the surface has been ploughed, the fluvic material may begin **just below the plough layer** and still qualify

Stratification due to marine/lacustrine/ fluviatile deposition

Eutric FLUVISOL (Epiloamic, Katoarenic, Ochric)



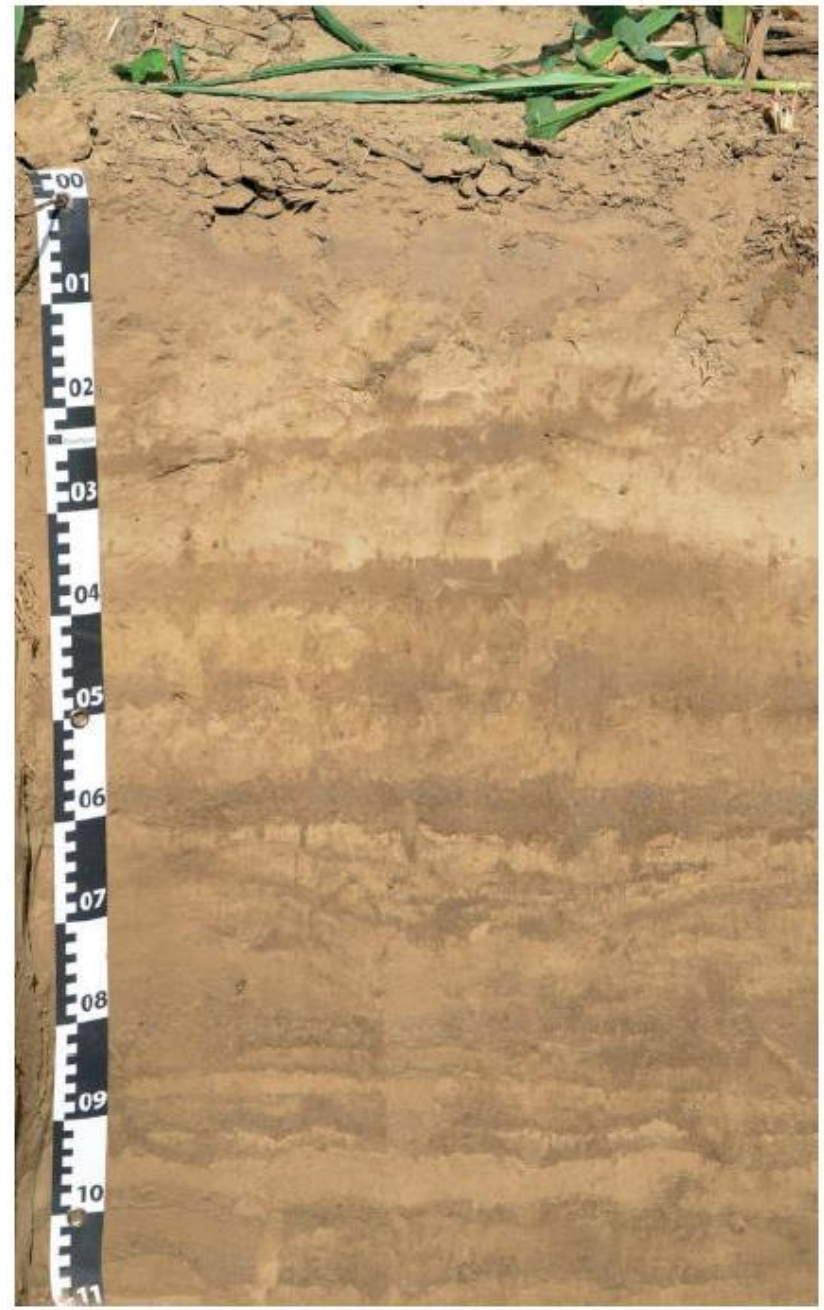
1 – FLUVISOL

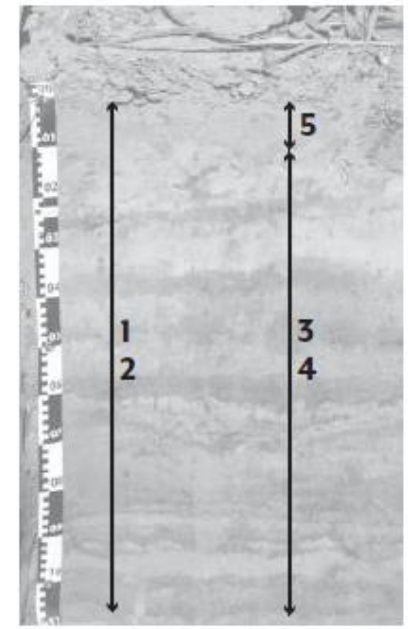
fluvic material ≥25 cm thick and starting ≤25 cm from the mineral soil surface. Fluviatile origin of sediment is recognize by distinct stratification in ≥25% of its volume.

REMARK

under humus horizon, Bw horizon with accumulation of oxides is visible. It meets most of the criteria of *cambic horizon* – except thickness.

Pantofluvic FLUVISOL (Polyarenic, Polysiltic, Ochric)





1 – FLUVISOL

fluvic material ≥25 cm thick and starting ≤25 cm from the mineral soil surface. Fluviatile origin of sediment is recognize by distinct stratification in ≥25% of its volume.

Arenosols

Other soils having within 100 cm of the mineral soil surface:

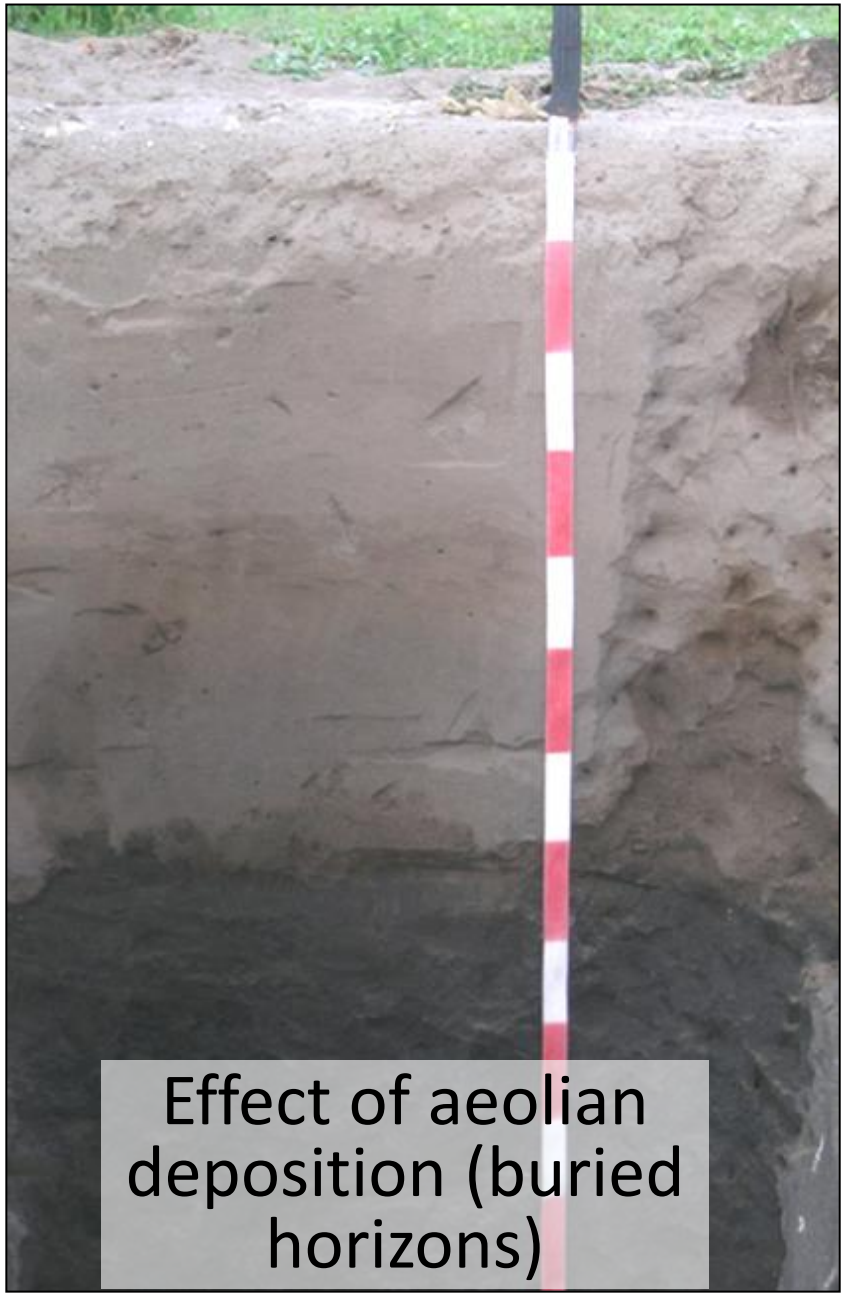
1. a weighted average texture class of loamy sand or sand; *and*
2. layers of finer texture, if present, with a combined thickness of < 15 cm; *and*
3. layers with ≥ 40% (by volume, related to the whole soil) coarse fragments, if present, with a combined thickness of < 15 cm.

ARENOSOLS[11]

Arenosol = soil that is sandy through most of the upper 100 cm.

- the upper profile is mainly **sand or loamy sand**
- any **finer-textured layers** are only **thin**
- any layers very rich in **coarse fragments** are also only **thin**

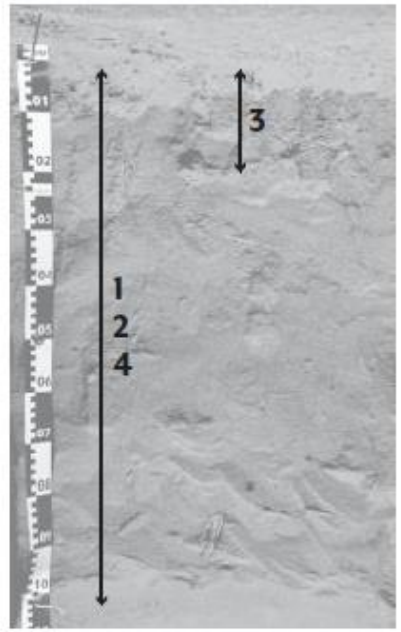
Soil with loamy sand texture



Effect of aeolian deposition (buried horizons)

Effect of aeolian deposition (layering)

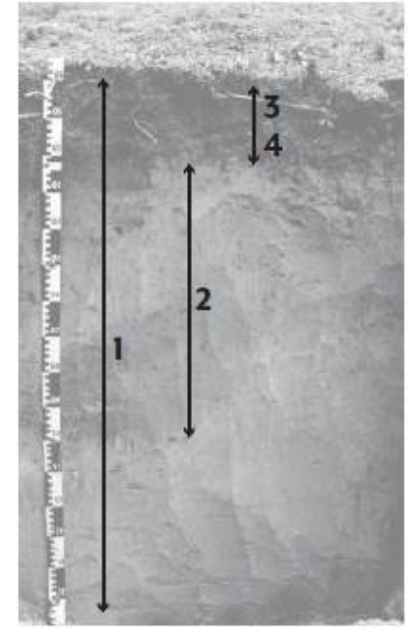
Protic ARENOSOL (Aeolic, Rubic)



1 – ARENOSOL

texture class of loamy sand or sand to a depth of 100 cm from mineral soil surface. Layers of finer texture (e.g. loam) or with ≥40% coarse fragments (stones, gravels) have thickness less than 15 cm.

Brunic ARENOSOL (Aric, Ochric)



1 – ARENOSOL

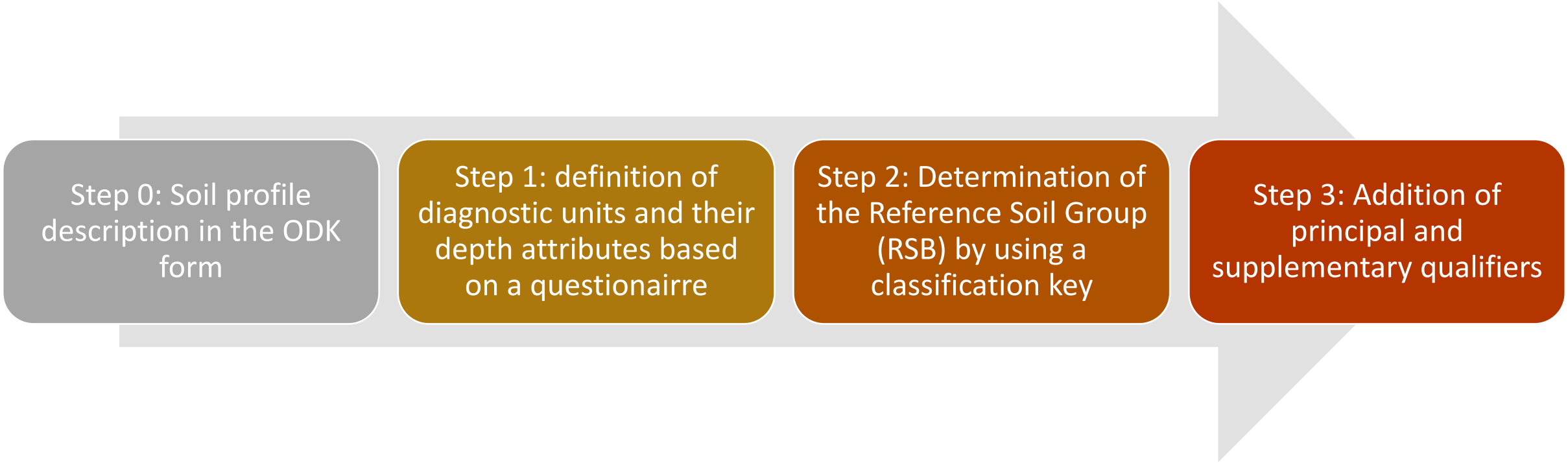
texture class of loamy sand or sand to a depth of 100 cm from mineral soil surface. Layers of finer texture (e.g. loam) or with ≥40% coarse fragments (stones, gravels) have thickness less than 15 cm.

Other soils:

REGOSOLS

Regosol = weakly developed soil that does not meet the criteria of any earlier WRB group in the key. It is the fallback group when no stronger diagnostic horizon, property, or material places the soil elsewhere.

Soil classification in the Soils4Liberia Soil Porfile Description ODK form



Important note: The workflow in the ODK form was indended to support the fieldwork, therefore it is a significant simplification of the WRB workflow. For detailed definitions, criteria and complete classification you should consult the WRB guideline.