

Capacity Building in Soil Profile Description and Soil Classification

Adam Csorba PhD, Yuri Gelsleichter PhD, Erika Micheli DSc, Tamás Szegi PhD, Marta Fuchs PhD



1. Introduction

WHO ARE WE?

- MATE is **one of the largest agriculture-focused universities** in Central Europe.
- It is also among the most internationally engaged universities in Hungary, particularly through the **Stipendium Hungaricum scholarship** program.
- Each year, **we host around ~ 700 students from across Africa**, studying agriculture, environmental sciences, food technology, and related disciplines.
- The **Department of Soil Science** has a **long history** and strong expertise in pedology, soil description, classification, mapping, and the development of soil information systems.
- We were/are **partners in several Africa-focused initiatives**



Long-term EU - AU Research
and Innovation Partnership
for **Food and Nutrition Security**
and **Sustainable Agriculture**



MAJOR TASKS OF MATE IN THE SOILS4LIBERIA PROJECT

1. **Developing tools for soil profile description, classification, and sampling**

- Preparation of detailed guideline documents
- Concise field handouts and reference sheets
- Electronic field-data recording forms (tablet/smartphone)
- Paper-based backup forms for areas without connectivity

2. **Conduct practical training for the field team leaders**

- Indoor sessions introducing pedological concepts and terminology
- Outdoor workshops to practice soil profile description and classification
- Emphasis on hands-on learning and consistency among surveyors

3. **Providing broader capacity building**

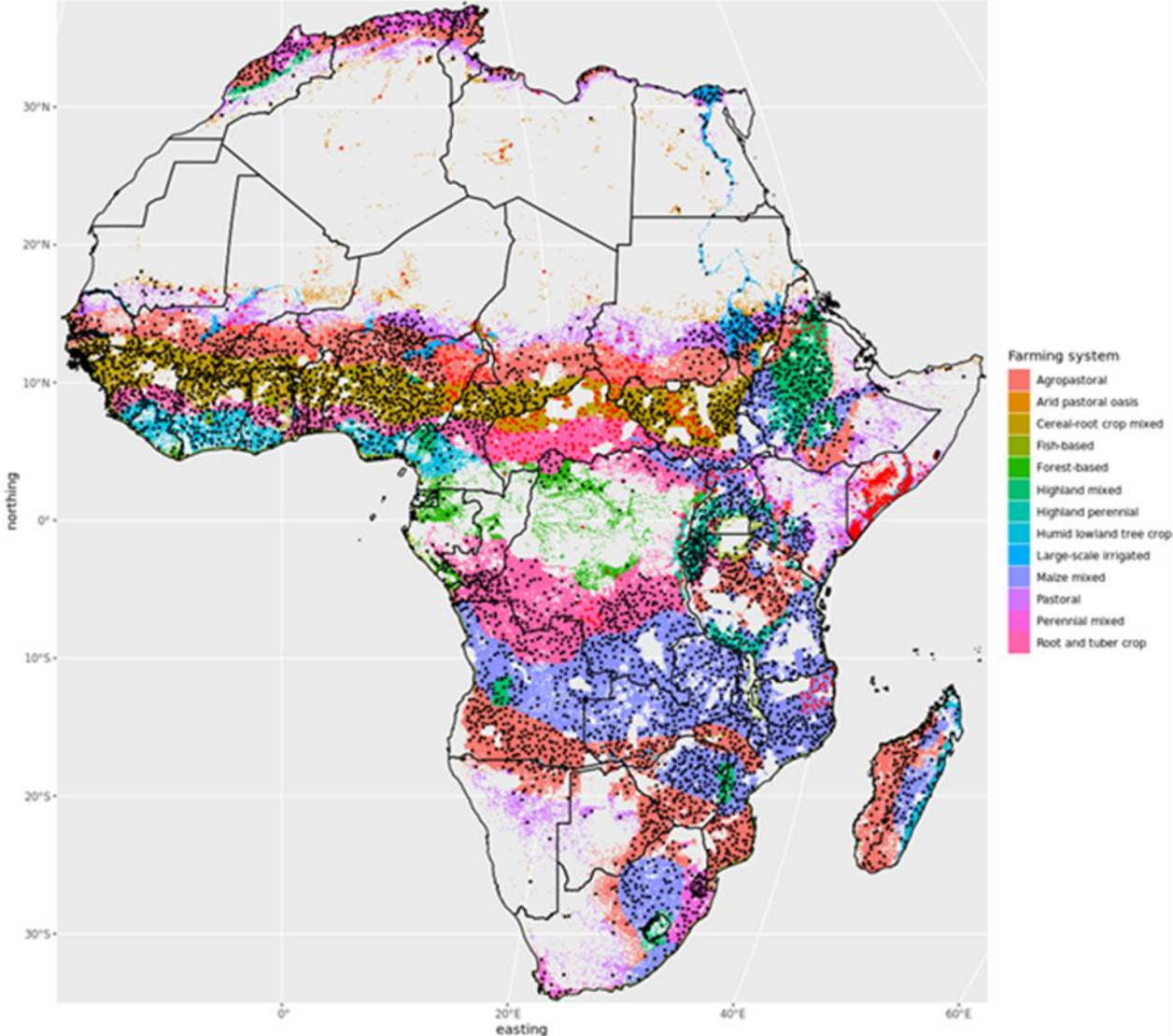
- Developing teaching materials on the key pedological topics
- Soil functions and formation
- Soil physics, chemistry and biology
- Soil description and classification

Direct support to national soil survey activities

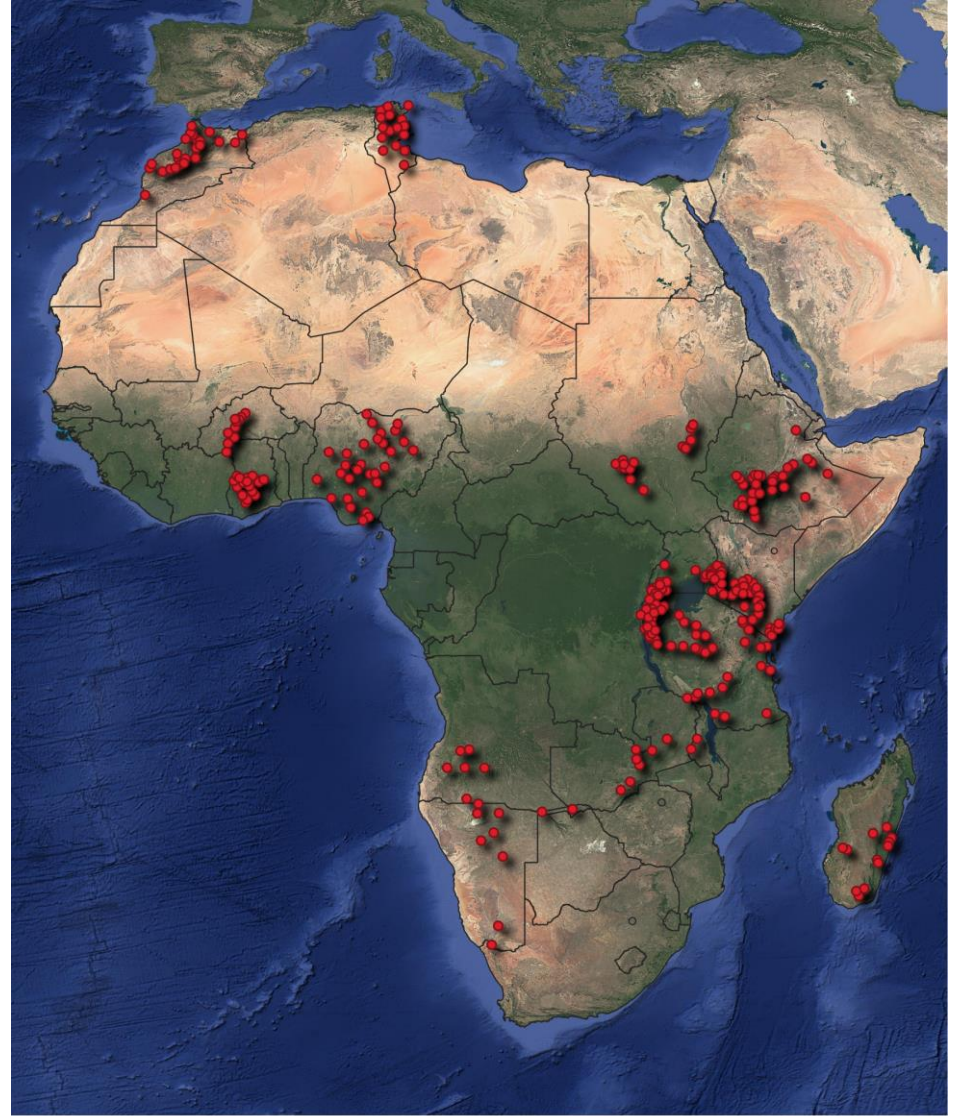
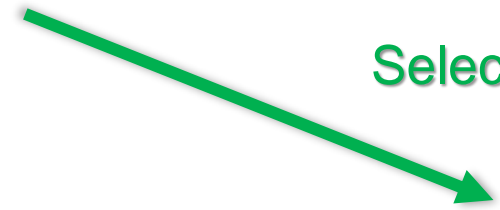
Building long-term academic and institutional capacity in Liberia

2. Background information: „baseline sites” and „reference sites” in Soils4Africa

~15.000 sites



Selected 250 sites



SAMPLING IN SOILS4AFRICA

Soils4Africa aimed to build an open-access Soil Information System (SIS) for Africa that allows for monitoring soil quality (and also mapping)

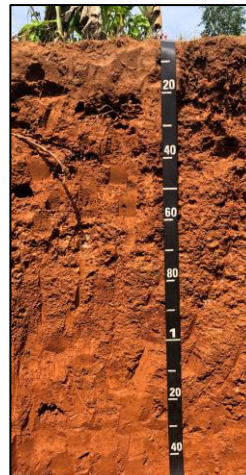
1. „Baseline sampling sites” or „standard monitoring sites”

- Pre-selected by the sampling design
- Two samples were collected – topsoil (0 – 20 cm) and subsoil (20 – 50 cm)
- The samples are composite samples collected at four sublocations at the site, preferably with auger
- An electronic ODK form was used to record information of sampling, environment, land use, and soil conditions



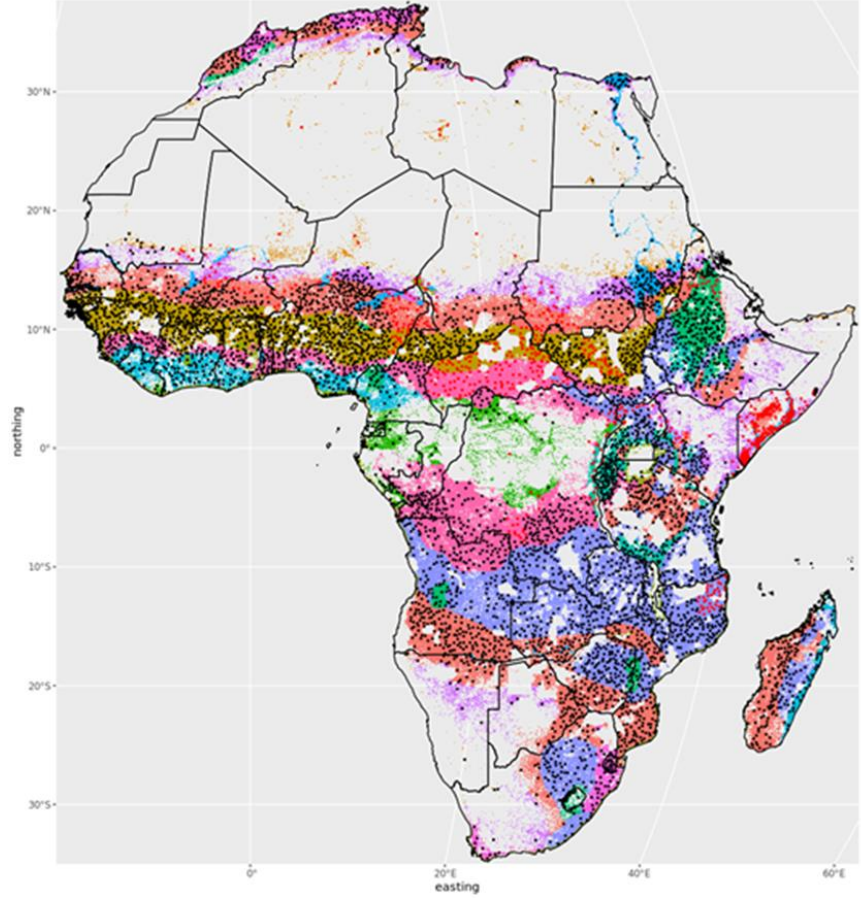
2. „Reference (RS) sites” – extraordinary sites selected from the baseline locations

- Not extra, but extraordinary sites – additional activities
- Soil profiles!
- Only in selected countries, sites were selected by Country Supervisors
- RS sites represent characteristic land-use types, soil types, and agroecological zones

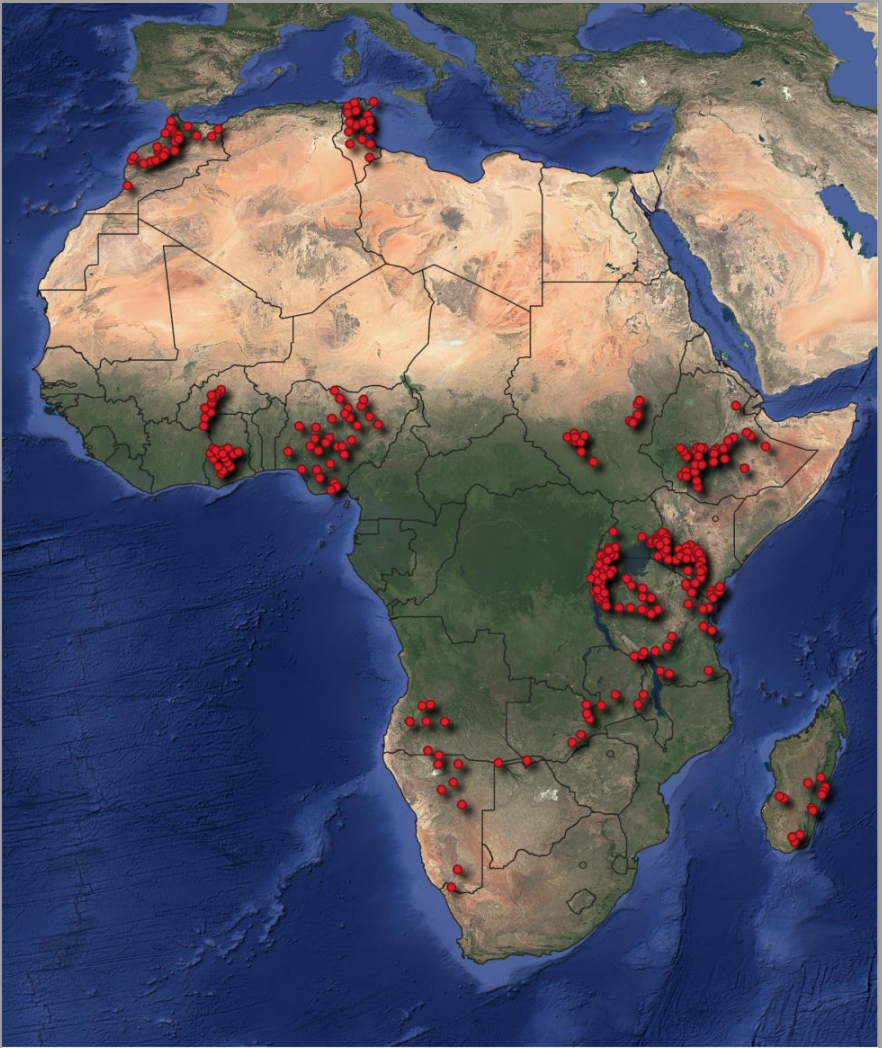


SAMPLING SITE TYPES IN SOILS4AFRICA

Baseline locations

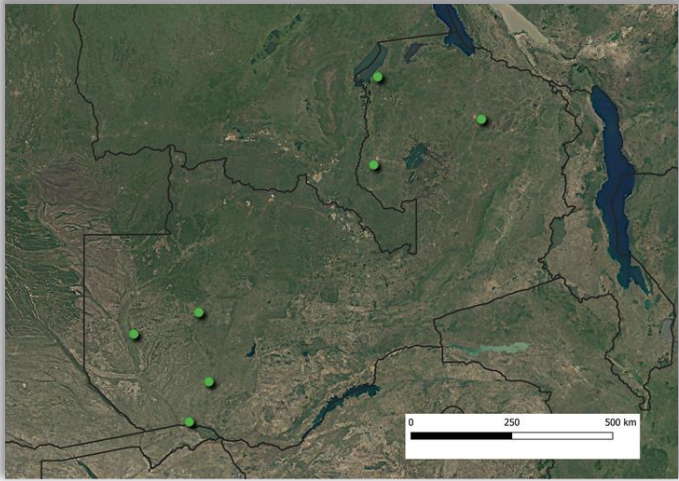


Minimalistic Reference Sites

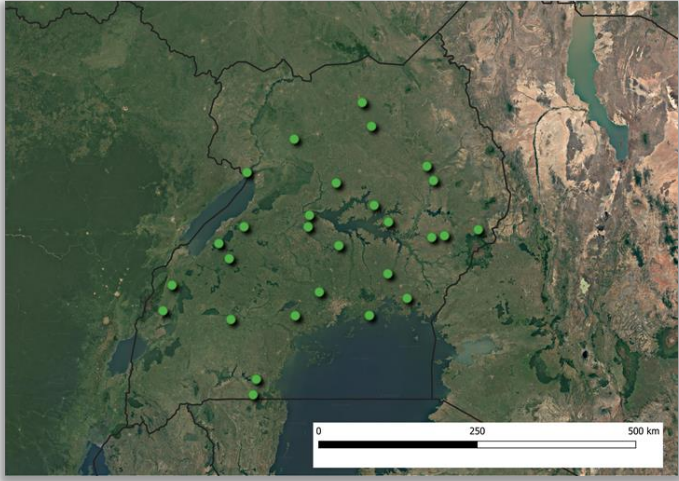


Advanced Reference Sites

Zambia

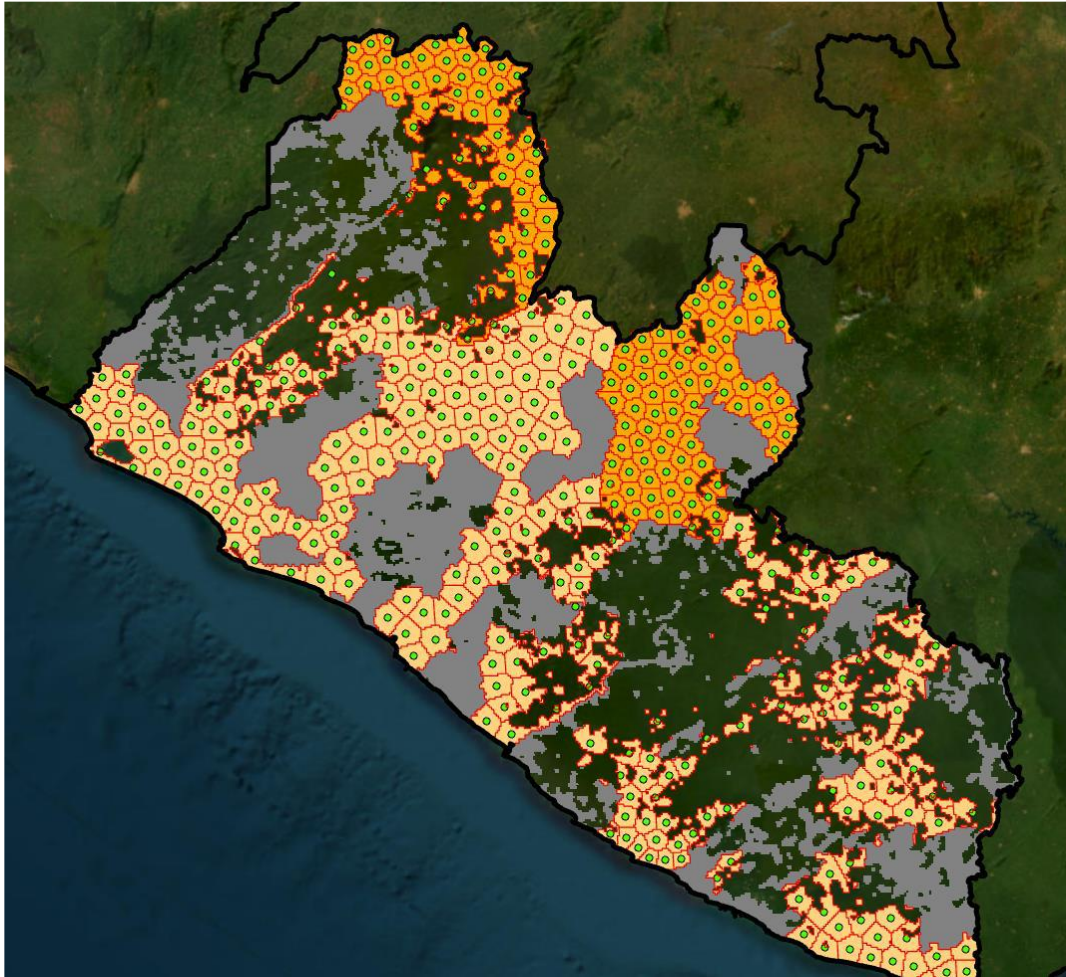


Uganda

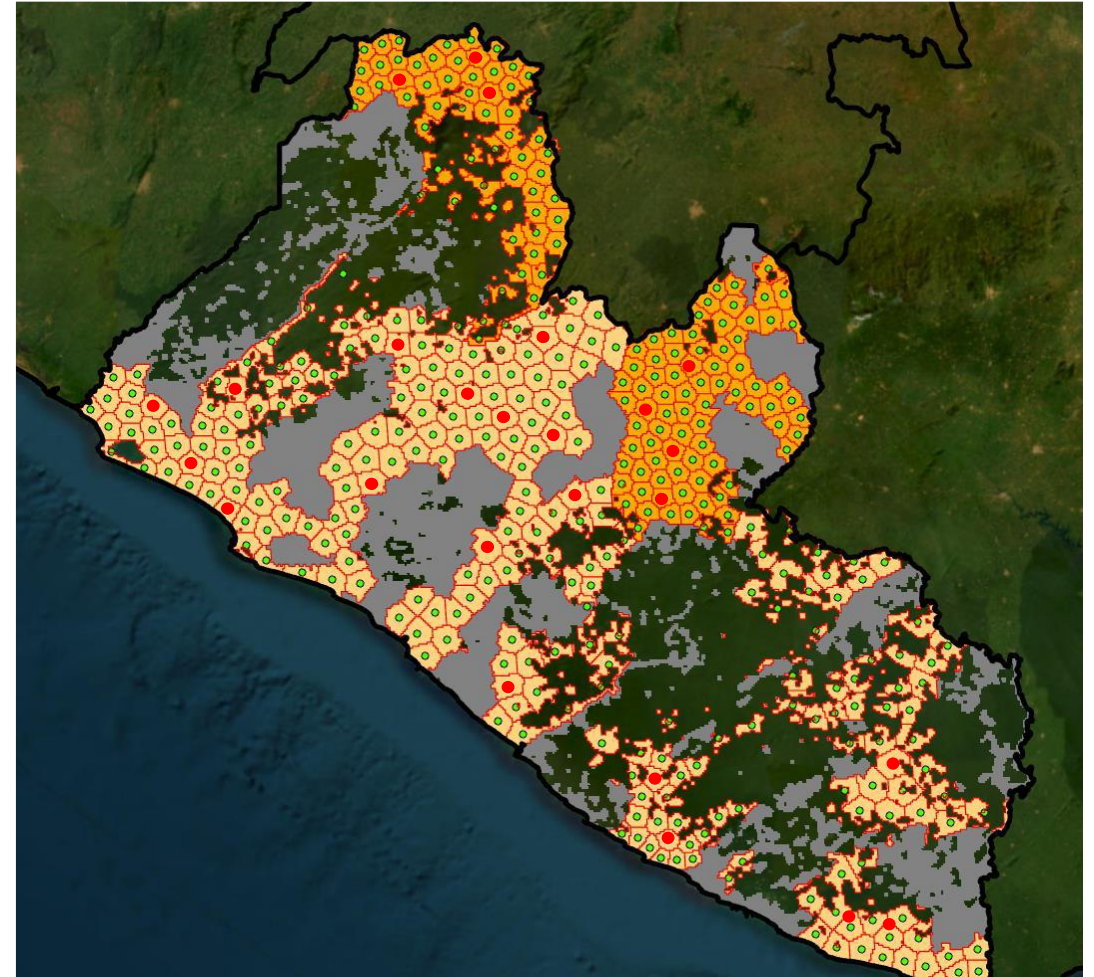


TRANSLATION THE CONCEPT TO THE SOILS4LIBERIA PROJECT

Soils4Liberia „baseline”
locations



Soils4Liberia „Advanced Reference
Site” locations – full soil profiles



Based on the preliminary concept of the sampling design

Soil-forming factors

Soil forming processes

Horizon designation (Soil ABC)

Adam Csorba PhD, Yuri Gelsleichter PhD, Erika Micheli DSc, Tamás Szegi PhD,
Marta Fuchs PhD



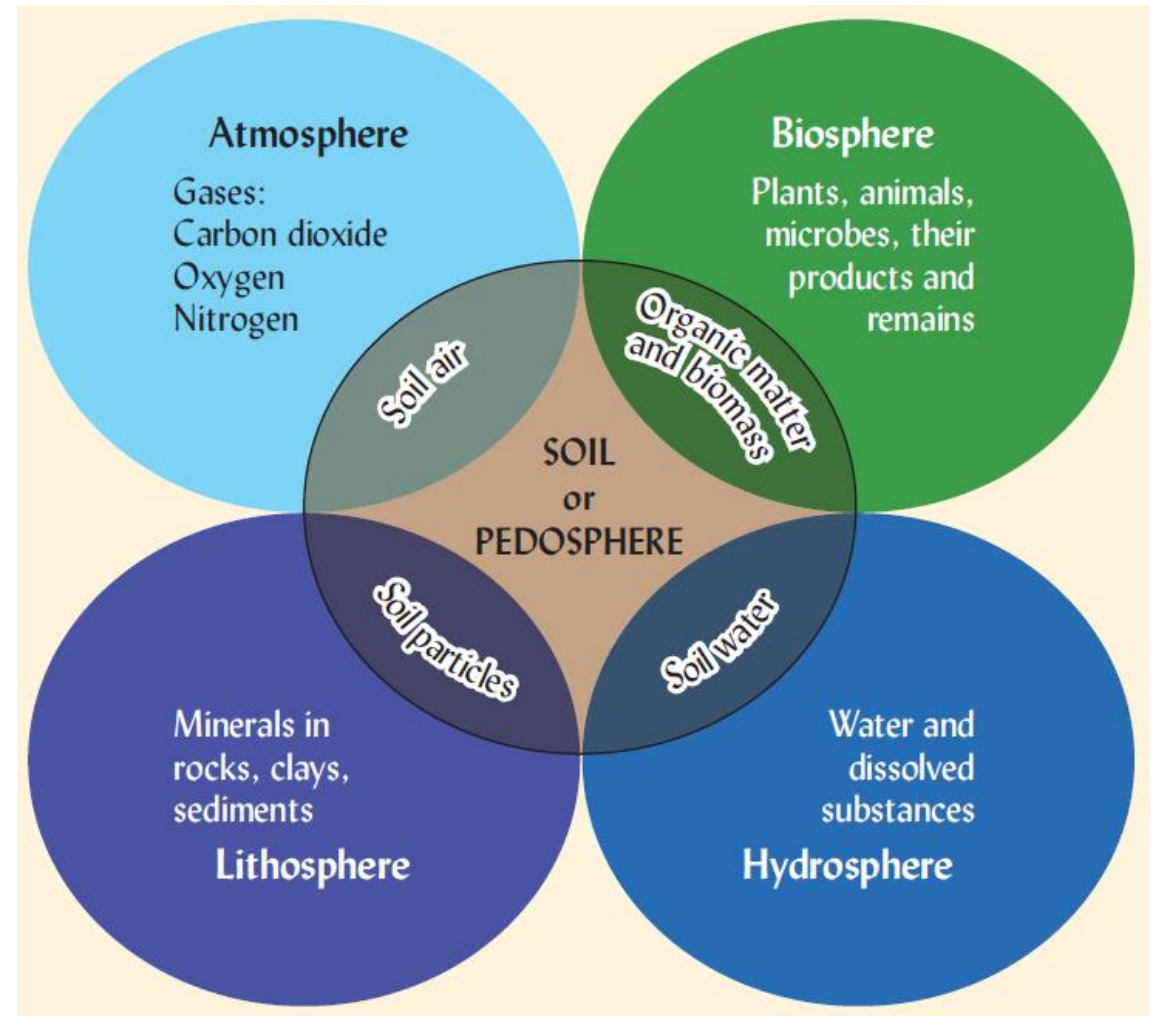
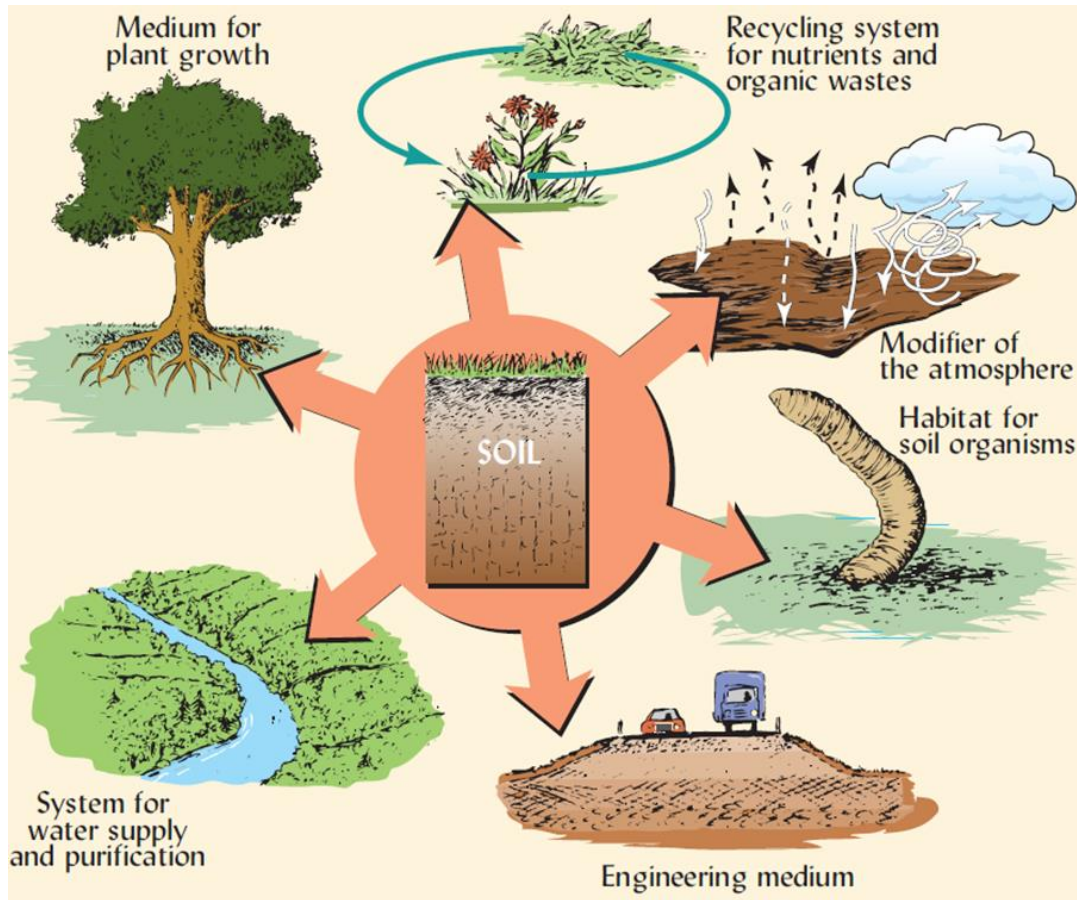
Soil functions

Soils deliver ecosystem services that enable life on Earth



2015
International
Year of Soils
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Soils as natural bodies – functions of the soils



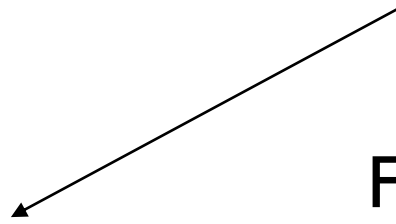
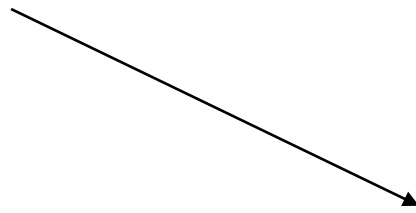
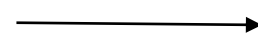
Soil forming factors

Soil forming factors

Define what kind of soil form at a given point of the Earth

Soil forming processes

Responsible for the development of horizons in the soil, and define the soils properties



Soil genesis

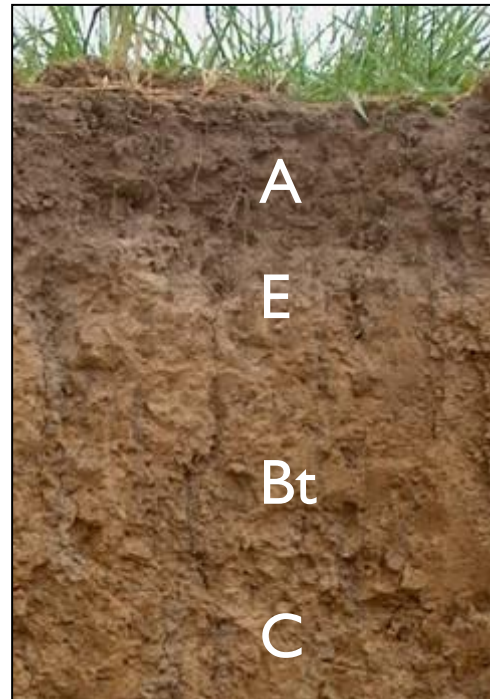
Parent material

Topography

Climate

Biological activity

Time



- Weathering
- Formation of organic matter
- Leaching
- Plinthite formation
- Ferallitization
- Nitidization
- Clay migration
- Acidification
- Gleying
- etc...

Soil-forming factors

Overview

Soil properties result from the interaction of **five soil-forming factors: climate, organisms, relief (topography), parent material, and time.**

Understanding these factors helps interpret **soil morphology, horizon development, and classification.**

Key considerations in Liberia

- 1. Parent material:** Influences **texture, structure, drainage, and nutrient status**, despite strong climatic overprinting.
- 2. Relief:** Controls **water movement, erosion, and deposition**; slope position often determines drainage conditions.
- 3. Climate:** Dominant factor; humid tropical conditions cause **intense weathering, strong leaching, and accumulation of Fe/Al oxides**, producing **deeply weathered red and yellow soils.**
- 4. Organisms:** Vegetation, soil fauna, microorganisms, and human activity affect **organic matter, structure, bioturbation, and nutrient cycling.**
- 5. Time:** Long-term weathering in stable landscapes leads to **deeply developed tropical soil profiles.**

Surveyors should **anticipate soil conditions before fieldwork** using climate, geology, and topography, and **record site characteristics in the field** (vegetation, land use, slope, drainage, parent material, erosion evidence).

Soil-forming factors

Parent material

Parent material is **the material that soil develops from**, and may be rock that has weathered in place, or material that has been deposited by wind, water, or ice.

The **character and chemical composition of the parent material plays an important role** in determining soil properties, especially during the early stages of development.

Parent material provides the **mineralogical and textural foundation of the soil**. In Liberia, crystalline rocks, sedimentary formations and transported materials contribute differently to soil texture and nutrient reserves.

Under humid tropical weathering, the original mineralogical differences may become less pronounced as soils become deeply weathered and dominated by secondary clay minerals and oxides. Nevertheless, parent material still influences texture, stoniness, drainage and local variability.

Soil-forming factors

Parent material

Composition, resistance to weathering



1. Crystalline Basement Rocks (dominant)

(granites, gneisses, schists)

Soil influence:

- Medium to coarse texture
- Deep weathering profiles
- Low nutrient reserves
- Often red/yellow soils

2. Sedimentary Rocks

(sandstone, shale, limestone —
local occurrence)

Soil influence:

- More variable texture (sand
→ clay)
- Can retain more nutrients
(locally)
- Often layered soil profiles

3. Fluvial & Alluvial Deposits

(river and floodplain sediments)

Soil influence:

- Stratified layers
- Variable texture with depth
- Often more fertile
- Weak horizon development

4. Colluvial Materials

(slope deposits, mixed material)

Soil influence:

- Heterogeneous
composition
- Irregular horizons
- Often unstable / weakly
developed

5. Coastal & Marine Deposits

(coastal plains, estuaries)

Soil influence:

- Fine textures (clay-rich)
- Poor drainage
- Possible salinity or
sodicity
- Strong hydromorphic
features

6. Organic Deposits (local)

(swamps, wetlands)

Soil influence:

- High organic matter
- Water saturation
- Formation of H / O
horizons



Soil-forming factors III.

Climatic conditions

Climate is perhaps the **most influential** of the four factors acting on parent material because it determines nature and intensity of weathering that occurs over large geographic areas.

The principal climatic variables that influencing soil formation are:

- **effective precipitation,**
- **temperature.**

Climate and Weather Conditions

- **Climate is the dominant soil-forming factor in Liberia.**
- Humid tropical conditions (**high rainfall and temperatures**) cause **intense chemical weathering, strong leaching of bases and silica, and accumulation of Fe and Al oxides.**
- These processes lead to **deeply weathered profiles, red/yellow colours, low natural fertility, and frequent hydromorphic features.**

- ↔ Plant cover
- ↔ Water management of soils
(downward, balanced, upward)
- Profile & horizon development

Precipitation also affects horizon development factors like the translocation of dissolved ions through the soil.

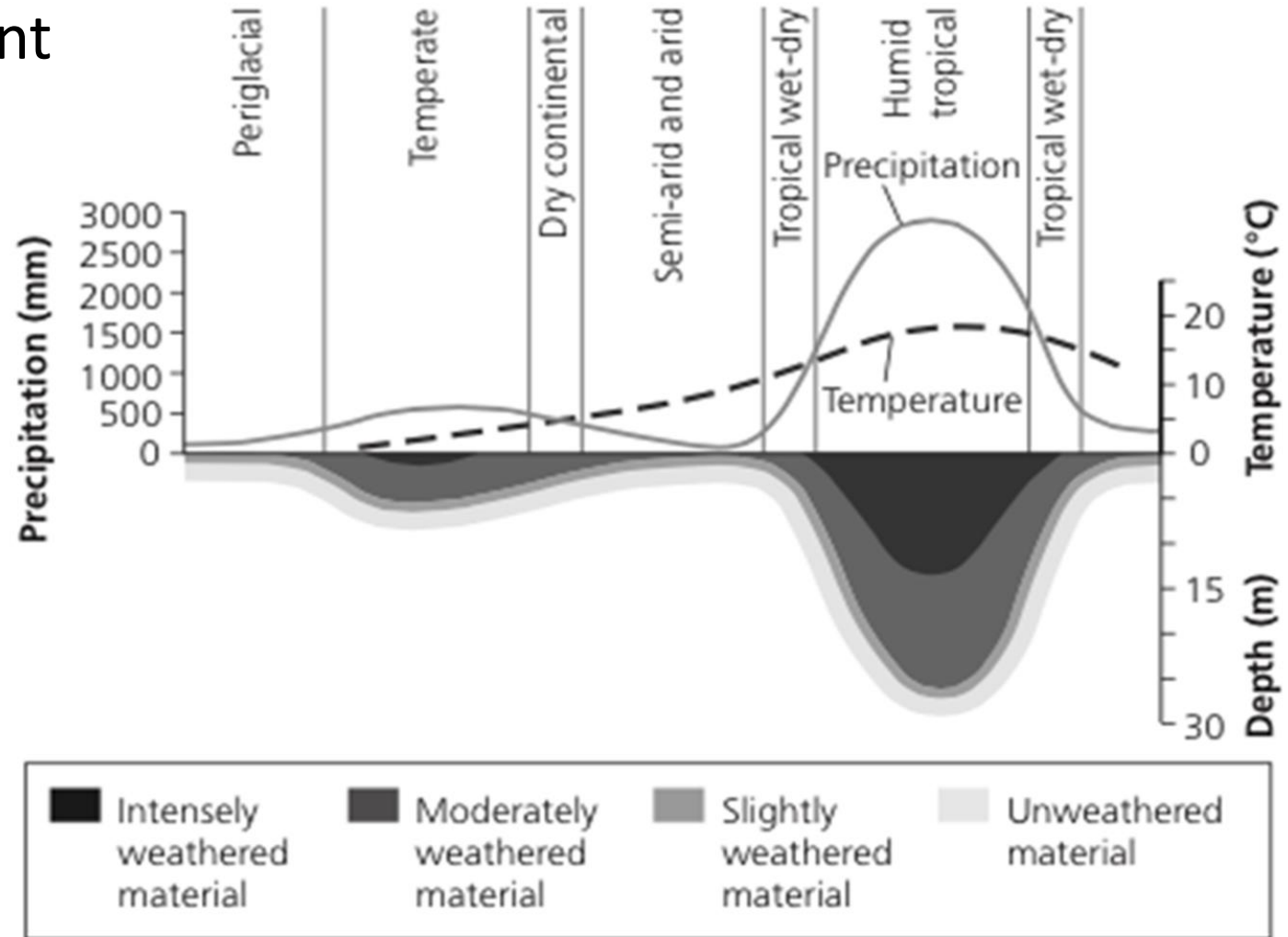
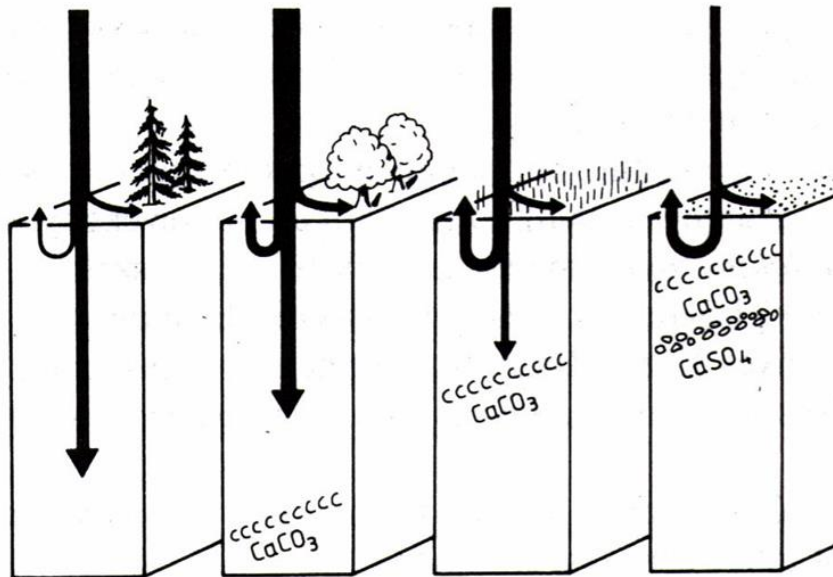
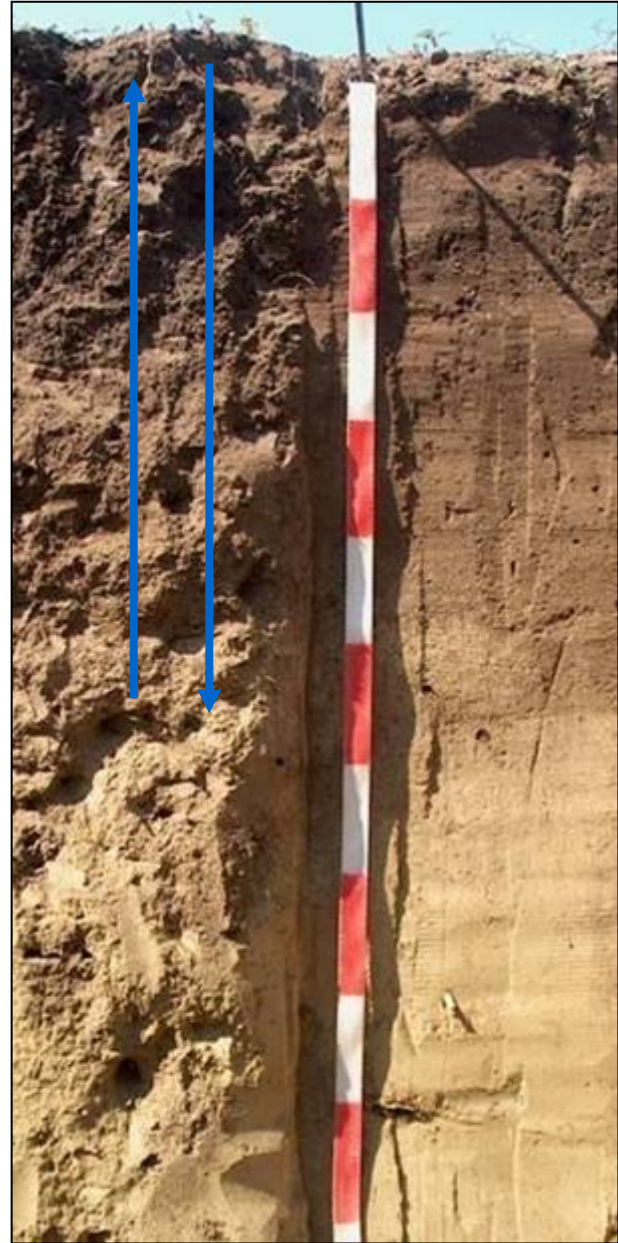
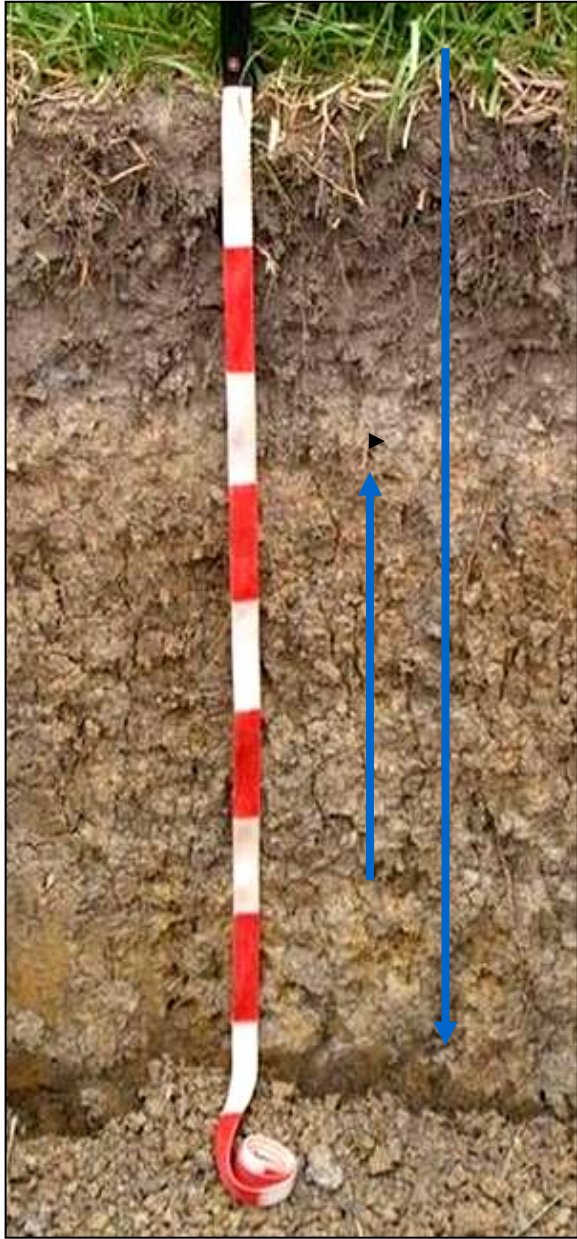
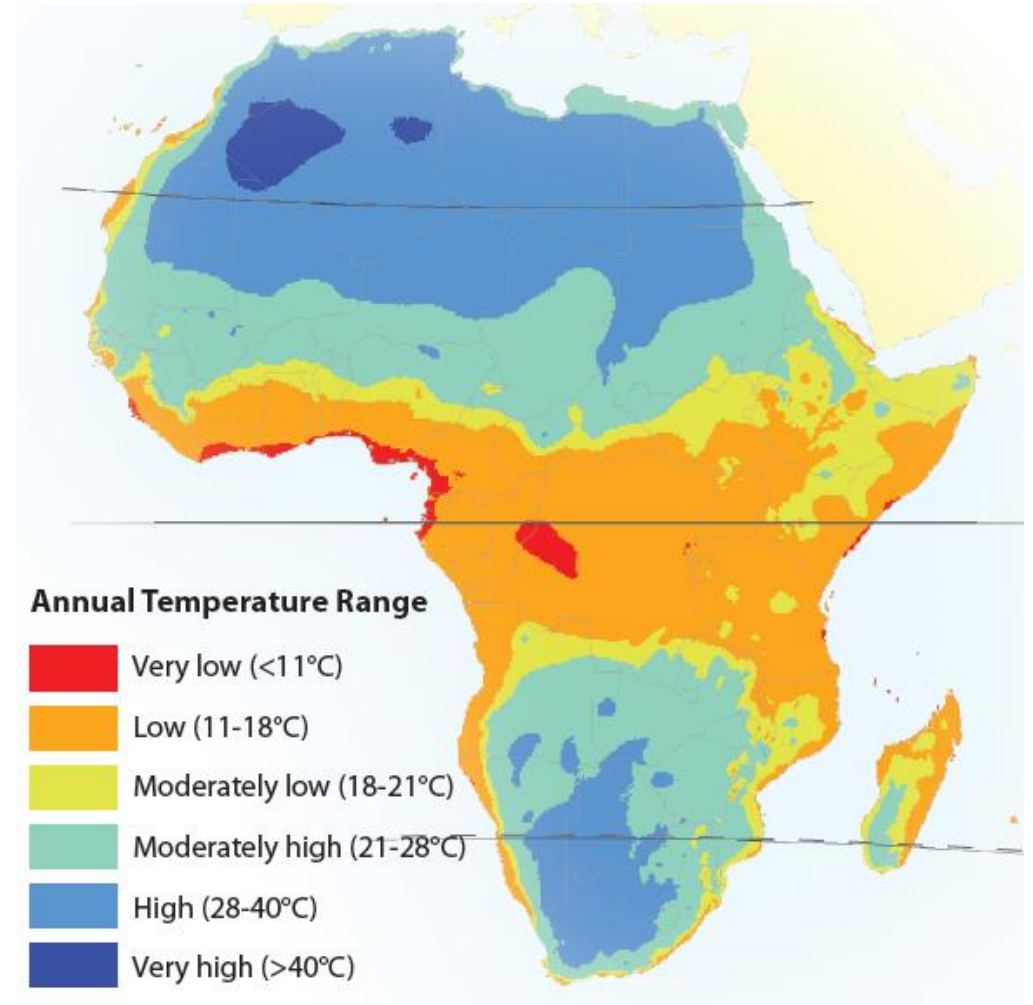
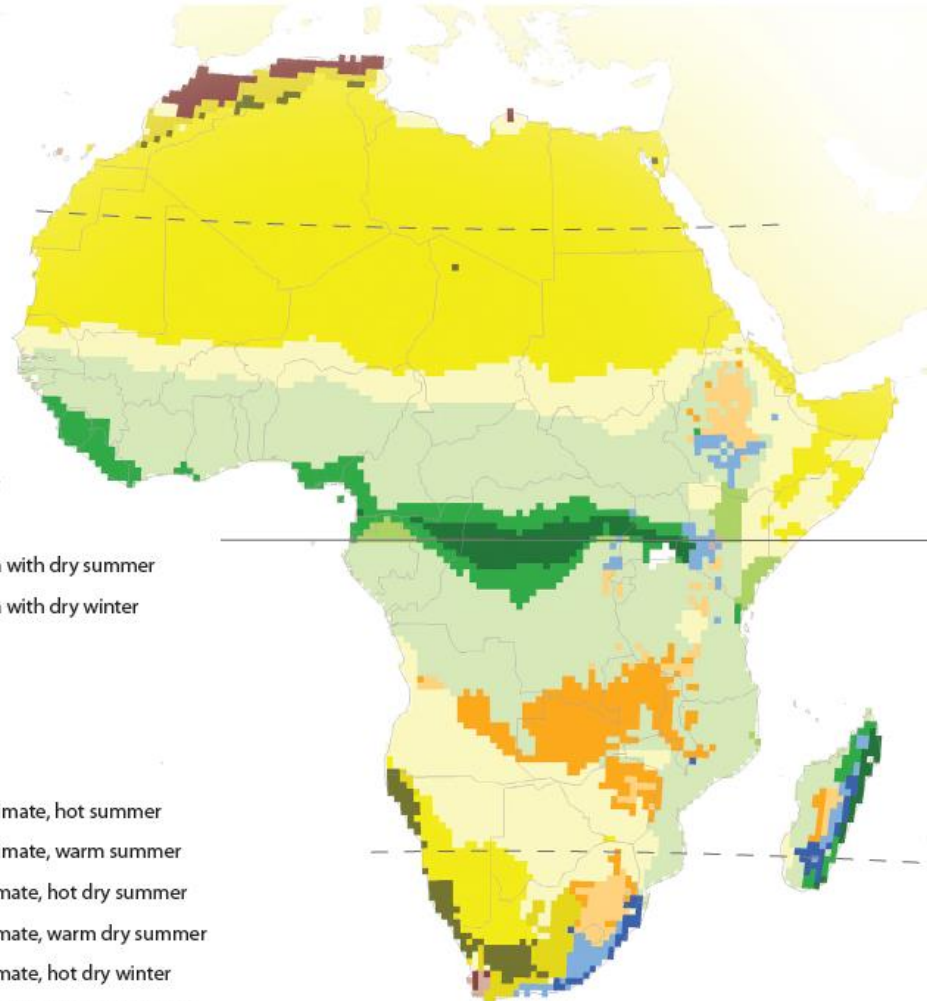


Figure 3.3 Depth of weathering profile and climate



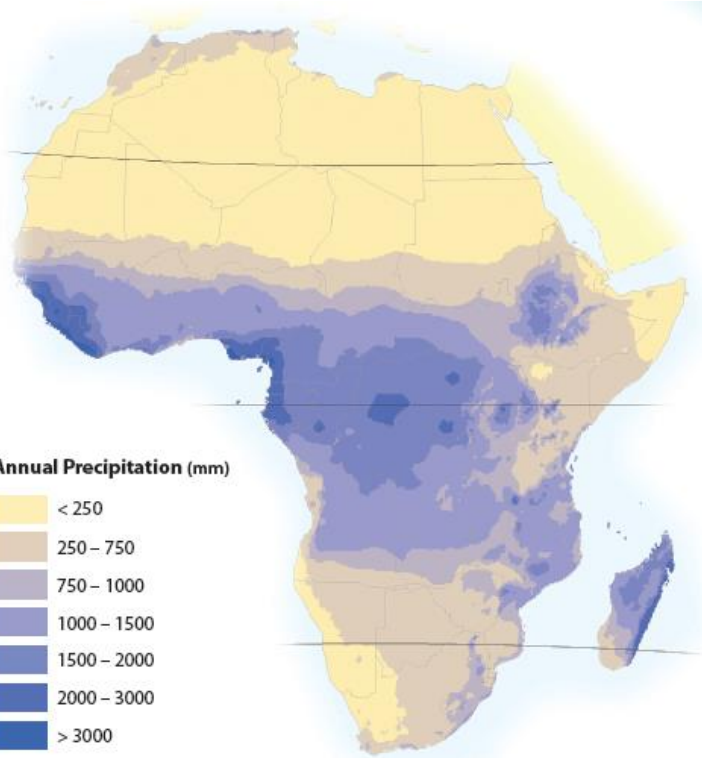
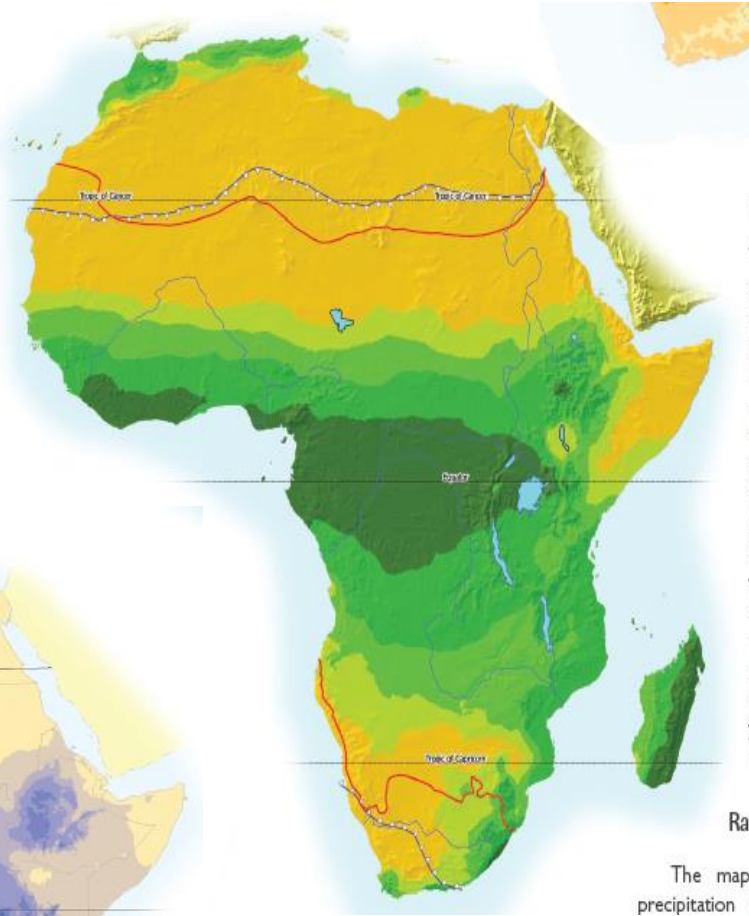
Recording information on soil-forming factors

Attributes related to climatic conditions



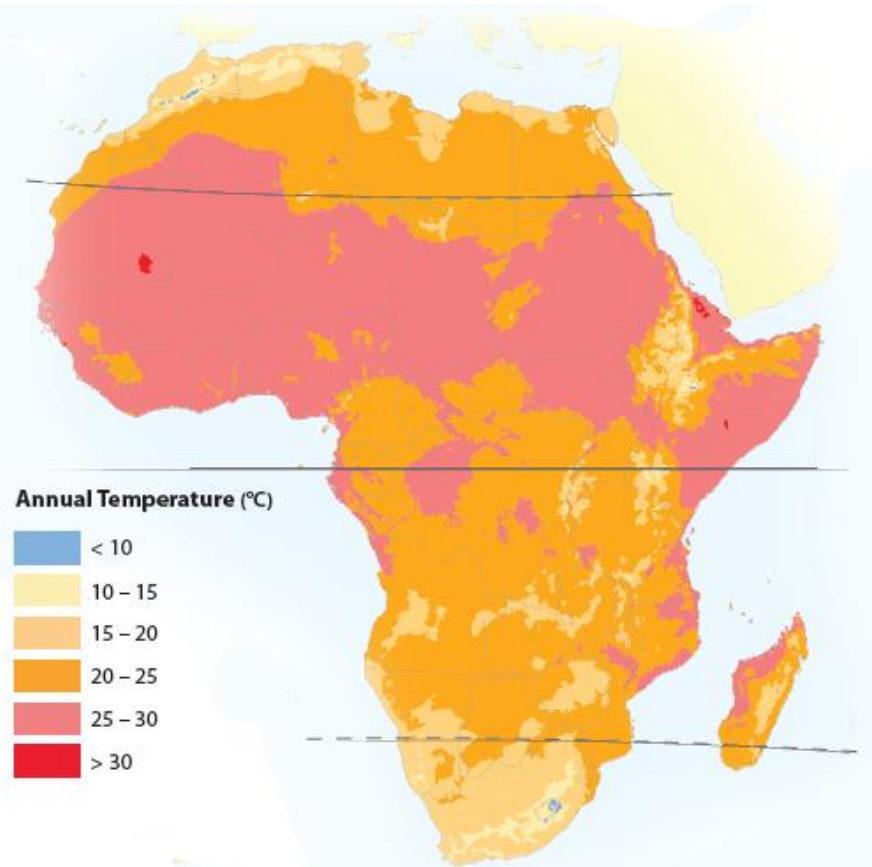
Length of growing period

- 0 - 60 days (arid)
- 60 - 120 days (dry semi-arid)
- 120 - 180 days (moist semi-arid)
- 180 - 270 days (sub-humid)
- 270 - 365 days (humid)
- tropical isotherm
- summer rains



Annual Precipitation (mm)

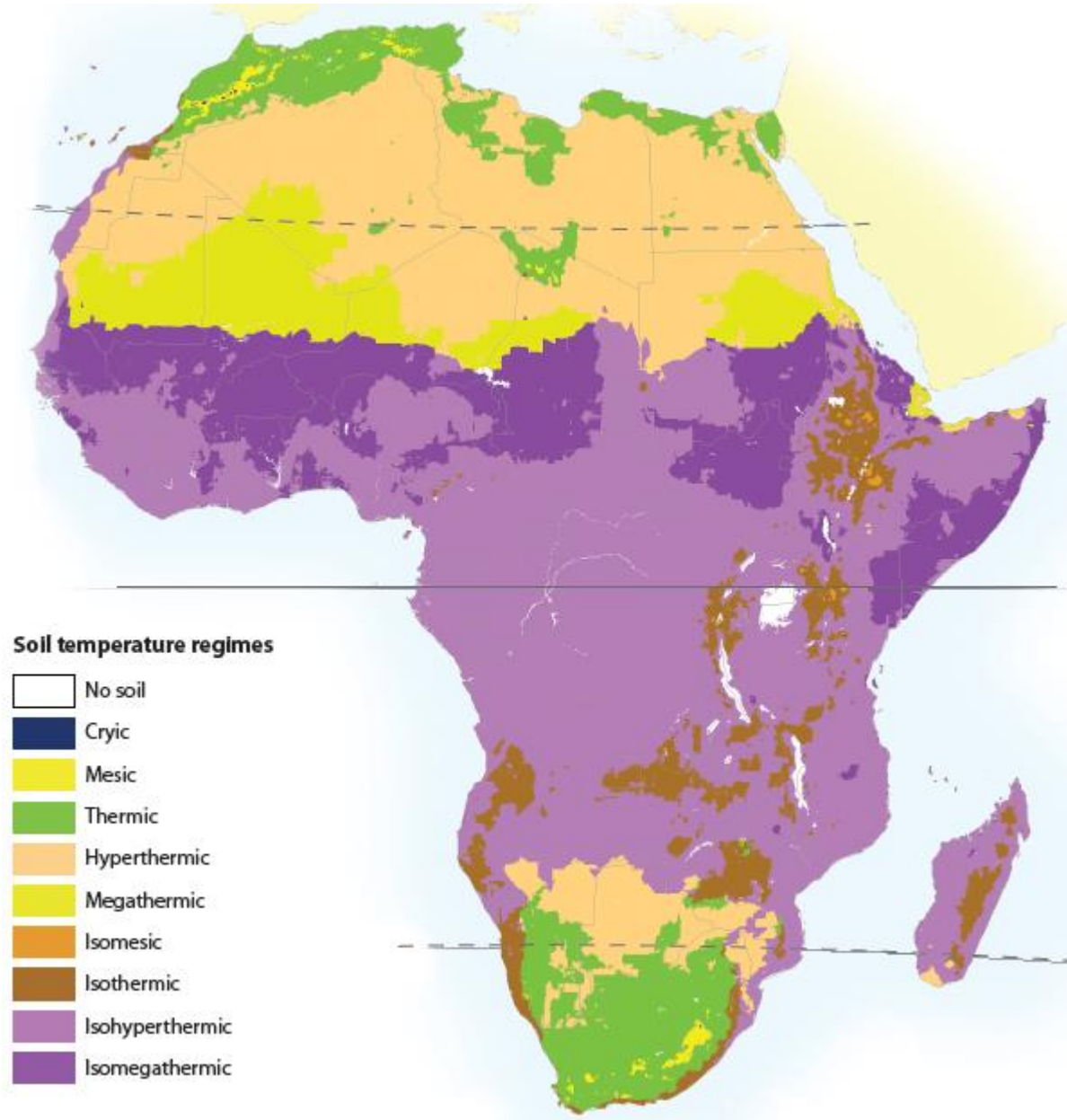
- < 250
- 250 - 750
- 750 - 1000
- 1000 - 1500
- 1500 - 2000
- 2000 - 3000
- > 3000



Annual Temperature (°C)

- < 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- > 30

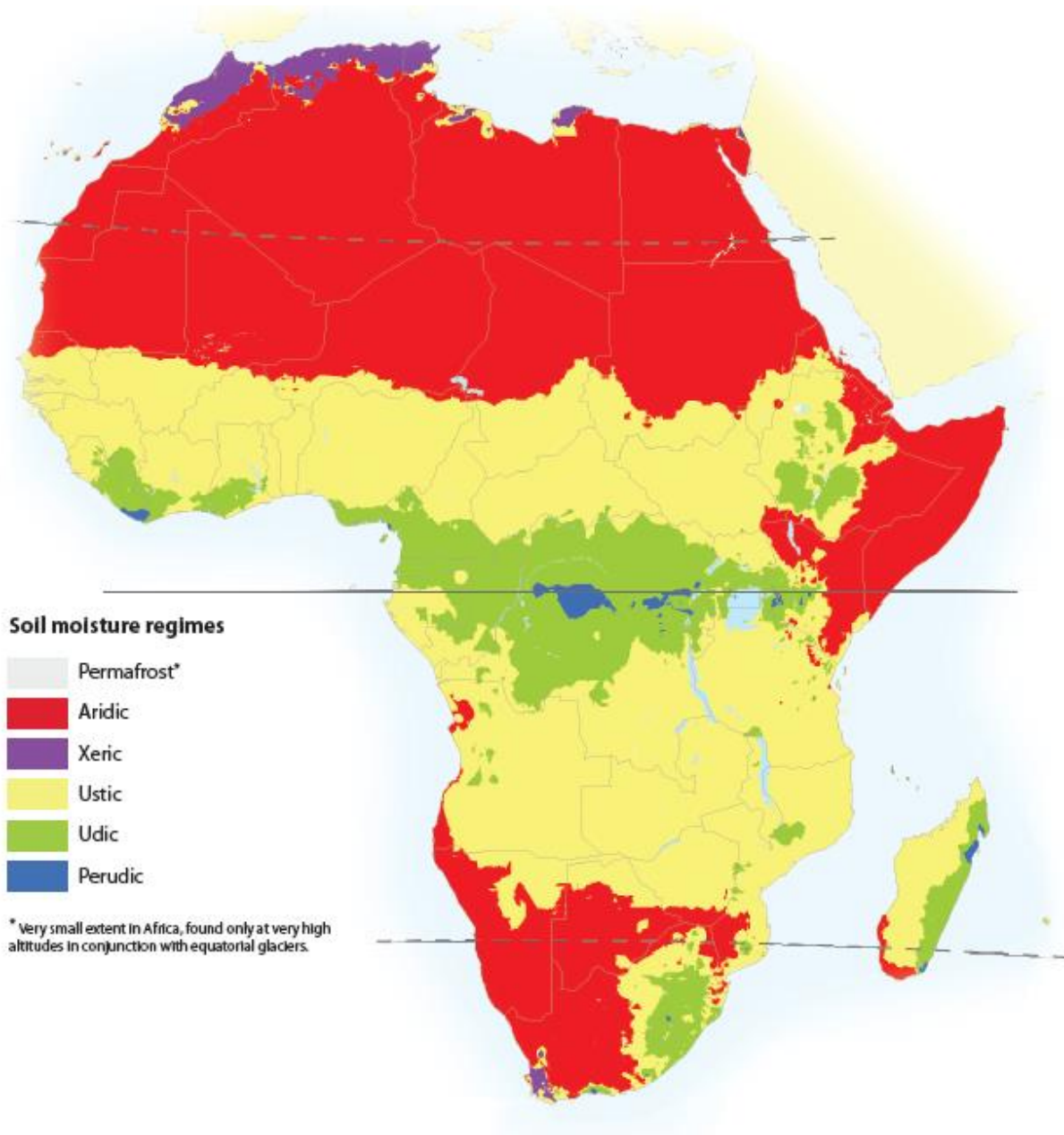
The map precipitation (



The **isohyperthermic** regime, with equally high mean annual temperatures but small seasonal differences, typically shows permanently warm soil conditions, year-round biological activity, and deeply weathered profiles, often with thick ferrallitic or lateritic weathering mantles in humid tropical regions.

Implications for soil formation

- Very intense chemical weathering
- Rapid organic matter turnover
- Continuous decomposition
- Strong mineral alteration in subsoils
- Development of deep, highly weathered profiles
- **ferrallitisation and other tropical processes**



Soil moisture conditions in Liberia

Dominant regimes in Liberia:

- **Udic / Perudic** → soils moist most of the year
- **Aquic (local)** → seasonal water saturation
- **Peraquic (local)** → permanent saturation

What this means for soils

Udic / Perudic (most of Liberia):

- continuous water availability
- strong leaching
- deep weathering
- low nutrient retention

Locally: Aquic (valleys, depressions):

- periodic saturation
- oxygen deficiency
- redox features (mottling, grey colours)

Locally: Peraquic (swamps, wetlands):

- permanent saturation
- strong reducing conditions
- organic accumulation possible

Soil-forming factors

Topographic attributes

Topography has a significant impact on soil formation as it determines the movement or direction or deposition of water and other materials. Orientation affects microclimate which in turn affects vegetation.

Soil formation is faster on stable, undisturbed surfaces.

Relief (topography) controls **water movement, erosion, and deposition**, strongly influencing soil depth, drainage, and horizon development.

In humid tropical environments, **slope position** often determines whether soils are **well-drained, eroded, or waterlogged**.

1. Upland / Plateau (Summits)

(stable surfaces)

Soil influence:

- Deep, well-developed soils
- Strong weathering
- Good drainage

2. Slopes / Hillsides

(erosional zones)

Soil influence:

- Shallower soils
- Erosion dominant
- Weak horizon development

3. Footslopes / Lower Slopes

(transition zones)

Soil influence:

- Accumulation of materials
- More developed soils
- Variable drainage

4. Valley Bottoms / Depressions

(wet environments)

Soil influence:

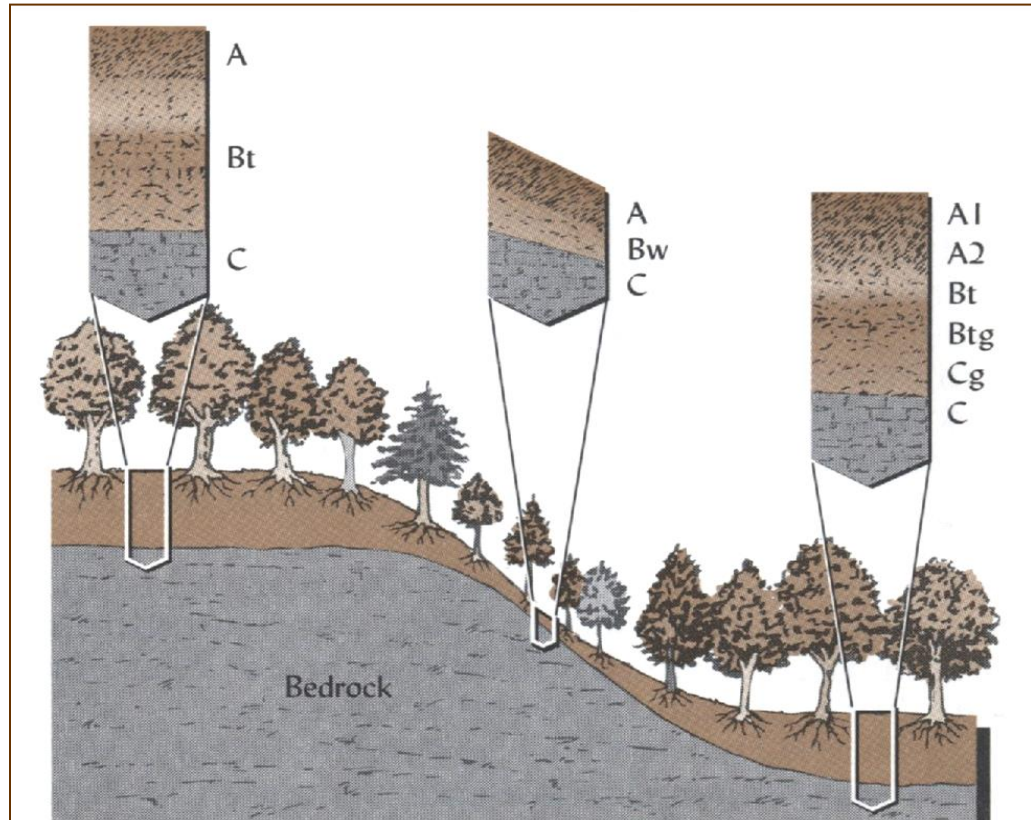
- Poor drainage
- Water saturation
- Redoximorphic features
- Gleying processes

Soil-forming factors

Topographic attributes

Steepness, aspect, position

→ Modify/alter the effect of the other soil forming factors on soil formation.



Steepness, topographical position

→ Parent material

→ infiltration → weathering

→ Erosion → transportation, sedimentation

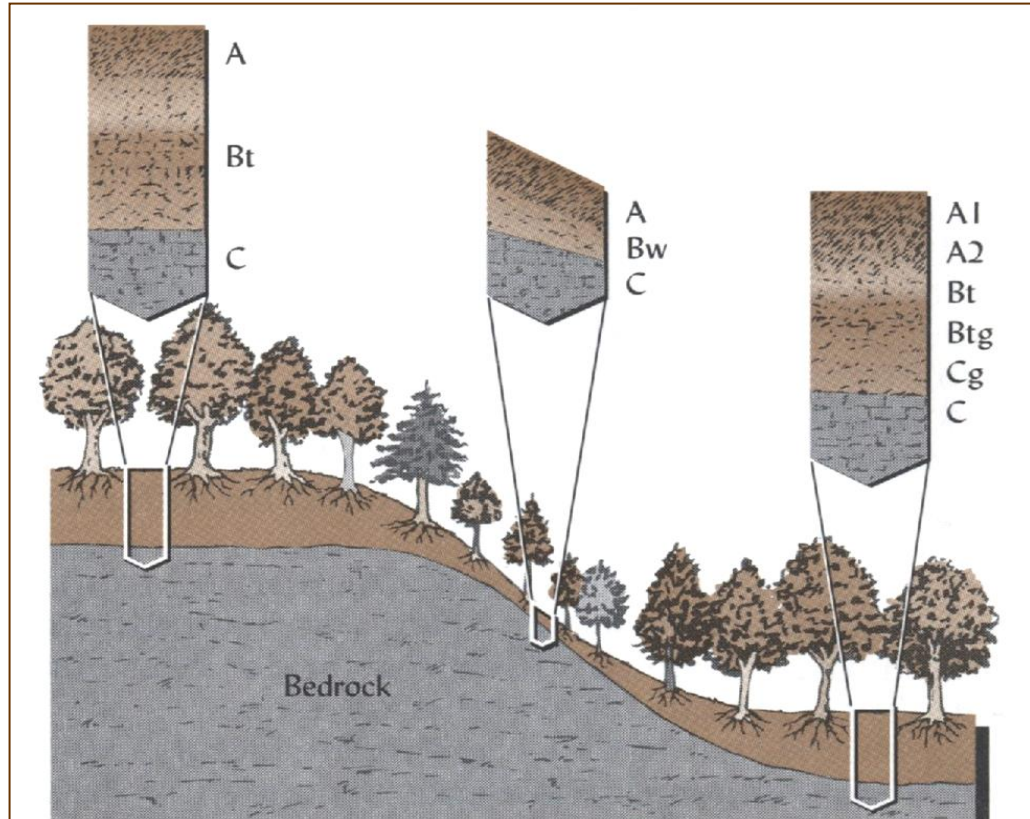
↔ development/degradation

Soil-forming factors

Topographic attributes

Steepness, aspect, position

→ Modify/alter the effect of the other soil forming factors on soil formation.



Aspect

→ change the pattern of precipitation, temperature and relative humidity of slopes



Warming and water management of soils; plant cover

Soil-forming factors

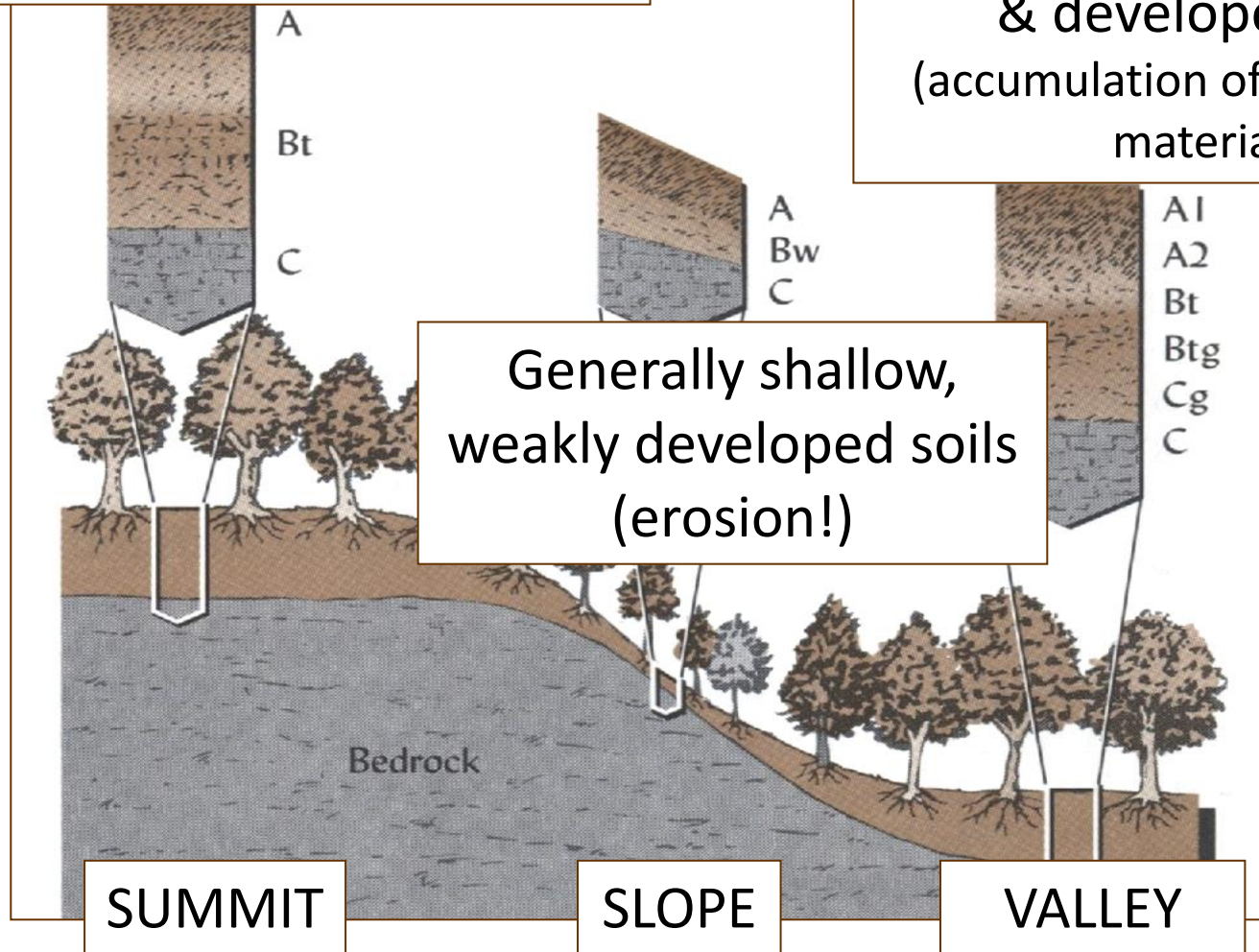
Topographic attributes

Topography (Steepness, aspect, position)

Generally more developed soils

Generally more weathered & developed soils
(accumulation of transported materials)

Generally shallow, weakly developed soils
(erosion!)



Soil-forming factors IV.

Vegetation and biological activity

Organism, both plant and animal, play an important role in the development and composition of soil.

Organisms add organic matter, aid decomposition, weathering and nutrient cycling.

The richness and diversity of soil organisms and plant life that grows on the surface is, of course, also tied to climate.

Soil-forming factors IV.

Vegetation and biological activity

Vegetation



Biomass (amount, composition, distribution)

Soil-forming factors IV.

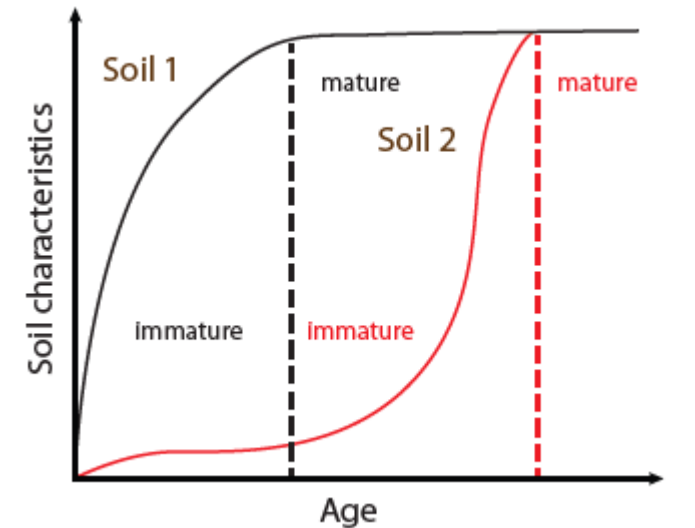
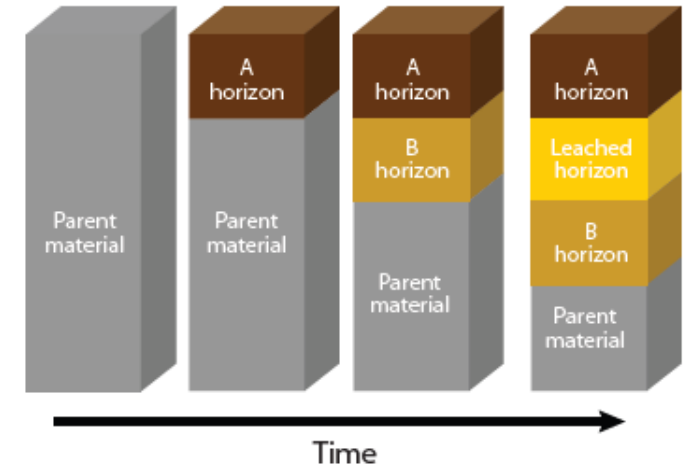
Vegetation and biological activity

Animal, anthropogenic factors



Soil-forming factors V.

Time



Absolute (age of the soil)

Relative (degree of weathering & profile development)

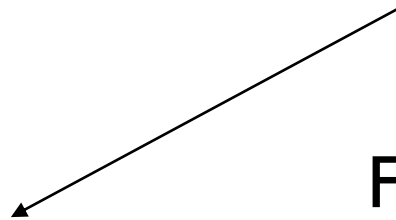
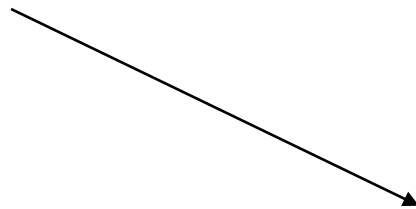
Soil forming processes

Soil forming factors

Define what kind of soil form at a given point of the Earth

Soil forming processes

Responsible for the development of horizons in the soil, and define the soils properties



Parent material

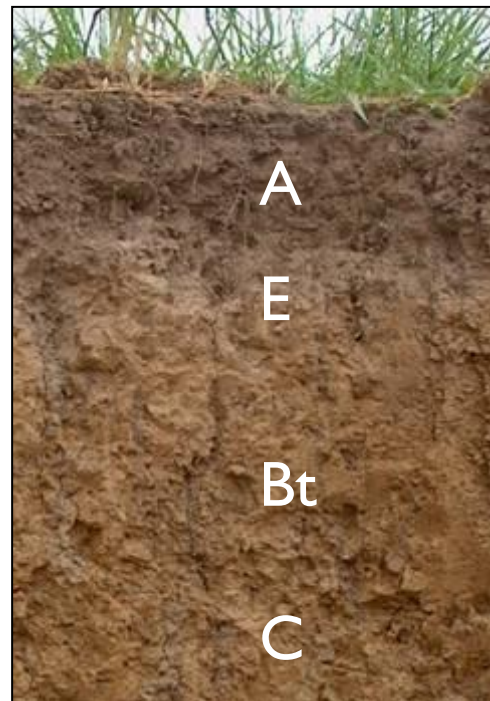
Topography

Climate

Biological activity

Time

Soil genesis



Weathering
Formation of organic matter

Leaching

Plinthite formation

Ferallitization

Nitidization

Clay migration

Acidification

Gleying

etc...

how Soil is formed



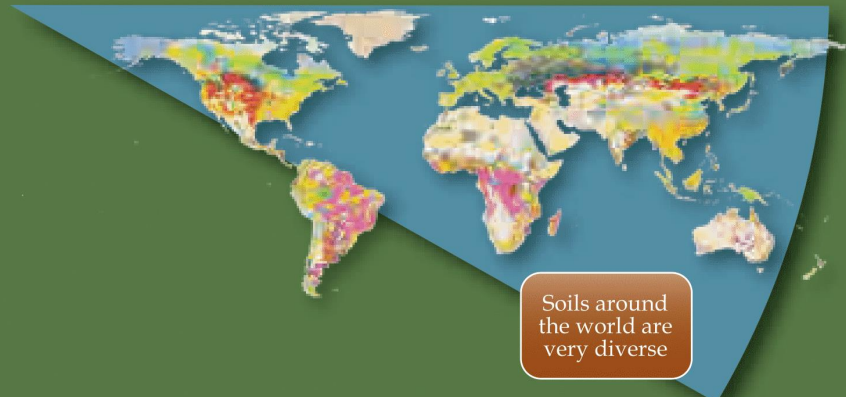
Soil average composition

- 5% Organic matter
- 25% Air
- 25% Water
- 45% Mineral

Soils are a key element of every landscape



2015
International Year of Soils
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Soils around the world are very diverse

Formation of soil is a long and complex process

Soil forming factors



Parent material



Climate



Organisms

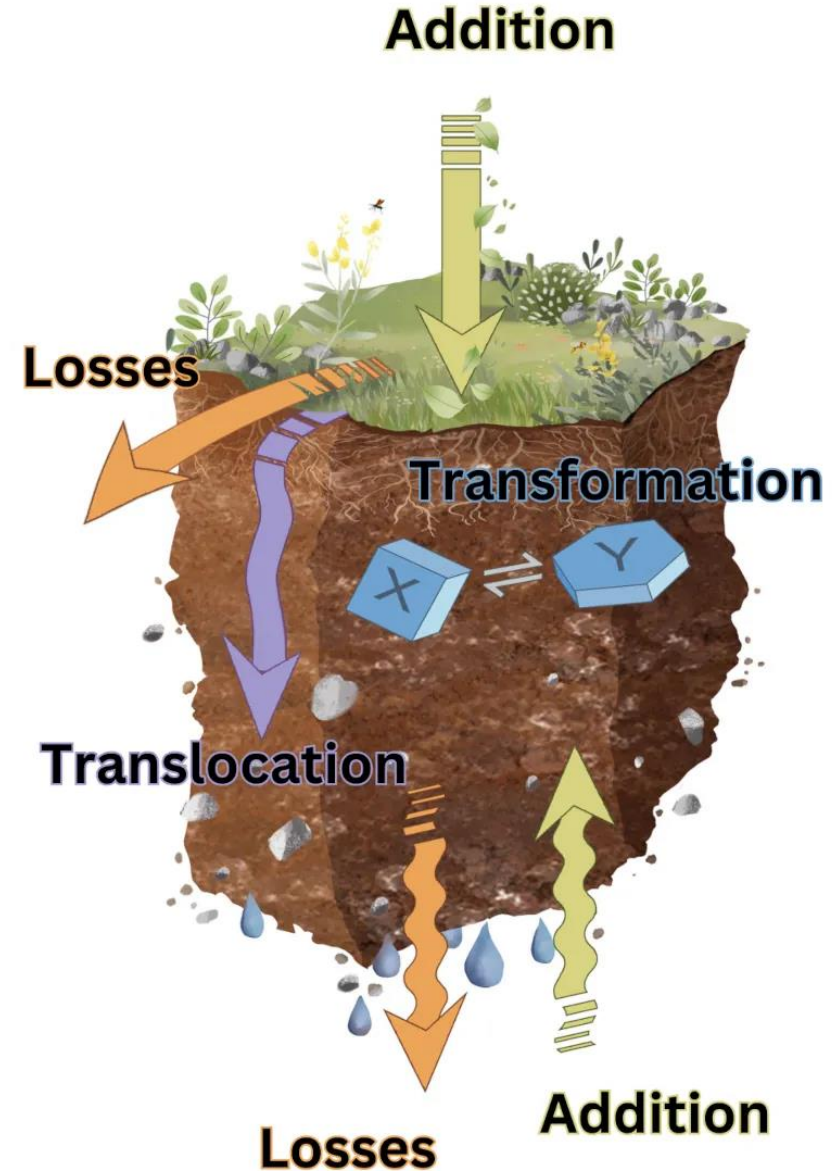


Topography

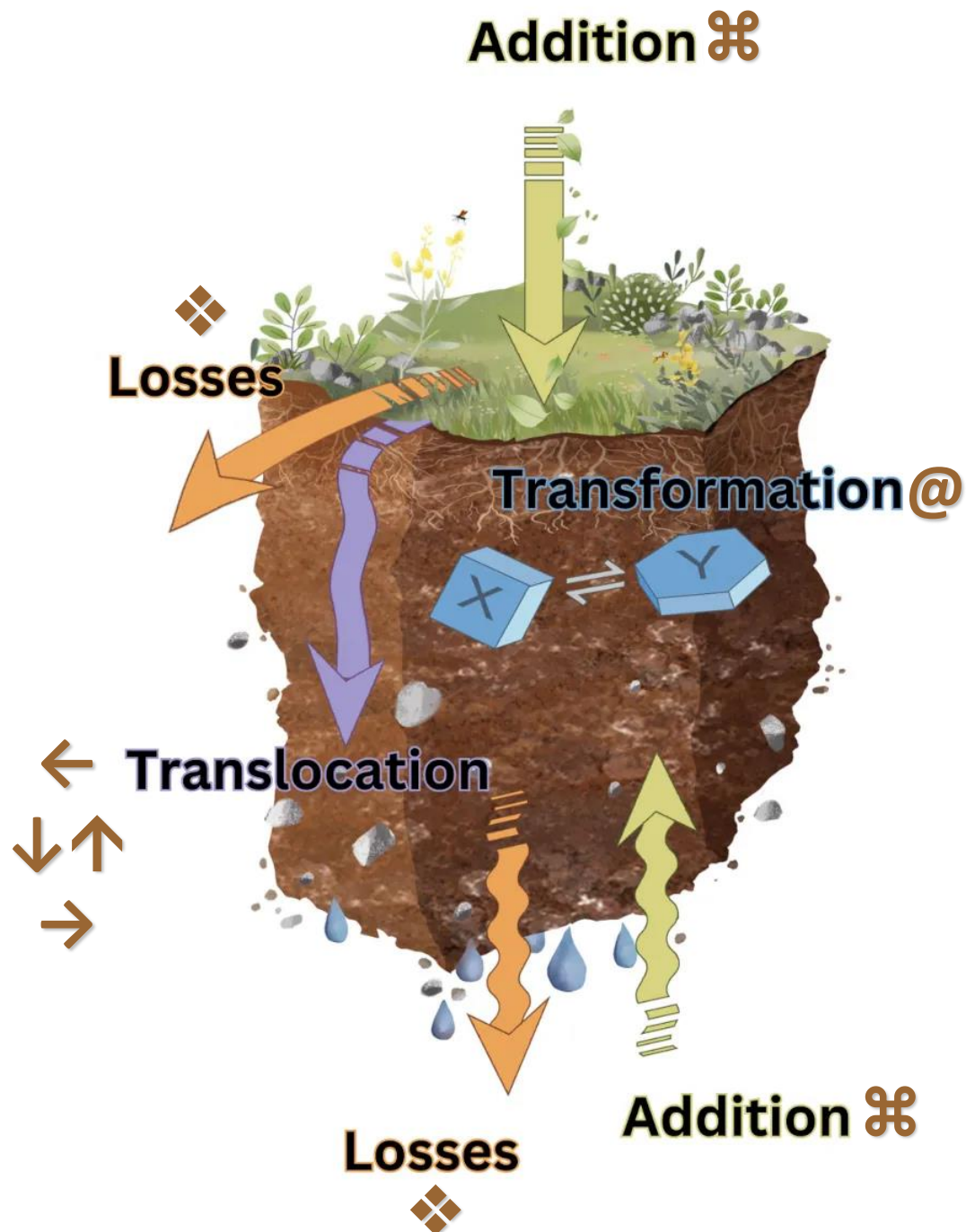


Time

Soil forming processes



Soil forming processes



- Peat formation ☒
- Humification ☒
- Weathering @
- Clay formation @
- Leaching ↓
- Clay illuviation ↓
- Salinization/sodification ↑
- Shrinking&swelling @
- Nitidization @
- Ferralitization @↓
- Plinthite formation @→←↓↑
- Gleization @→←↓↑
- Cementation @
- Soil degradation ❖
- Deposition ☒

Dominant soil-forming processes in Liberia - Intense chemical weathering

Under hot and humid conditions, mineral alteration is very strong. Primary minerals break down rapidly, releasing bases and silica. Easily weatherable minerals disappear over time.

This results in:

- Very deep weathering profiles
- Dominance of secondary clay minerals
- Accumulation of iron and aluminium oxides
- Low nutrient reserves

This process forms the foundation for most other tropical soil processes.



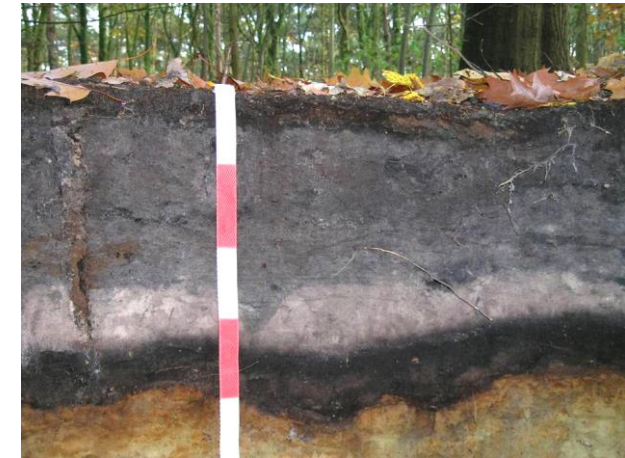
Dominant soil-forming processes in Liberia - Leaching

High rainfall causes continuous downward movement of water through the profile. Soluble bases (Ca, Mg, K, Na) and silica are progressively removed.

This leads to:

- Acidification
- Low base saturation
- Nutrient depletion
- Strong chemical differentiation

Leaching is a fundamental driver of soil development in Liberia.



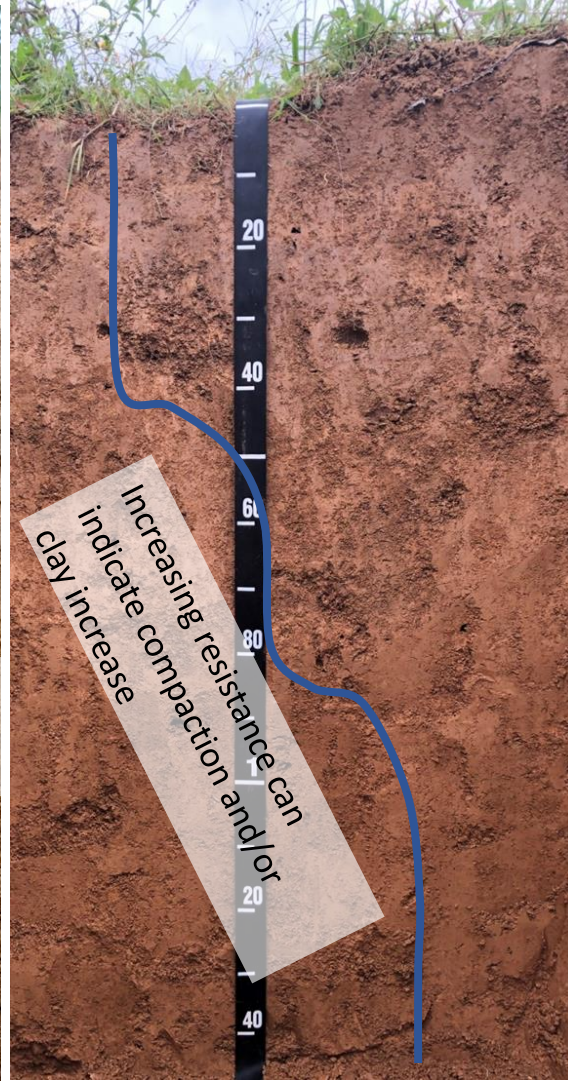
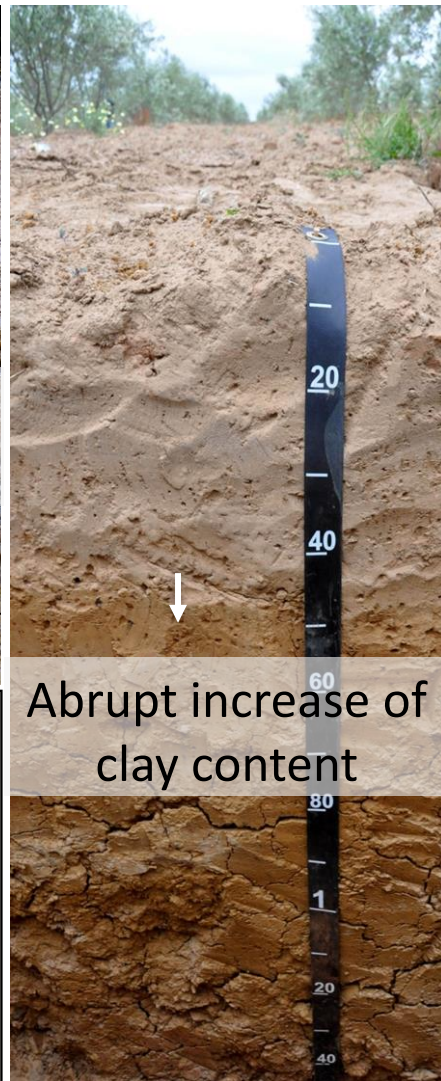
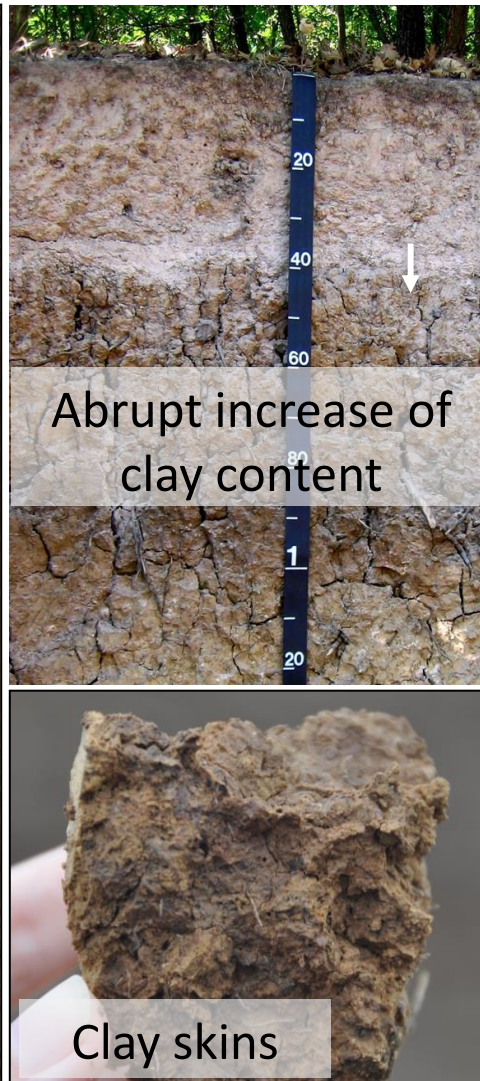
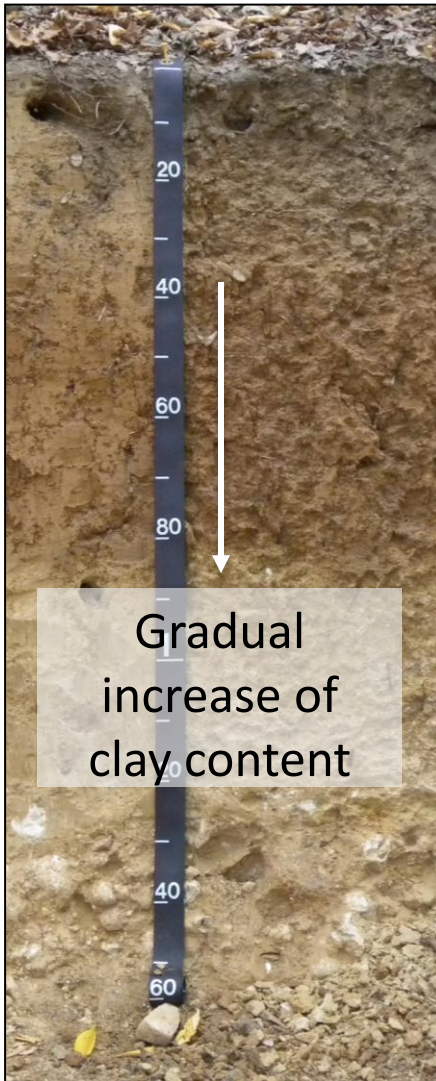
Dominant soil-forming processes in Liberia - Clay translocation

Fine clay particles are dispersed in upper horizons and transported downward with percolating water. They accumulate in subsoil horizons.

Field indicators:

- Increase in clay content with depth
- Clay coatings on ped faces
- Textural differentiation

This process leads to the development of clay-enriched subsoils.



Dominant soil-forming processes in Liberia - Humification

In Liberia's **warm and moist climate**, biological activity is very high. Plant residues decompose rapidly and are transformed into **humified organic matter**, while mineralisation also proceeds quickly.

Main effects on soils:

- formation of dark surface horizons
- accumulation of humified organic matter near the surface
- development of fine granular structure
- rapid turnover of litter and residues

Field indicators:

- dark A horizons
- fine granular or crumb structure
- thin litter layer due to rapid decomposition



Dominant soil-forming processes in Liberia - Ferrallitisation

Ferrallitisation is a **strong tropical weathering process** in which **silica and bases are progressively removed**, while **iron and aluminium oxides remain and accumulate residually**. It develops under **warm, humid conditions** with long-term leaching and intense mineral alteration.

Typical field indicators are:

- red and yellow colours
- very deep weathering profiles
- uniform clay distribution
- low cation exchange capacity
- highly weathered mineralogy

It is one of the **dominant soil-forming processes in Liberia** and produces deeply weathered tropical soils.



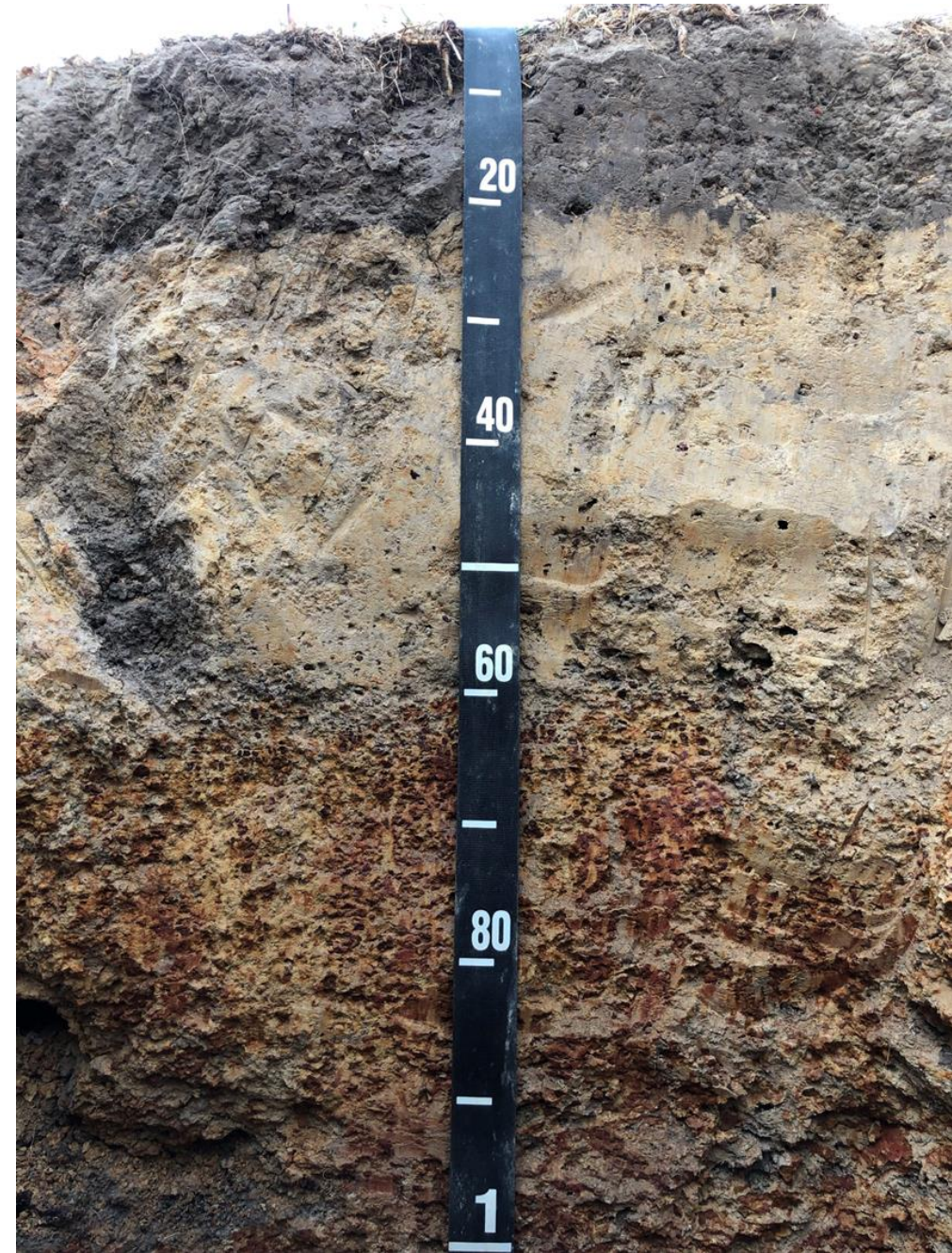
Dominant soil-forming processes in Liberia - Plinthite formation and cementation by iron

Where groundwater fluctuates or seasonal water saturation occurs, iron is mobilized and later segregated. Repeated wetting and drying cause iron concentrations to form soft plinthite, which may irreversibly harden when exposed.

Field indicators:

- Reddish mottles
- Iron nodules
- Partially hardened zones
- Iron-cemented layers

This process is common in tropical landscapes with fluctuating water tables.



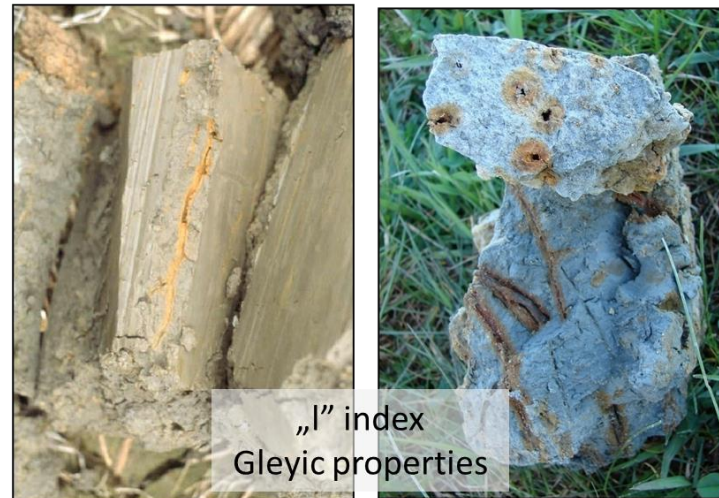
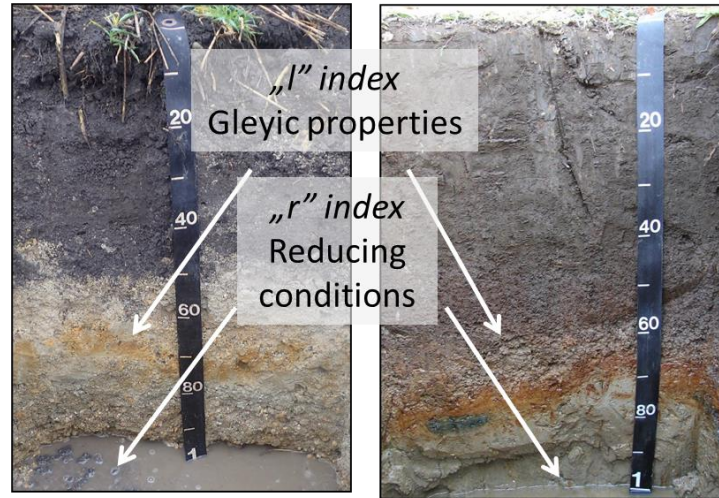
Dominant soil-forming processes in Liberia – Redox process and gleying

In poorly drained environments, oxygen becomes limited. Iron is reduced under saturated conditions and re-oxidized when oxygen returns.

Field expressions:

- Grey, bluish or greenish matrix colours
- Rusty mottles
- Redox concentrations
- Evidence of seasonal saturation

These processes are typical in valley bottoms and depressions.



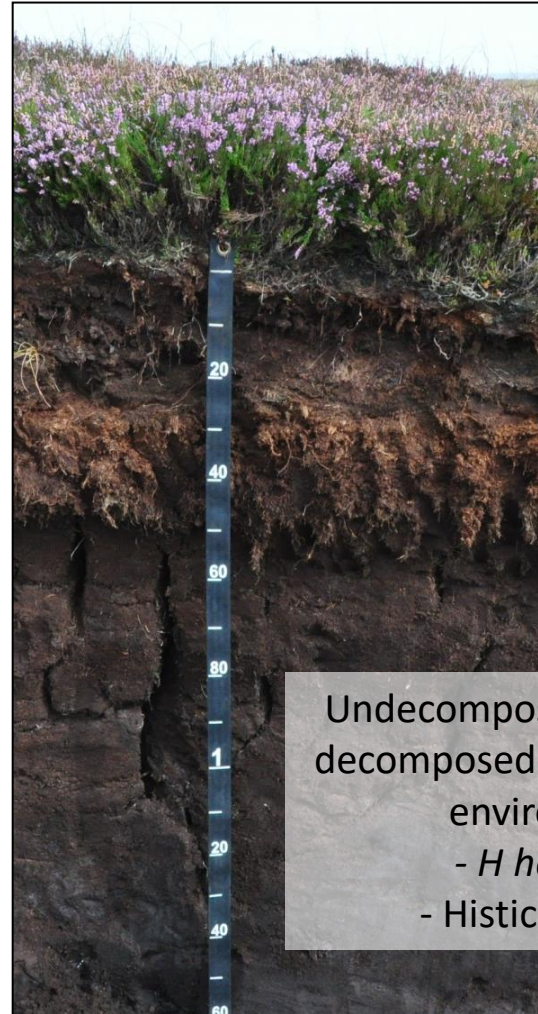
Dominant soil-forming processes in Liberia - Peat formation

In permanently saturated environments, decomposition slows down because of anaerobic conditions. Organic residues accumulate.

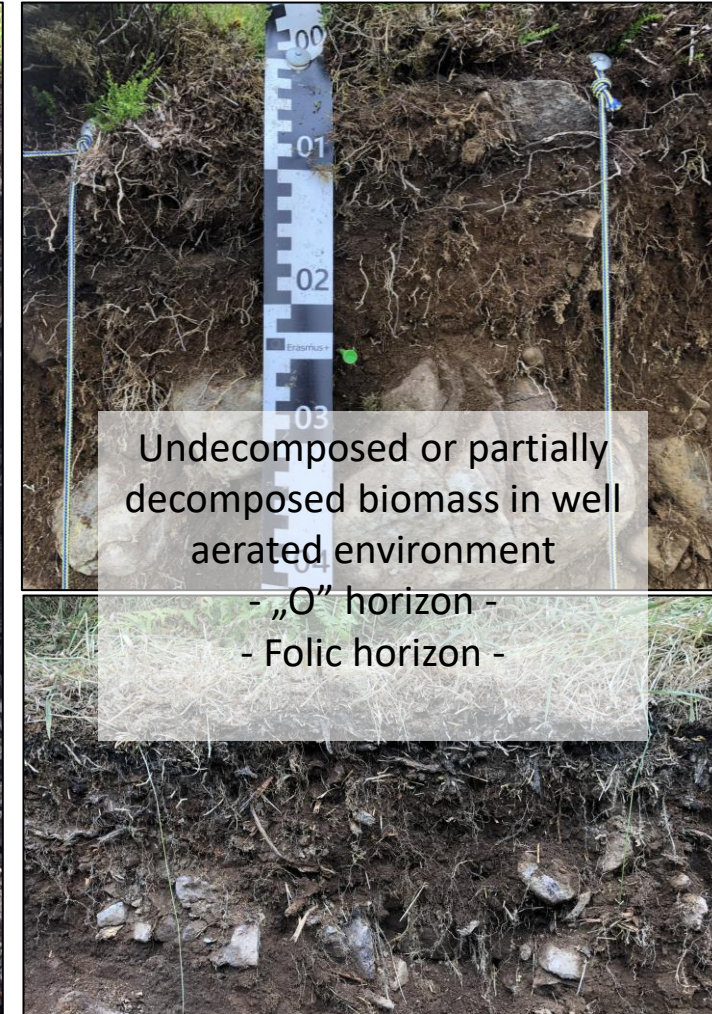
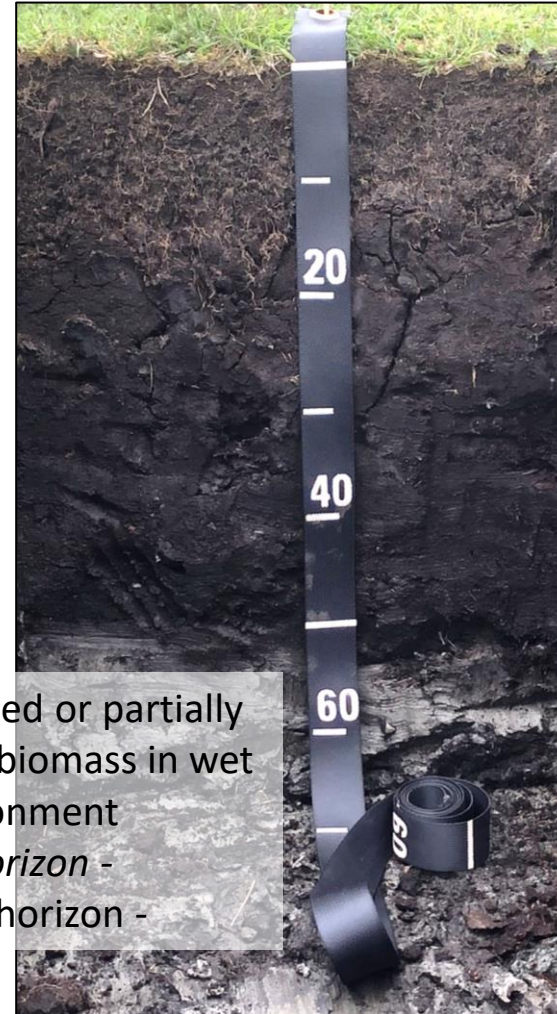
This process leads to:

- Thick organic layers
- Dark, fibrous material
- Peaty horizons

Although less common in upland humid tropics, it occurs in swamps and wetlands.



Undecomposed or partially decomposed biomass in wet environment
- *H* horizon -
- Histic horizon -



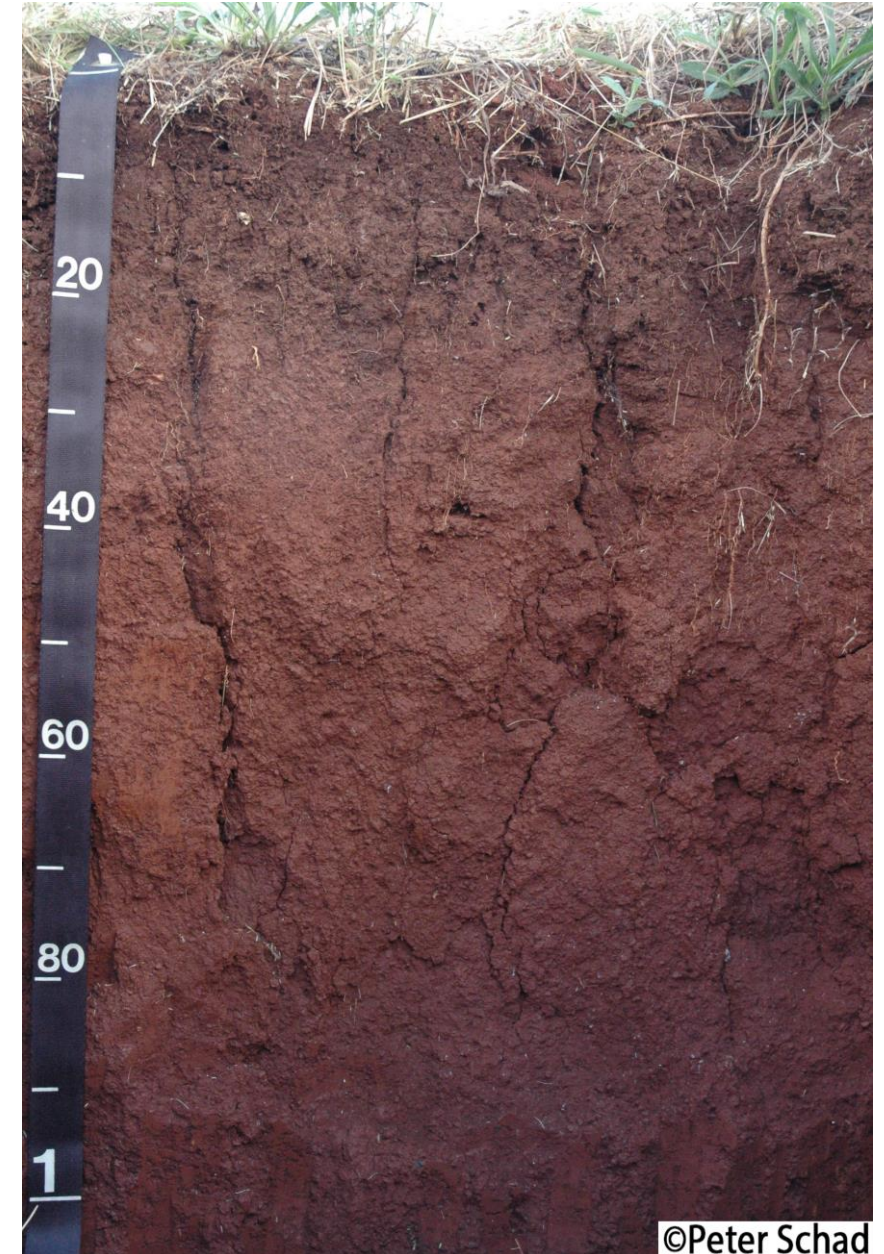
Undecomposed or partially decomposed biomass in well aerated environment
- „O” horizon -
- Follic horizon -

Dominant soil-forming processes in Liberia - Nitidization

Nitidization is a **humid-tropical soil-forming process** that produces a **stable, well-structured clay-rich subsoil** and is associated with the development of a **nitic horizon**. Typical field indicators are:

- strong, well-developed blocky structure
- shiny ped faces
- high aggregate stability
- gradual textural transitions

It reflects **long-term stable pedogenesis under warm, humid conditions**. In some landscapes, however, a nitic subsoil may show **rejuvenation**, meaning that later erosion, deposition, or slope processes partly reset the upper profile while the older nitic subsoil remains preserved.



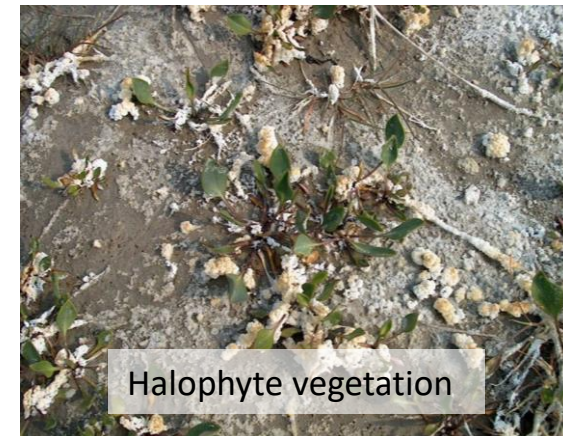
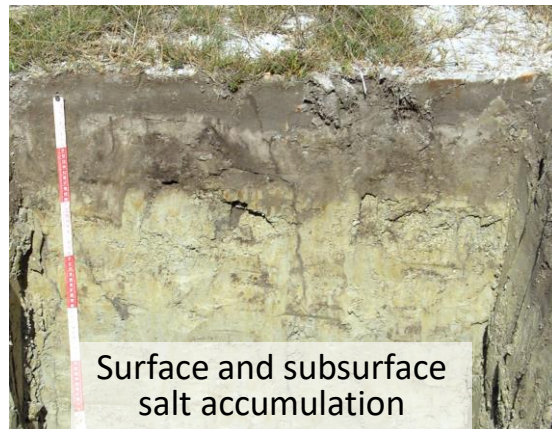
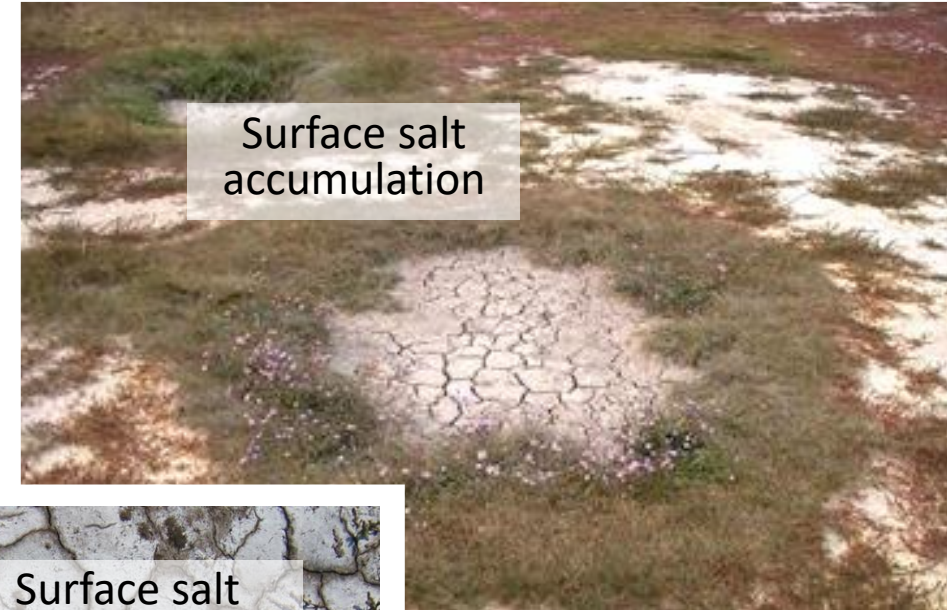
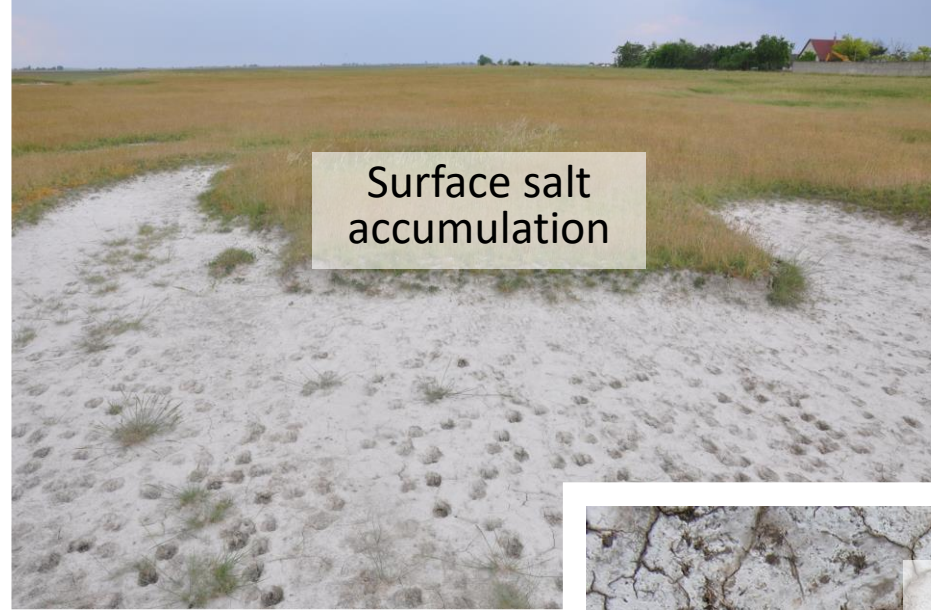
Processes That May Occur Locally in Liberia - Salinization (mainly coastal influence)

In Liberia, salinisation is **not a widespread soil-forming process**.

Because of the humid tropical climate and high rainfall, soluble salts are usually **leached out of the soil profile**.

However, **localised salinisation may occur in:**

- coastal lowlands
- estuarine environments
- tidal flats and mangrove zones
- poorly drained sites influenced by seawater or brackish water



Processes That May Occur Locally in Liberia - Sodification (coastal or marine-influenced settings)

In Liberia, sodification is **not a widespread inland process**.

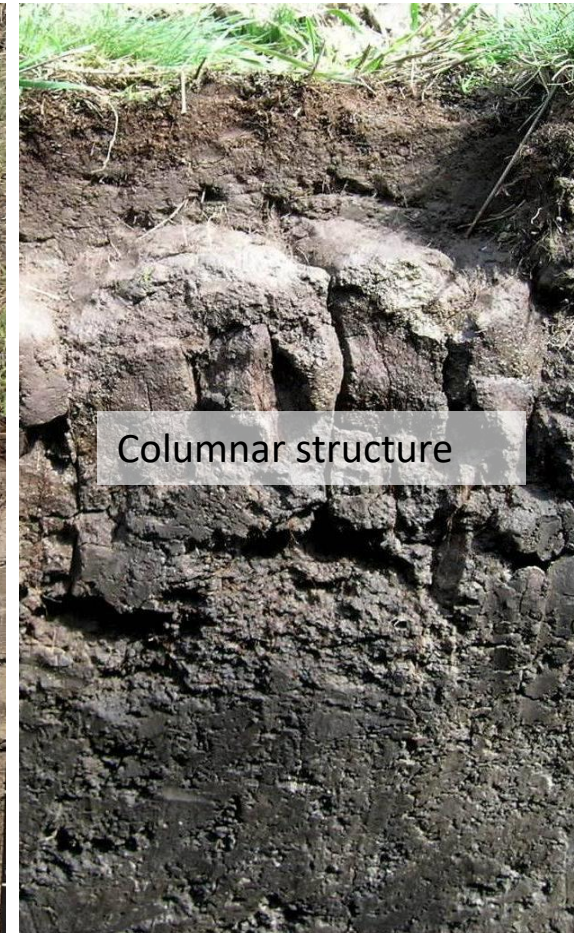
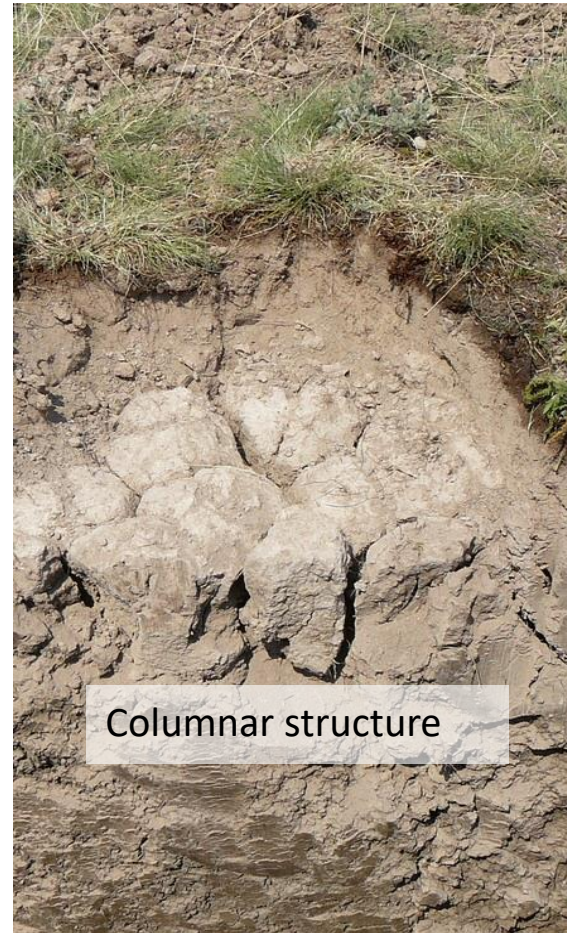
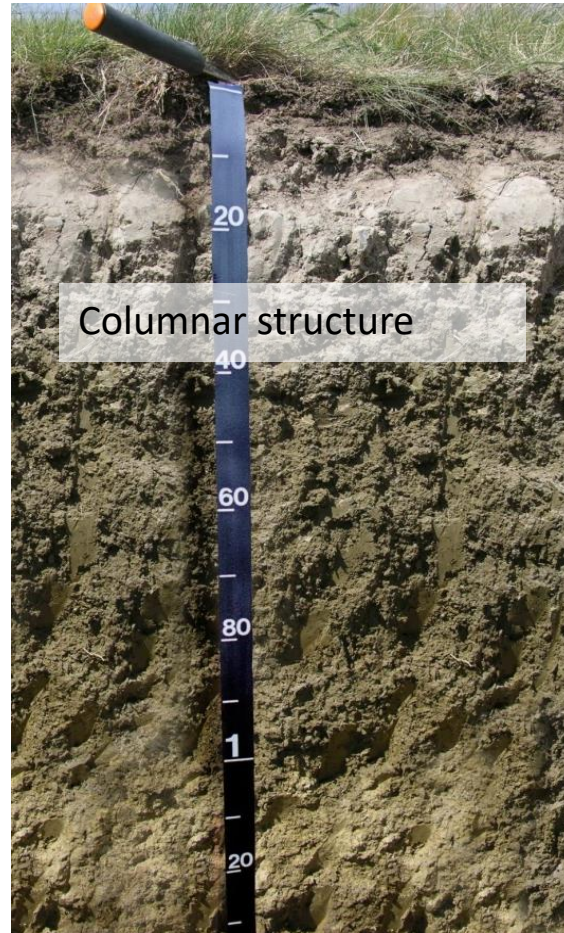
Under the country's humid tropical climate, strong leaching usually prevents large-scale accumulation of exchangeable sodium.

However, **localized sodification may occur** in:

- coastal lowlands
- estuarine environments
- marine or brackish sediment zones
- poorly drained coastal sites with saline influence

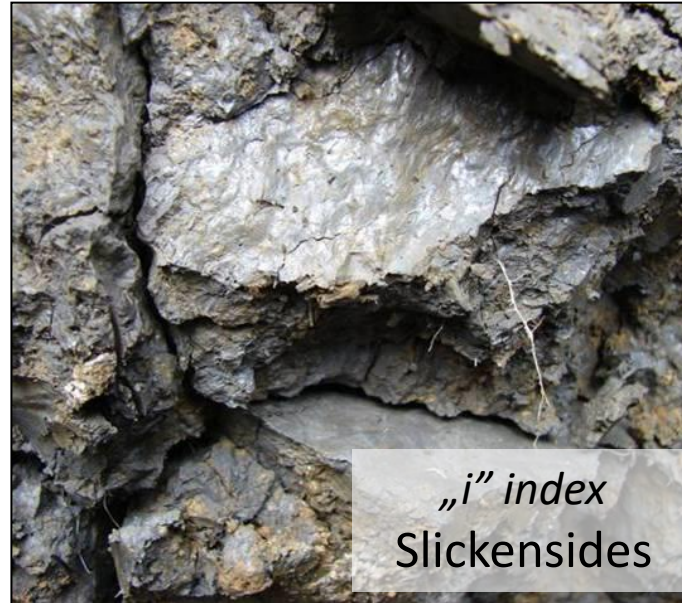
What happens:

- sodium accumulates on exchange sites
- clay may disperse
- subsoil becomes dense and poorly structured
- columnar or prismatic structure may develop



Processes That May Occur Locally in Liberia - Shrinking and swelling

In soils containing significant amounts of swelling clay minerals, repeated wetting and drying cause shrinking and swelling. This leads to surface cracks, slickensides, and wedge-shaped aggregates. While large-scale shrinking and swelling soils are unlikely in most humid tropical uplands, localized shrink–swell behaviour may occur depending on parent material.



Processes Highly Unlikely in Liberia - Accumulation of and cementation by calcium carbonate (calcification)

Under arid climates, calcium carbonate may accumulate and form calcic or petrocalcic horizons. In humid tropical Liberia, continuous leaching prevents carbonate accumulation, making such horizons highly improbable.



Processes Highly Unlikely in Liberia - Accumulation of and cementation by gypsum (gypsification)

Gypsum accumulation requires evaporative conditions exceeding precipitation. The humid tropical climate of Liberia does not favour gypsum formation.



Processes Highly Unlikely in Liberia - Accumulation of and cementation by silica (silicification)

Silica cementation is characteristic of arid to semi-arid regions. In humid tropical environments, silica is generally leached rather than accumulated.



Additional (non-pedogenetic) processes - Sedimentation (fluvial and marine deposition)

Sedimentation is the accumulation of material transported by rivers, coastal waters, or gravity. It produces **layered deposits** with **abrupt changes** in texture, colour, or coarse fragment content and may bury former soil surfaces. This process can interrupt or reset soil development and often results in weak or irregular horizon differentiation.



Additional (non-pedogenetic) processes - Colluviation (mass movement on slopes)

Colluviation is the **downslope movement** and **accumulation of soil material** under the influence of gravity, often enhanced by water. It leads to heterogeneous deposits composed of mixed material derived from upslope positions. The resulting soil profile may show irregular structure, poor sorting, and disturbed or incomplete horizon development.



Additional (non-pedogenetic) processes - Volcanic deposition (tephra/ash deposition)

Volcanic deposition is the accumulation of ash, pumice, or other volcanic ejecta that is transported through the air and deposited as a new parent material.

It can create distinct, often uniform layers that bury pre-existing soil surfaces and restart soil development from a new material.

Fresh volcanic layers may be loose and porous, and even when weathered they often remain clearly separable from underlying horizons due to their sharp boundaries and contrasting material properties.



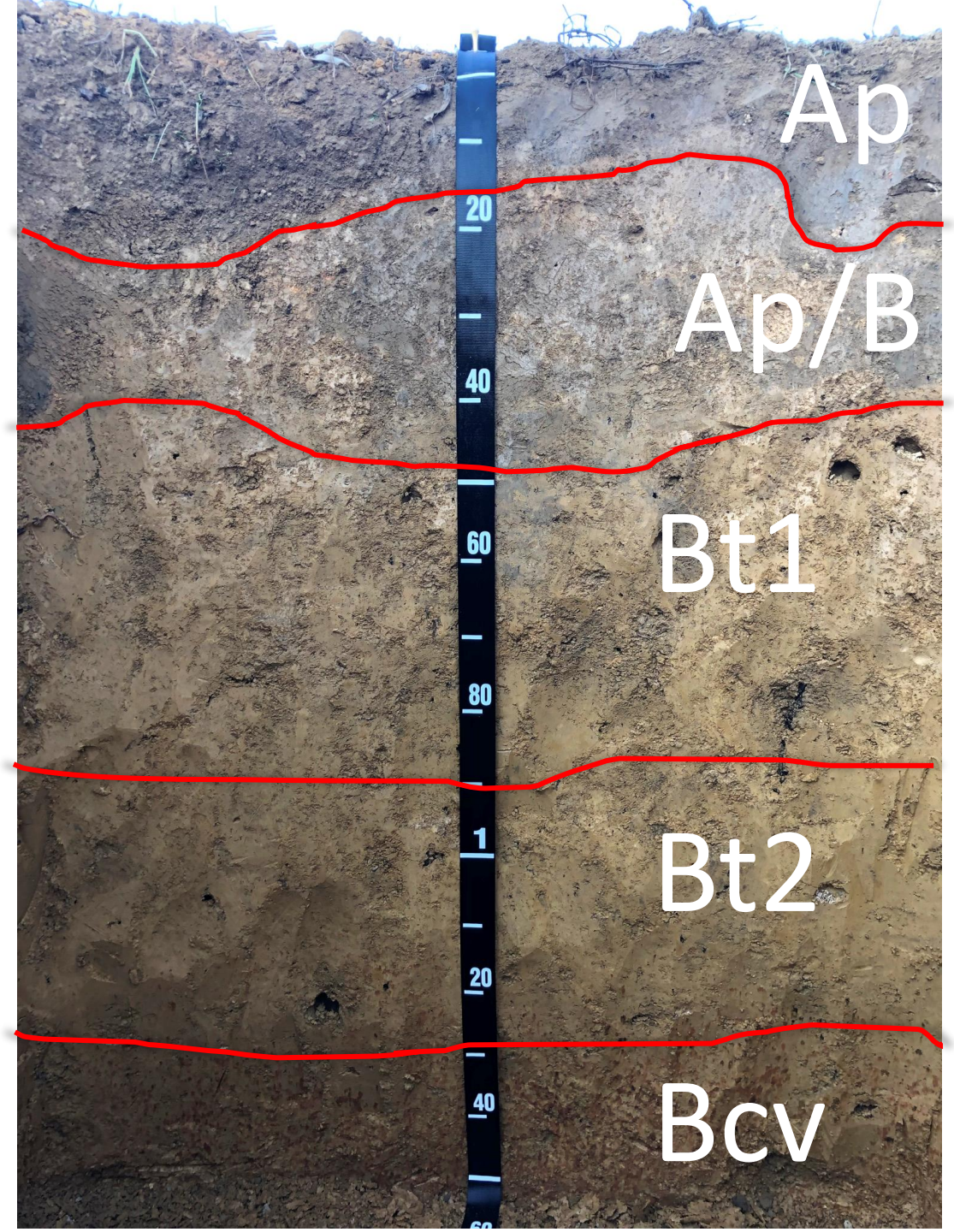
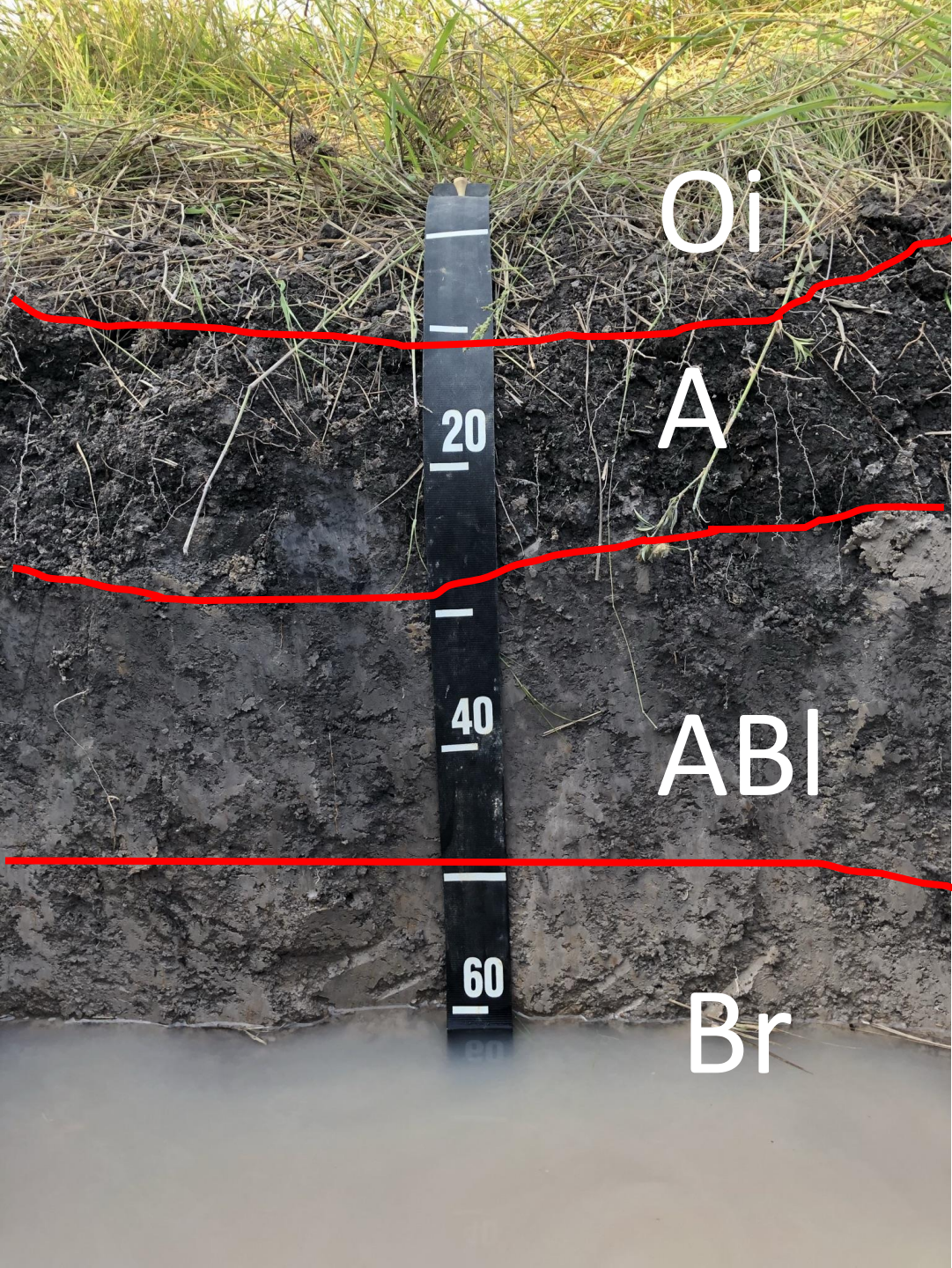
Designation of horizons and layers

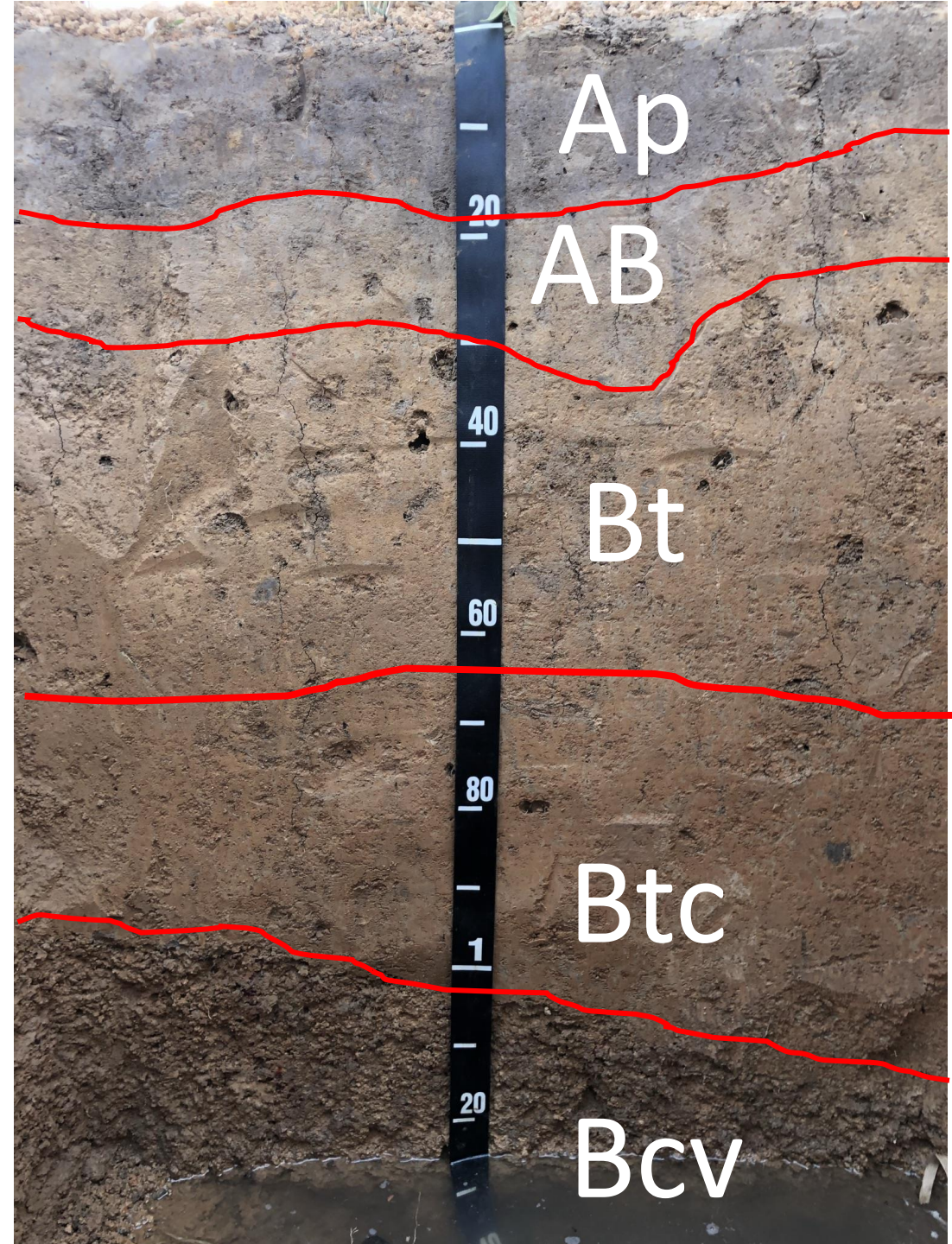
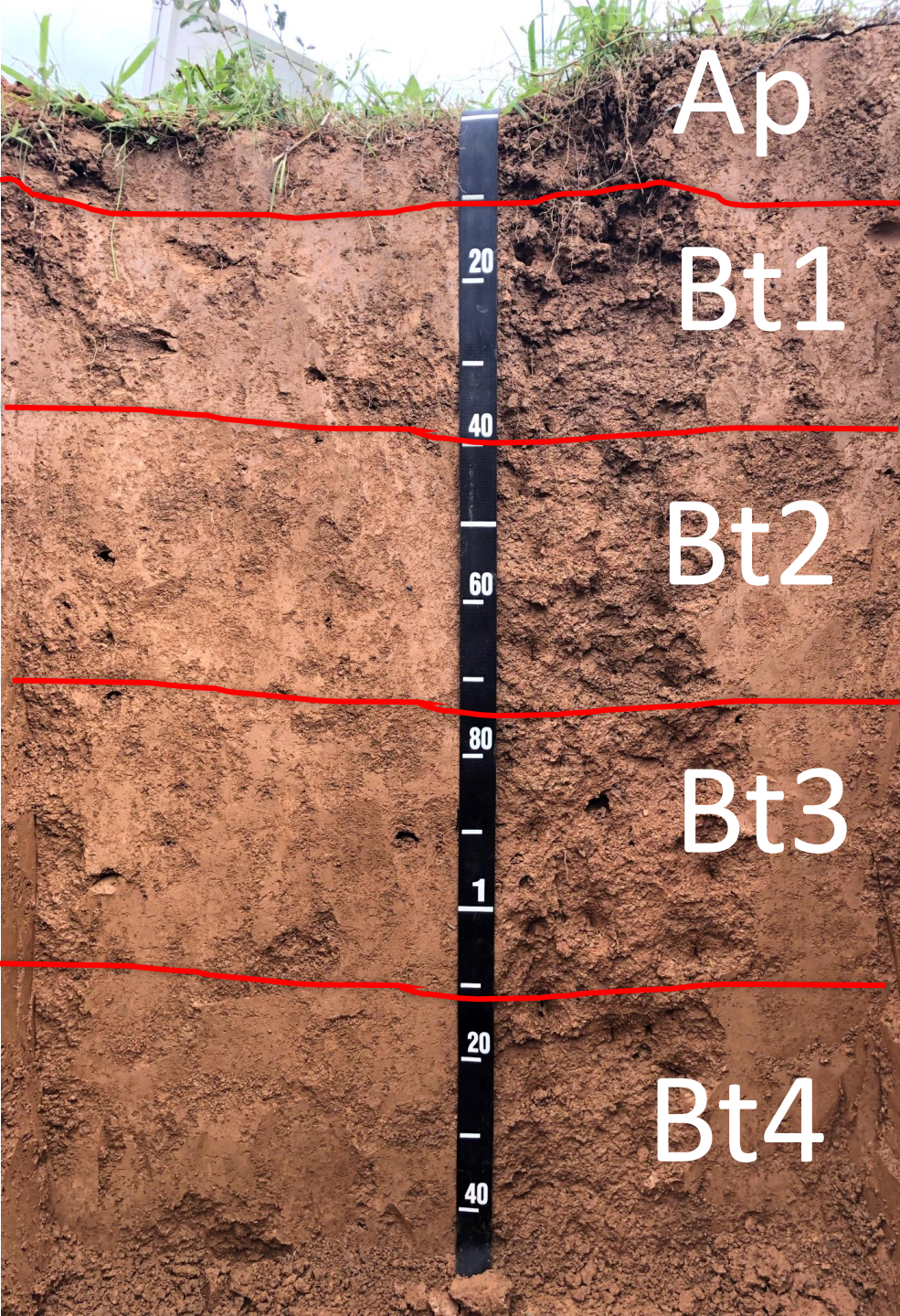
Additional (non-pedogenetic) processes - Erosion

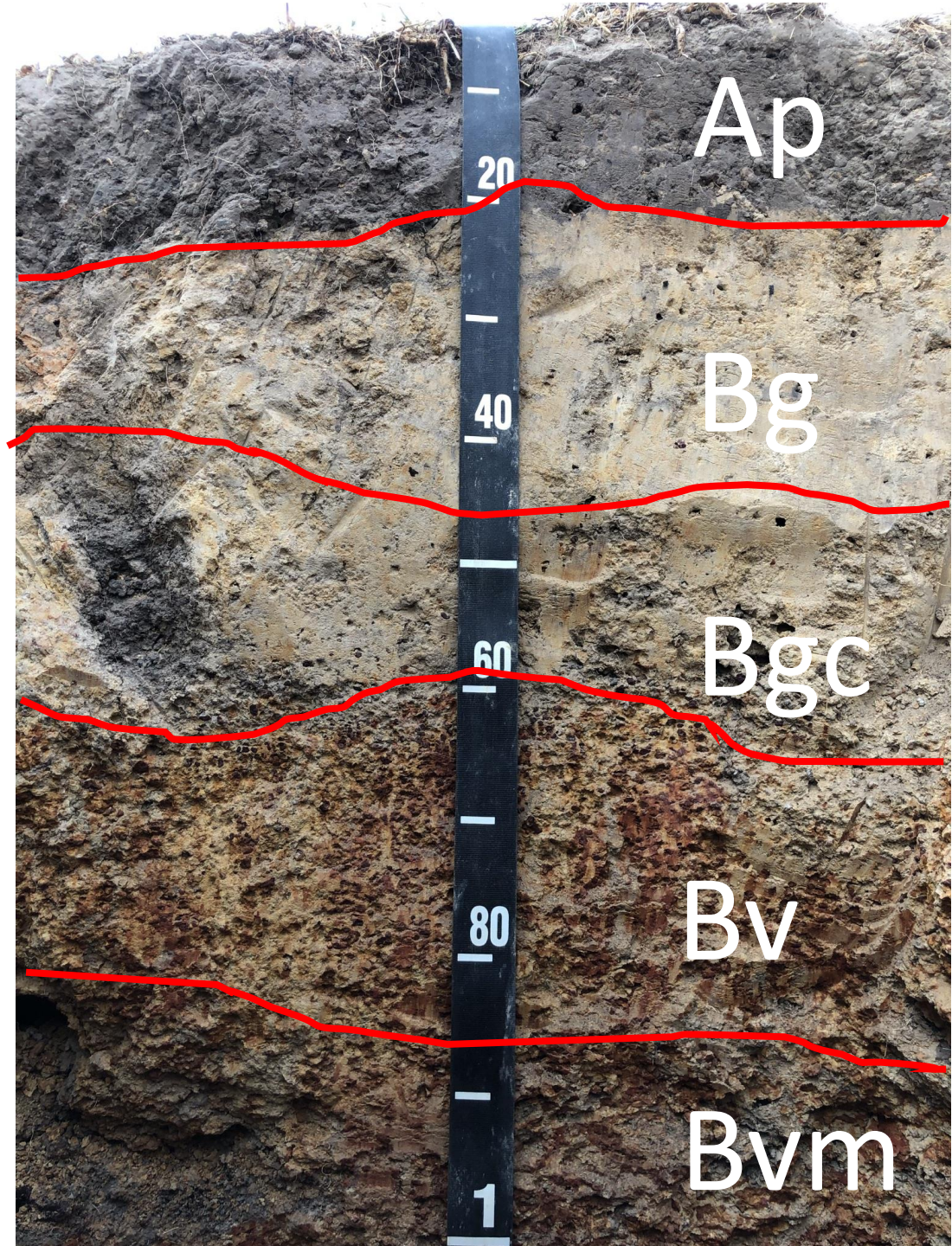
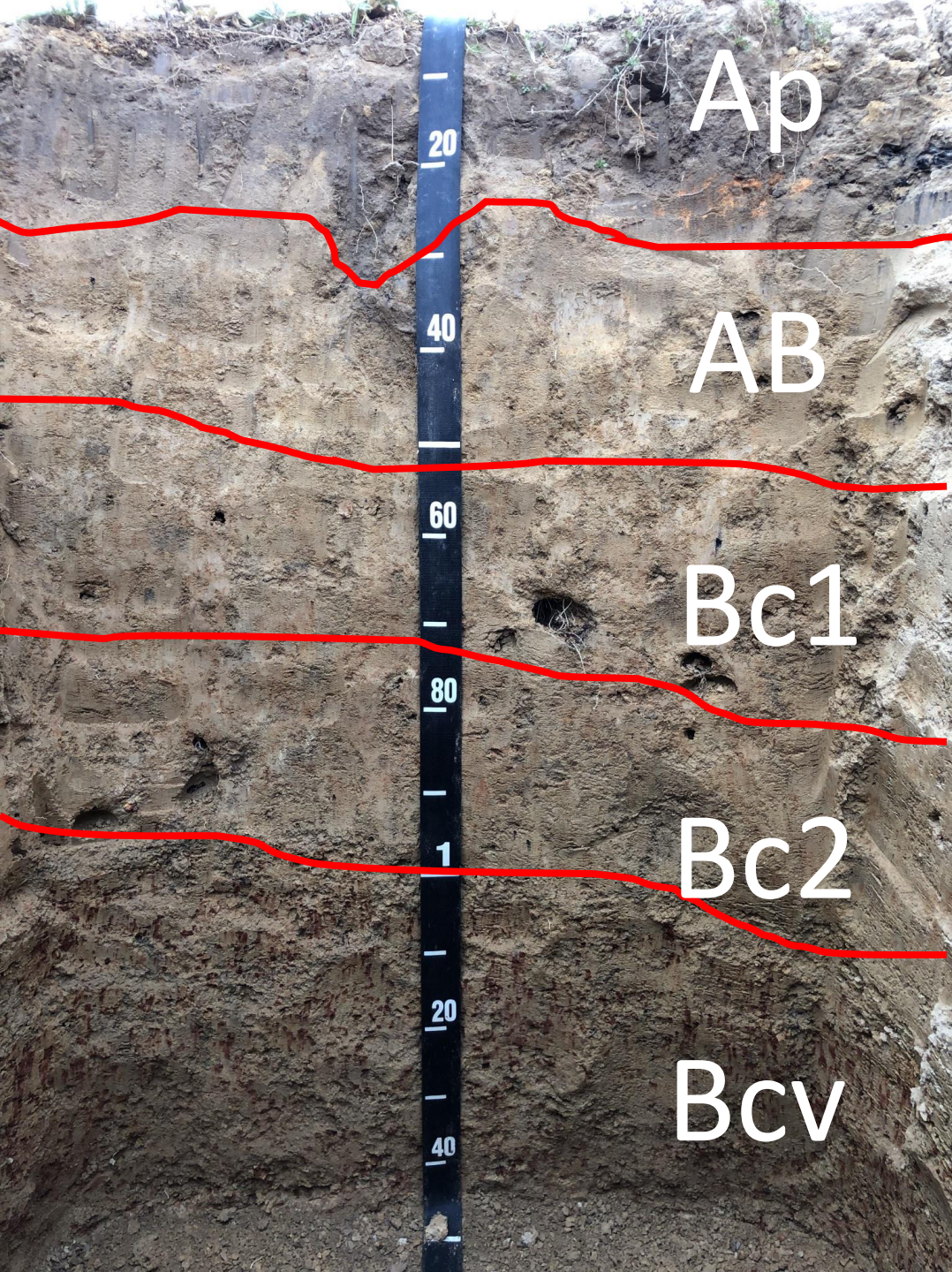
Erosion is the removal of soil material from the surface, typically caused by intense rainfall and runoff. It reduces horizon thickness, may truncate the profile, and can expose subsoil layers at the surface. Erosion alters the natural vertical development of the soil and must be recognized before interpreting pedogenic processes.

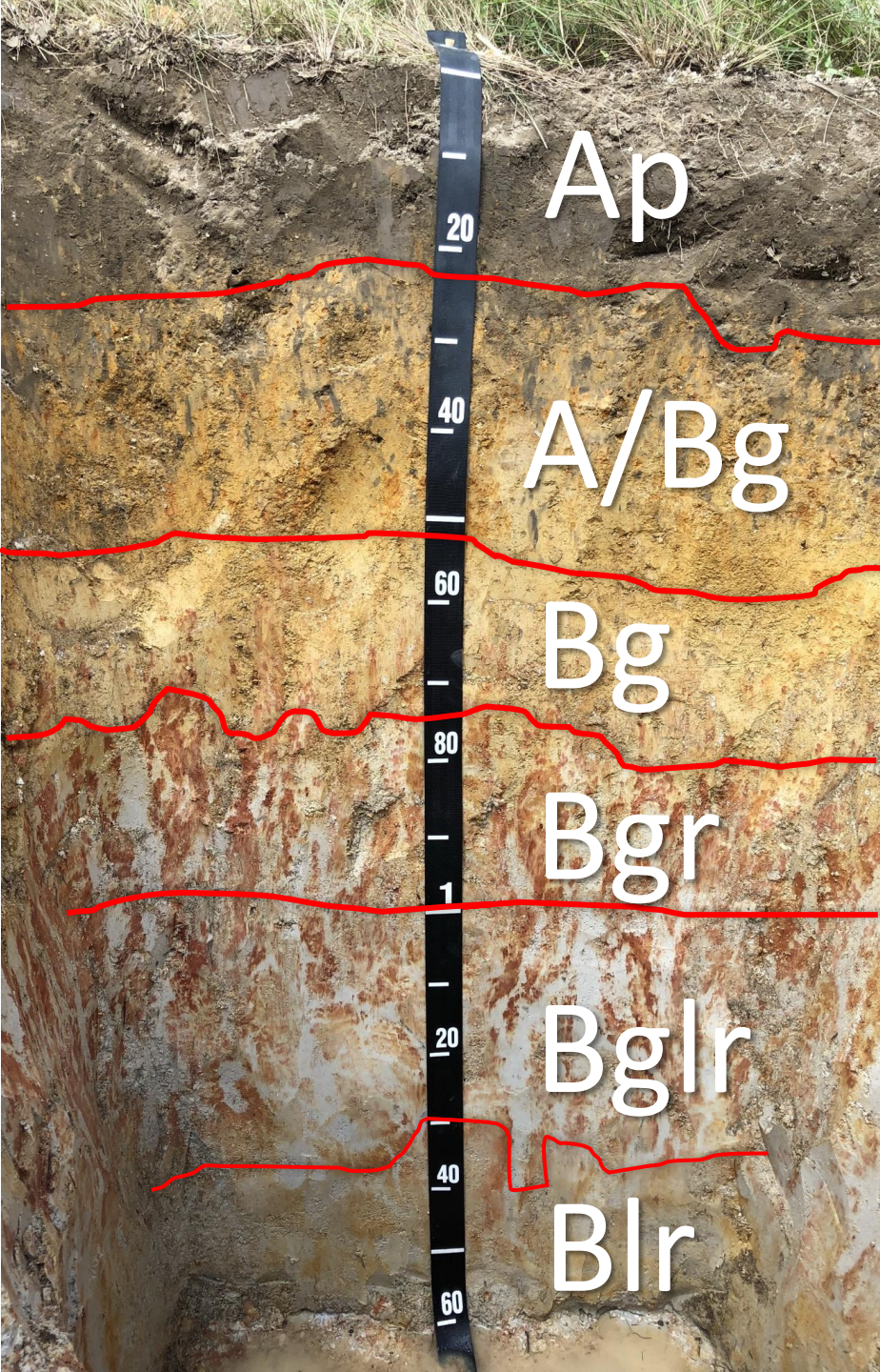


Designation of horizons and
layers









Ap

A/Bg

Bg

Bgr

Bglr

Blr

Designation of horizons and layers

Master horizons

Code	Determination
Mineral horizons	
A	Surface or near-surface mineral horizon with some organic accumulation, usually a darker colour than underlying horizons and/or smaller clay content than underlying horizons.
E	A near-surface mineral horizon characterized by a loss of clay, iron, aluminium, or some combination of these; usually lighter in color (higher value and/or lower chroma) than the overlying A and underlying B.
B	A mineral horizon characterised by one or more of the following: a concentration of clay, iron, aluminium, organic material or several of these; a structure and/or consistence unlike the horizons above and below; stronger colours (higher chroma and/or redder hue) than the horizons above and below.
C	Consolidated or unconsolidated material, usually partly weathered, little affected by pedogenic processes.
R	Hard bedrock that cannot be cut with a spade.
Organic horizons	
O	Horizons dominated by organic material consisting of undecomposed organic materials that have accumulated on the surface of either mineral or organic soils. O horizons are not saturated with water for prolonged periods.
H	These horizons dominated by organic material formed from accumulations of undecomposed or partially decomposed organic material. All H horizons are saturated with water for prolonged periods or were once saturated but are now drained artificially.

H horizon

H horizons are 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

O horizons are 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 of either mineral or organic soils;

O horizons are **not saturated with water** for prolonged periods.



A horizon

Surface or near-surface mineral horizon with some organic matter (humus) accumulation, usually with darker colour and/or smaller clay content than underlying horizons.



E horizon

A near-surface mineral horizon characterized by a **loss of clay, iron, aluminum, or some combination of these**; usually **lighter in color** (higher value and/or lower chroma) than the overlying A and underlying B.



B horizon

Mineral horizon that formed below an A, E, O or H horizon, characterised by one or more of the following:

- illuvial concentration of silicate clay, iron, aluminium, humus, carbonates, gypsum or silica (alone or in combination) ;
- accumulation of sesquioxides;
- evidence of removal of carbonates;
- a structure and/or consistence unlike the horizons above and below;
- stronger colours (higher chroma and/or redder hue) than the horizons above and below.

illuvial accumulation B horizon



transitional B horizon



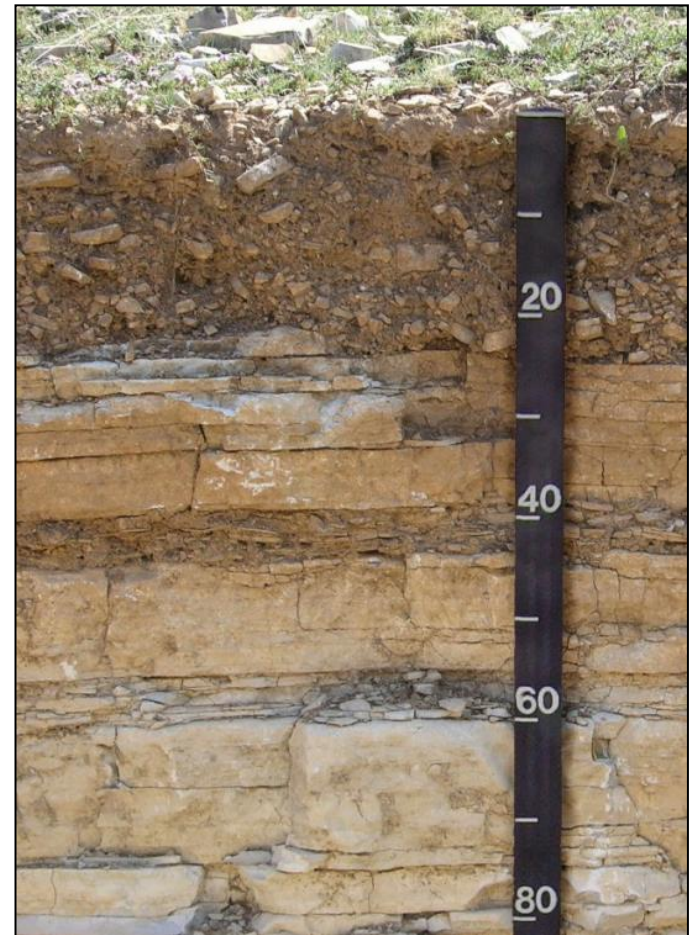
C horizon or layer

Horizons or layers, excluding hard bedrock, that are **little affected by pedogenetic processes**, and lack properties of **H, O, A, E** or **B** horizons.



R layer

Hard bedrock underlying the soil. Air-dry chunks of an R layer when placed in water will not slake within 24 hours.



Designation of horizons and layers

Transitional horizons



Transitional horizons

those with properties of two horizons
superimposed

those with the two properties
separate

For horizons dominated by properties of one master horizon but having subordinate properties of another
i.e. AB, EB, BE or BC

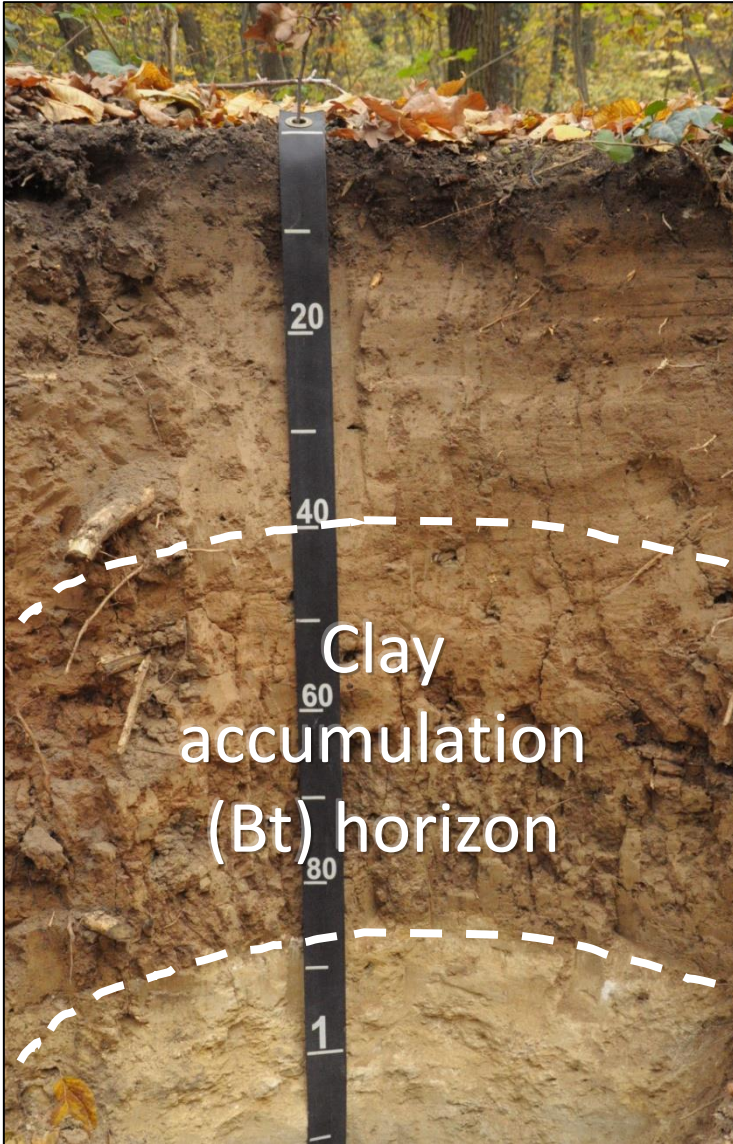
When distinct parts have recognizable properties of two kinds of master horizons
i.e. E/B, B/E, B/C or C/R

The dominant horizon' symbol is the first



Designation of horizons and layers

Vertical subdivisions



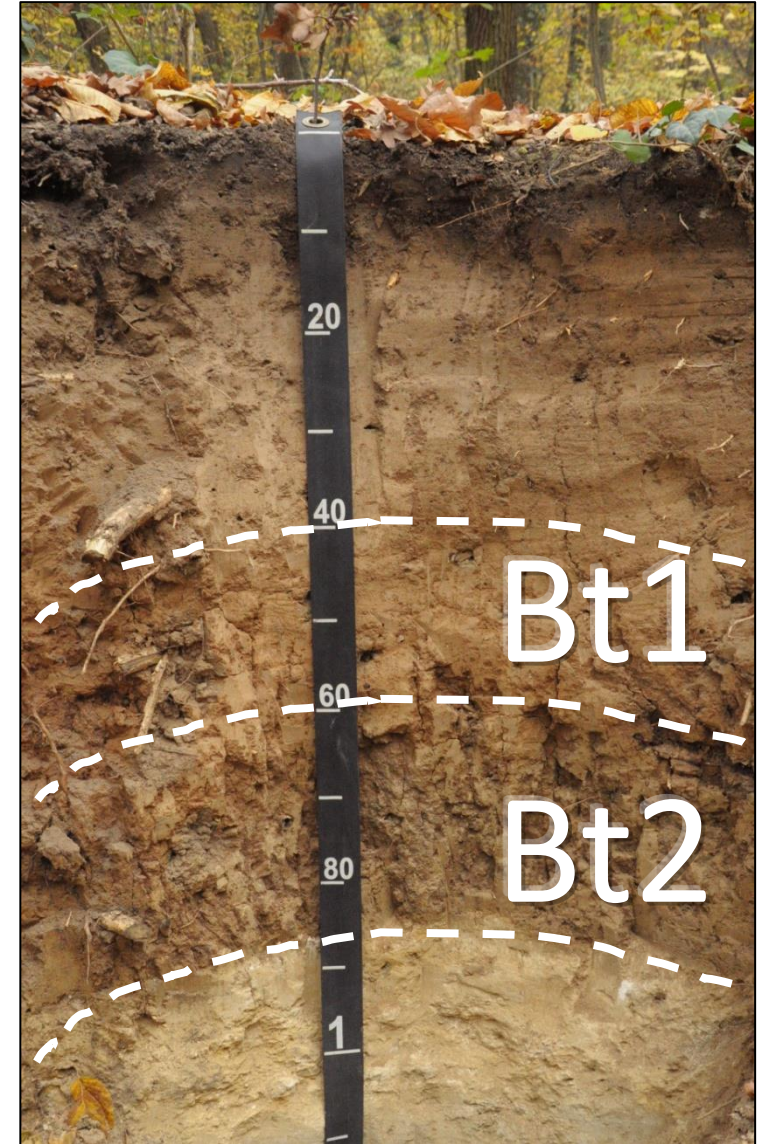
A horizon or layer may be **subdivided vertically** when clear morphological differences are visible within the same horizon.

Subdivisions are based on features such as:

- colour
- structure
- texture
- consistence

How to write them

- Use **Arabic numerals after all letters**
- number them **consecutively downward**
- numbering starts with **1** at whatever level subdivision begins



Designation of horizons and layers

Discontinuities



Discontinuities

In mineral soils, Arabic numerals are used as prefixes to indicate discontinuities.

Numbering starts with the second layer of contrasting material, which is designated „2“. Underlying contrasting layers are numbered consecutively.

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.

In organic soils, discontinuities between different kinds of layers are not identified.



Designation of horizons and layers

Subordinate characteristics

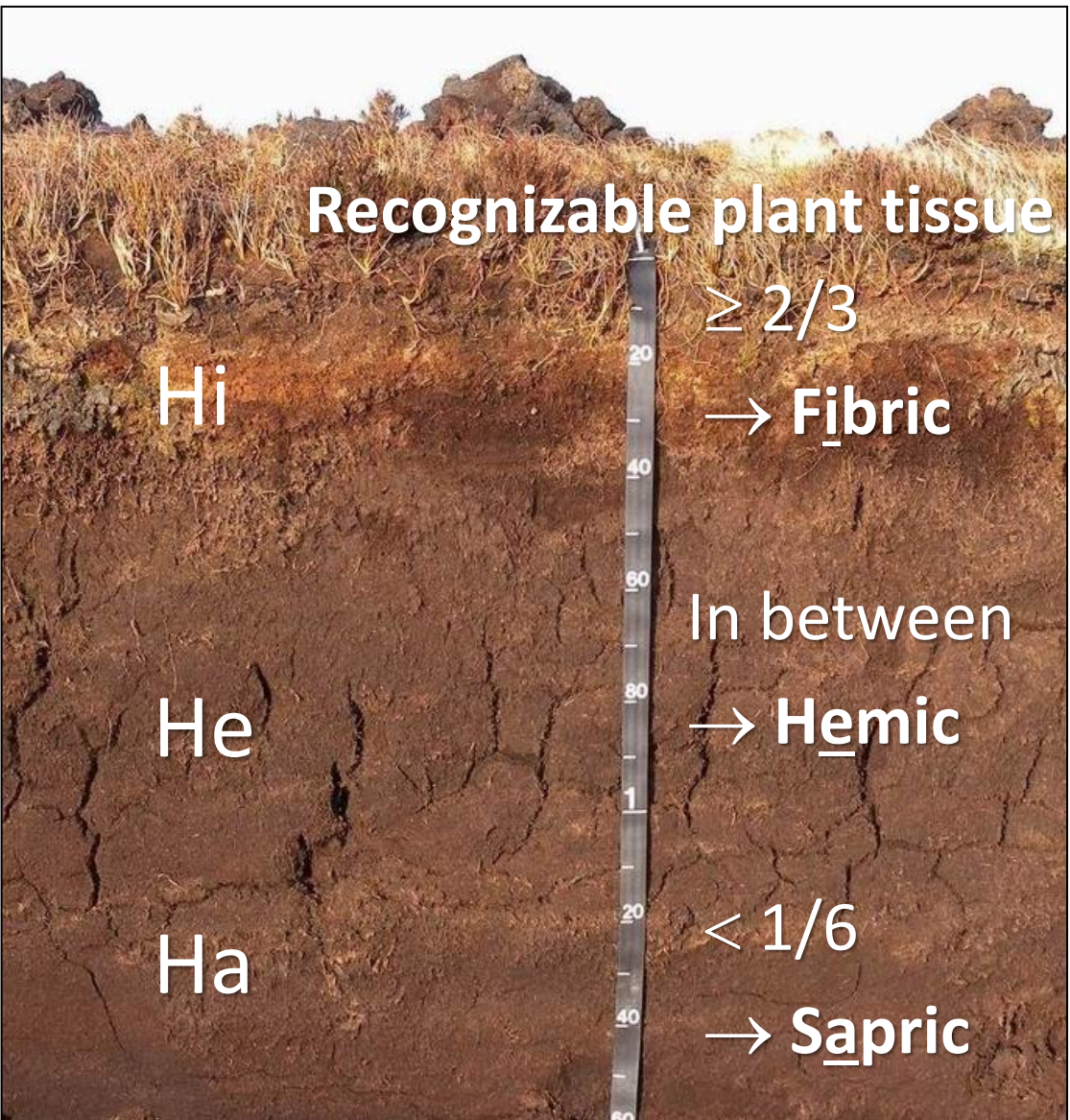
Suffix	Short description	Used for
a	Highly decomposed organic material	H and O horizons
b	Buried genetic horizon	mineral horizons
c	Concretions or nodules	mineral horizons
d	Dense layer (physically root restrictive)	mineral horizons, not with m
e	Moderately decomposed organic material	H and O horizons
g	Stagnic conditions	no restriction
h	Illuvial accumulation of organic matter	mineral horizons
l (FAO) ss (USDA)	Slickensides	mineral horizons
i	Slightly decomposed organic material	H and O horizons
l	Capillary fringe mottling (gleying)	no restriction
m	Strong cementation or induration (pedogenetic, massive)	mineral horizons
n	Pedogenetic accumulation of exchangeable sodium	no restriction
p	Ploughing or other human disturbance	no restriction, E, B or C as Ap
r	Strong reduction	no restriction
s	Illuvial accumulation of sesquioxides	B horizons
t	Illuvial accumulation of silicate clay	B 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
z	Pedogenic accumulation of salts more soluble than gypsum	no restriction

Suffix	Short description	Used for
a	Highly decomposed organic material	H and O horizons
e	Moderately decomposed organic material	H and O horizons
i	Slightly decomposed organic material	H and O horizons

a. Highly decomposed organic material has less than one-sixth (< 15 % by volume) visible plant remains.

e. Moderately decomposed organic material has between one-sixth and two thirds (15 – 65 % by volume) visible plant remains

i. Slightly decomposed organic material has in more than two-thirds (> 65 % by volume) visible plant remains.



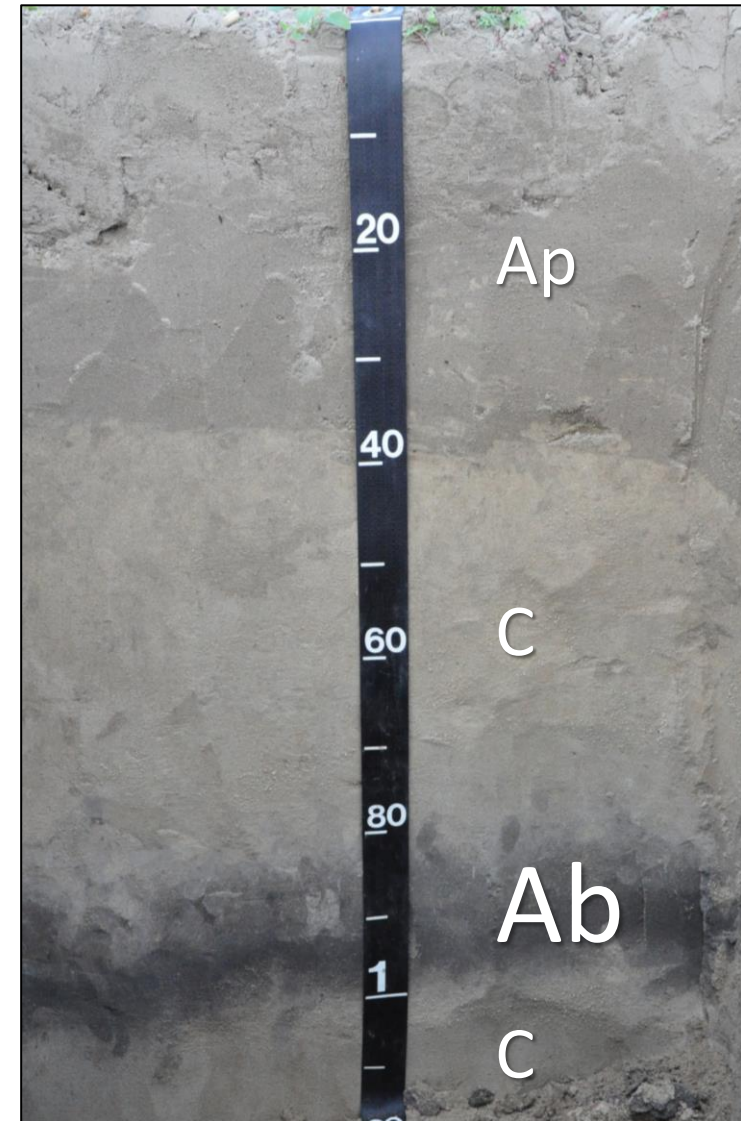
Suffix	Short description	Used for
b	Buried genetic horizons	mineral horizons

The suffix **b** denotes a **buried genetic horizon** in mineral soils.

It indicates that:

- a former soil horizon developed at an older land surface
- that horizon was later covered by younger material
- The buried horizon is still recognisable in the profile

The suffix **b** shows an **older soil horizon preserved below younger deposits.**



Suffix	Short description	Used for
c	Concretions or nodules	mineral horizons

The suffix **c** is used for **concretions or nodules** in mineral horizons.

These are:

- discrete concentrations of secondary mineral material
- clearly distinguishable from the surrounding soil matrix
- usually harder and more compact than the surrounding material

They may include:

- iron-rich nodules
- manganese-rich nodules
- other mineral concretions



Suffix	Short description	Used for
d	Dense layer (physically root restrictive)	mineral horizons

The suffix **d** is used for a **dense, physically root-restrictive layer** in mineral horizons.

Typical characteristics:

- very firm or compact material
- strong resistance to root penetration
- restricted pore space
- difficult movement of water and air
- roots concentrated above cracks or weak zones

Important:

Use **d** for a dense layer, but **not** when the horizon is cemented or indurated — that would be **m**.



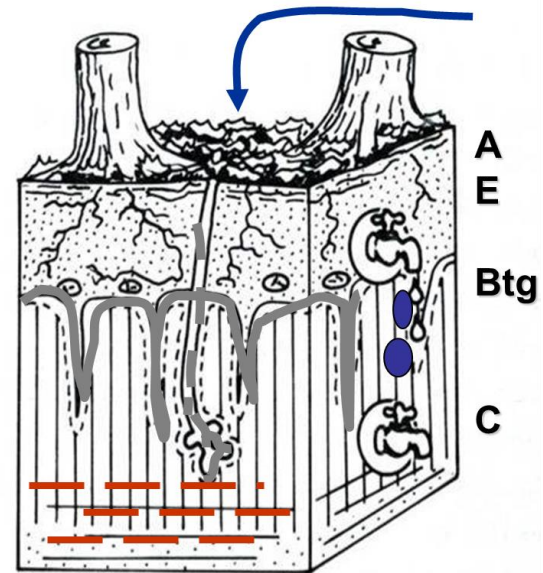
Suffix	Short description	Used for
g*	Stagnic conditions / *USA strong gley	no restriction

Typical indicators:

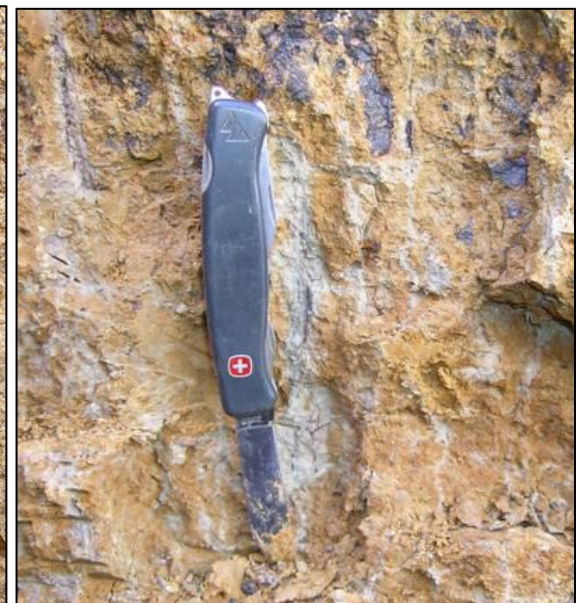
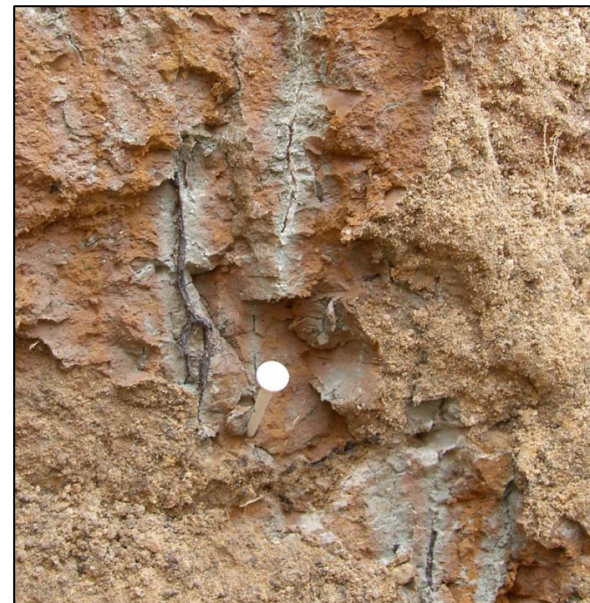
- grey, bluish, or pale matrix colours
- rusty mottles or redox concentrations
- signs of periodic or prolonged wetness
- reduced drainage conditions

What it means

- iron has been reduced and redistributed under wet conditions



Stagnic colour pattern



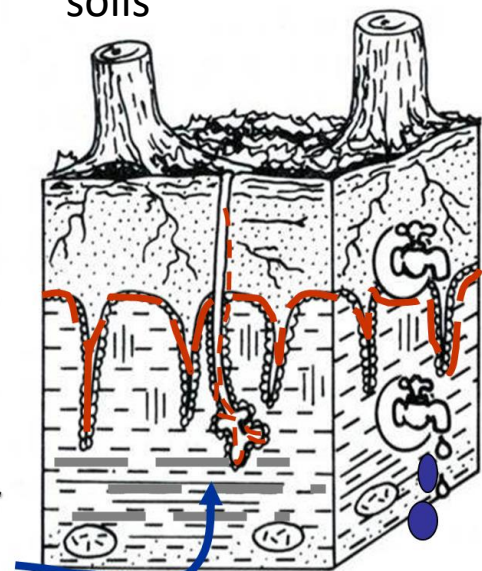
Suffix	Short description	Used for
I	Capillary fringe mottling (gleying)	no restriction

It reflects:

- influence of **shallow groundwater**
- wetness in the **capillary fringe**
- **partial or weak reduction conditions**

What this means in soil

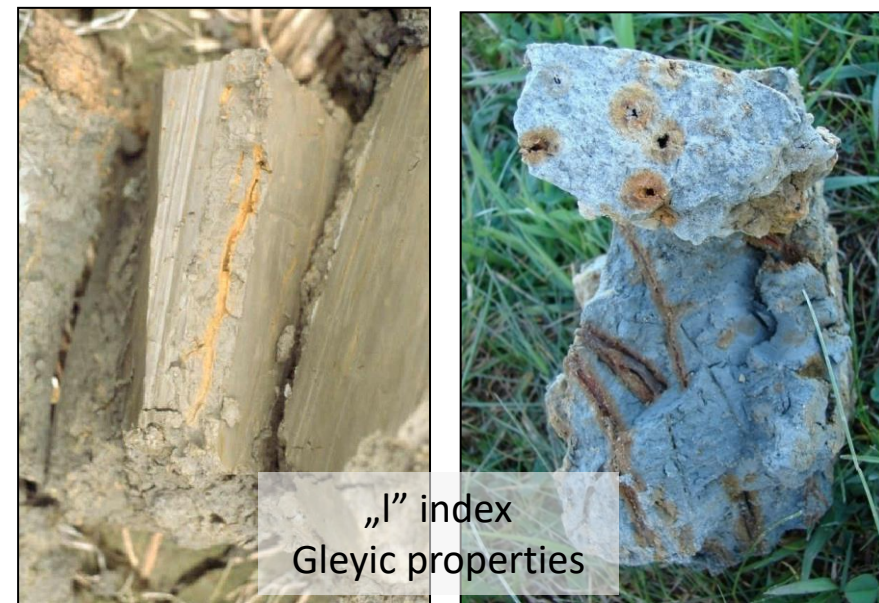
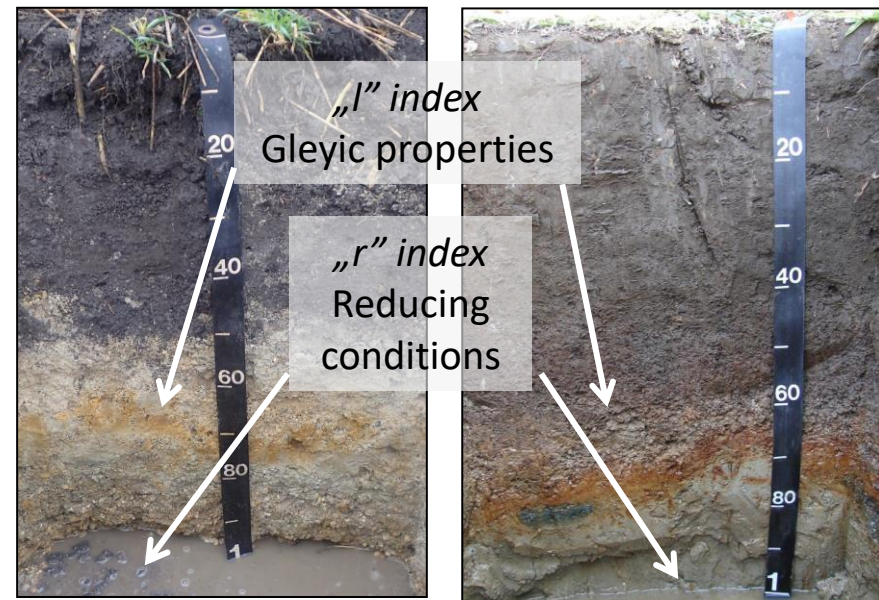
- water rises from below (not only from above)
- soil is affected by moisture but not always fully saturated
- weaker redox expression than in strongly reduced soils



Gleyic colour pattern

Field indicators

- greyish or pale zones
 - mottling near the groundwater zone
 - signs of periodic wetness from below
- often near the lower part of the profile



Suffix	Short description	Used for
r*	Strong reduction *only in FAO	no restriction

Typical characteristics:

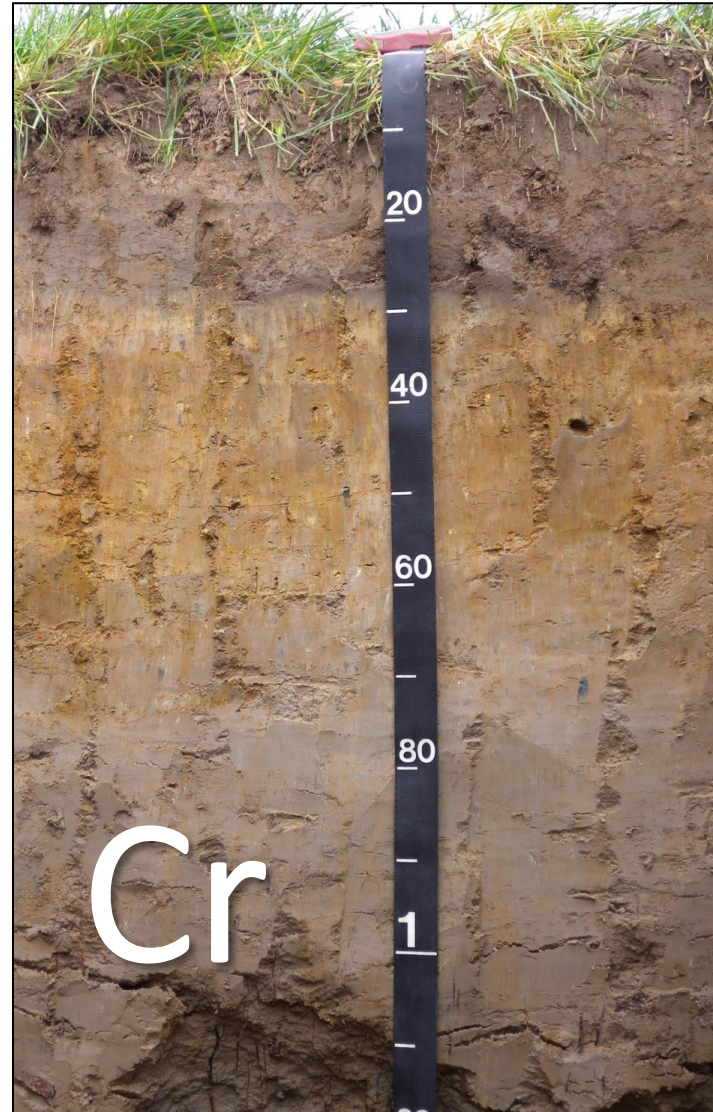
- very low oxygen conditions
- prolonged water saturation
- strongly reduced matrix
- grey, bluish, or dark reduced colours
- often associated with groundwater influence or permanent wetness

What it means

- iron is strongly reduced and mobilised
- The horizon reflects persistent anaerobic conditions

Key idea:

The suffix **r** indicates **strong reducing conditions**, not just general wetness.



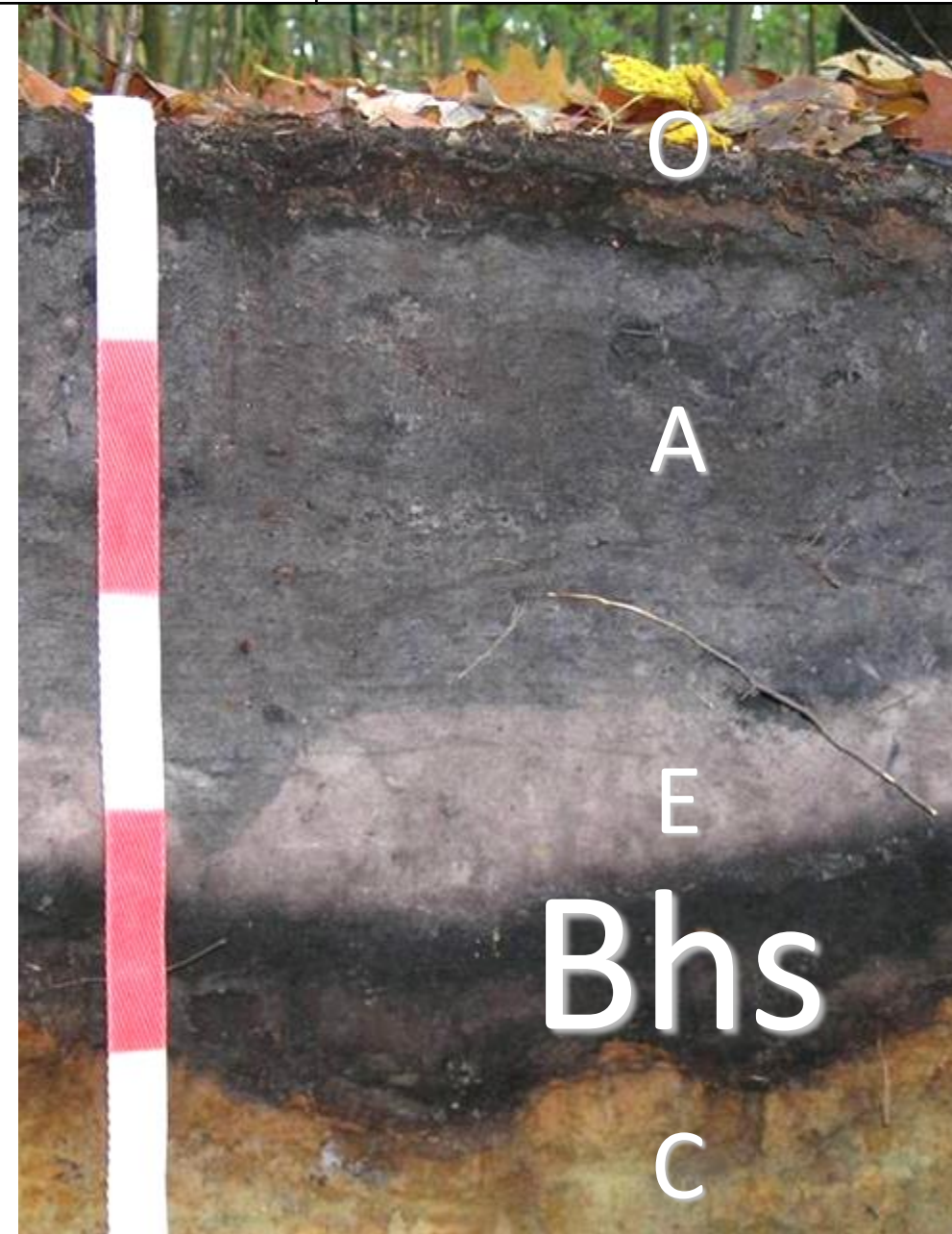
Suffix	Short description	Used for
h	Illuvial accumulation of organic matter	mineral horizons

Typical characteristics:

- dark subsurface horizon
- organic matter moved downward from upper horizons
- accumulation below an O, A, or E horizon

Common example

- **Bh** — B horizon enriched with illuvial organic matter
- **Bhs** — B horizon enriched with organic matter and sesquioxides



Suffix	Short description	Used for
i/*ss	Slickensides / *USA	mineral horizons

Slickensides are:

- polished, shiny slip surfaces
- formed by repeated **shrinking and swelling**
- produced by movement of clay-rich soil masses against each other

What this means

- the soil contains **shrink–swell clay behaviour**
- the horizon has been affected by internal soil movement
- strong volume change occurs between wet and dry conditions

Typical field indicators

- shiny, pressure-polished ped faces
- grooved or striated slip surfaces
- wedge-shaped or distorted aggregates
- deep cracks in dry periods



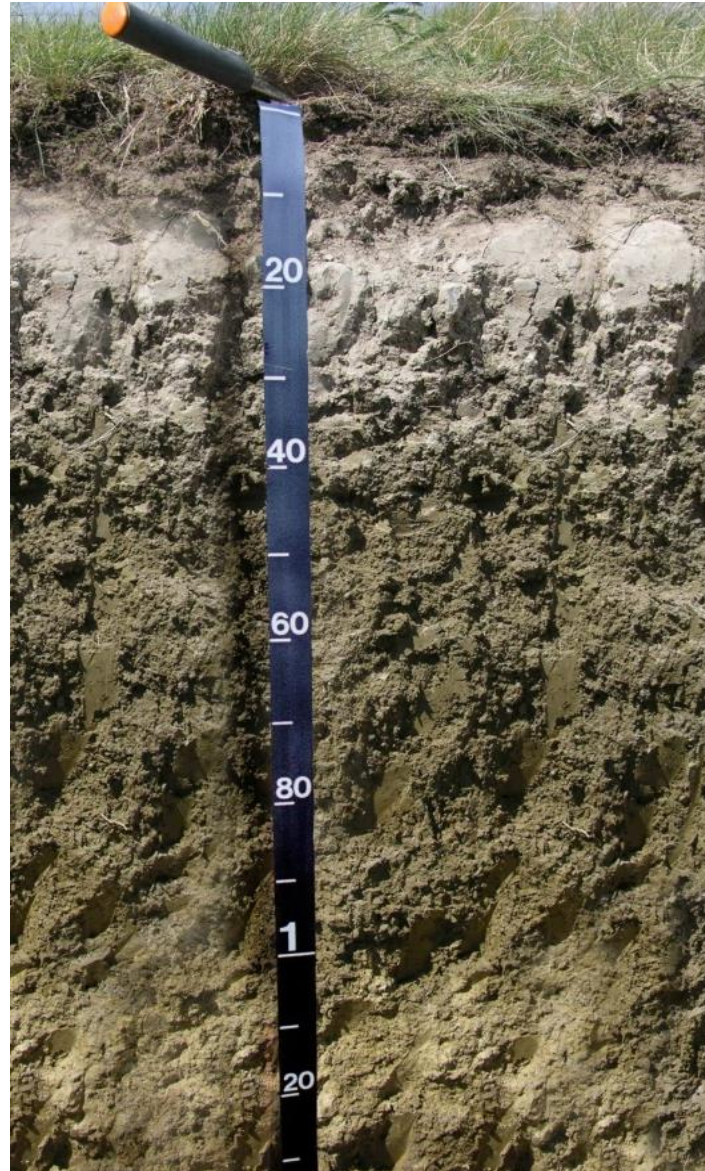
Suffix	Short description	Used for
n	Pedogenetic accumulation of exchangeable sodium	no restriction

Typical characteristics:

- Sodium affects the exchange complex
- clay may disperse
- structure may become columnar
- Subsoil may become dense and hard when dry
- infiltration and rooting may be restricted

Liberia context

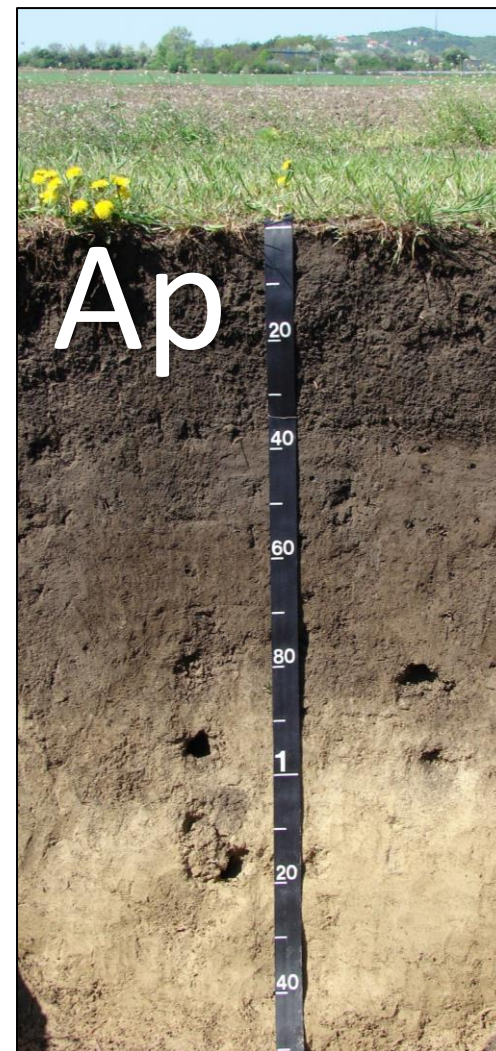
- mainly relevant in **coastal or marine-influenced settings**
- uncommon in most inland humid environments because strong leaching usually prevents sodium accumulation



Suffix	Short description	Used for
p	Ploughing or other human disturbance	no restriction (E, B or C as Ap)

Typical characteristics:

- ploughed or tilled surface layer
- mixed soil material
- disturbed natural structure
- abrupt lower boundary of the cultivated layer
- artefacts or anthropogenic features may occur



Suffix	Short description	Used for
s	Illuvial accumulation of sesquioxides	B horizons

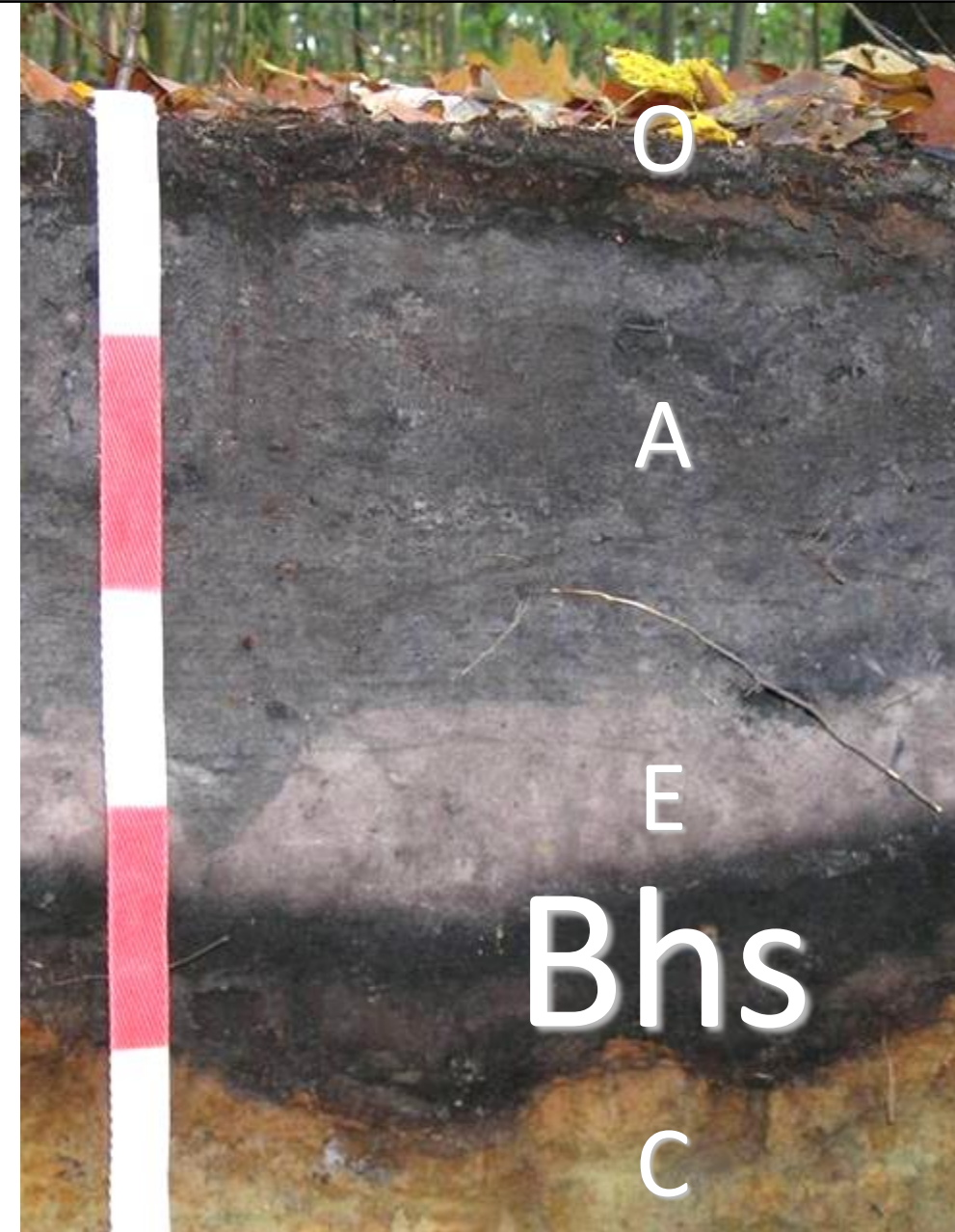
The suffix **s** is used for **B horizons** showing **illuvial accumulation of sesquioxides**, mainly **iron and aluminium compounds**.

Typical characteristics:

- reddish, brownish, or dark subsoil enrichment
- accumulation of Fe and Al compounds in the B horizon
- often associated with leaching from upper horizons
- may occur together with **h** as **Bhs**

What it means

- material has moved downward and accumulated in the subsoil
- the B horizon records chemical translocation and enrichment



Suffix	Short description	Used for
o	Residual accumulation of sesquioxides (pedogenetic)	B horizons

Typical characteristics:

- strong red, red-brown, or yellow-brown colours
- highly weathered appearance
- enrichment by Fe and Al oxides
- concentration formed **in situ**, not mainly by illuvial deposition

What it means

- Intense weathering and desilication have removed other components
- iron and aluminium oxides remain and become relatively concentrated

Key idea:

The suffix **o** indicates a **residual, in-place accumulation of sesquioxides in a B horizon**.

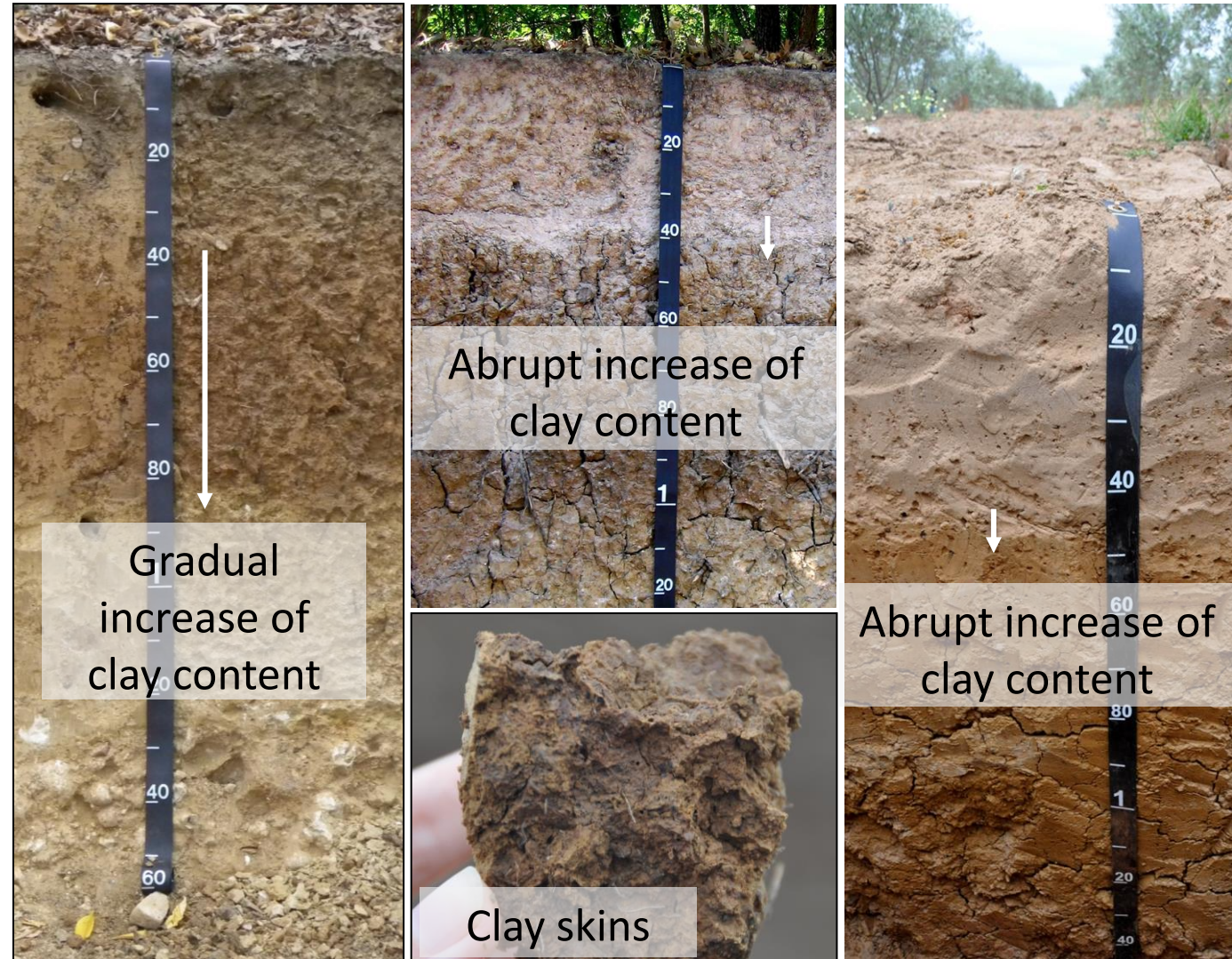


Suffix	Short description	Used for
t	Illuvial accumulation of silicate clay	mineral horizons

Typical characteristics:

- increase in clay content with depth
- gradual or abrupt textural differentiation
- clay coatings on ped faces or pore walls
- development of a clay-enriched subsoil

The suffix **t** indicates that clay has been **translocated and deposited in the horizon**, not just that the soil is clayey.



Suffix	Short description	Used for
w	Development of colour or structure	B horizons

The suffix **w** is used for **B horizons** that show **pedogenic development of colour and/or structure**, but **without clear evidence of specific illuvial accumulation**.

Typical characteristics:

- stronger colour than adjacent horizons
- development of soil structure
- change in consistence or aggregation
- evidence of weathering and pedogenesis
- no clear clay coatings, sesquioxide illuviation, or other specific accumulation feature



Suffix	Short description	Used for
z	Pedogenic accumulation of salts more soluble than gypsum	no restriction

Typical indicators:

- white or pale salt crusts
- salt accumulation at the surface or in the upper subsoil
- halophytic vegetation
- saline patches or crusted wet spots

What it means

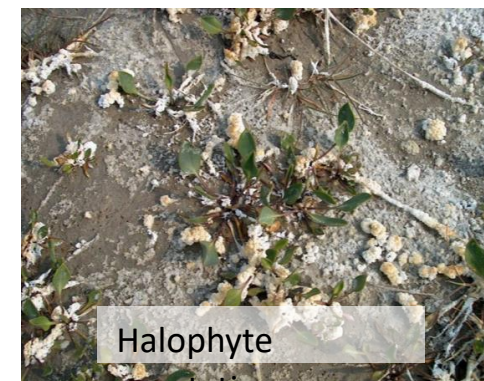
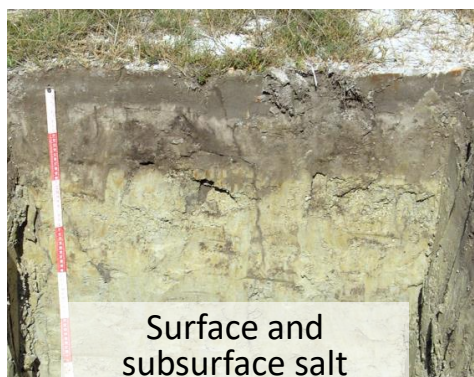
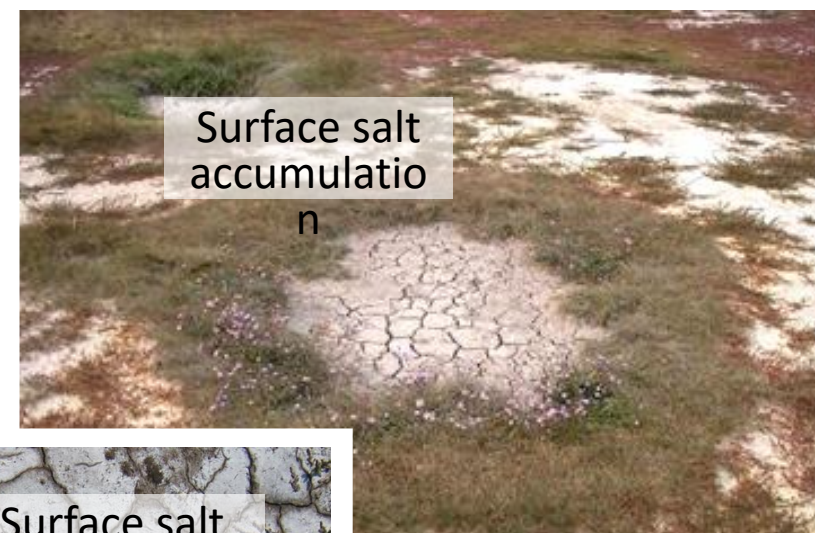
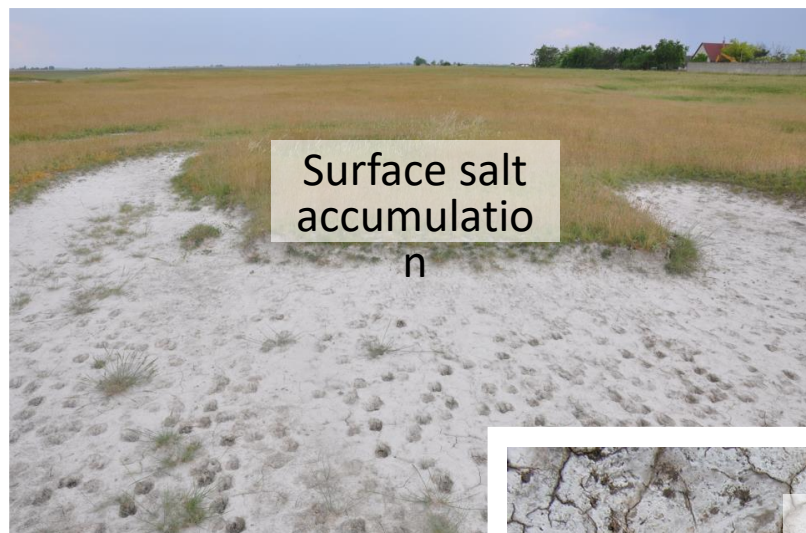
- soluble salts have accumulated in the horizon
- evaporation or saline water influence exceeds leaching locally

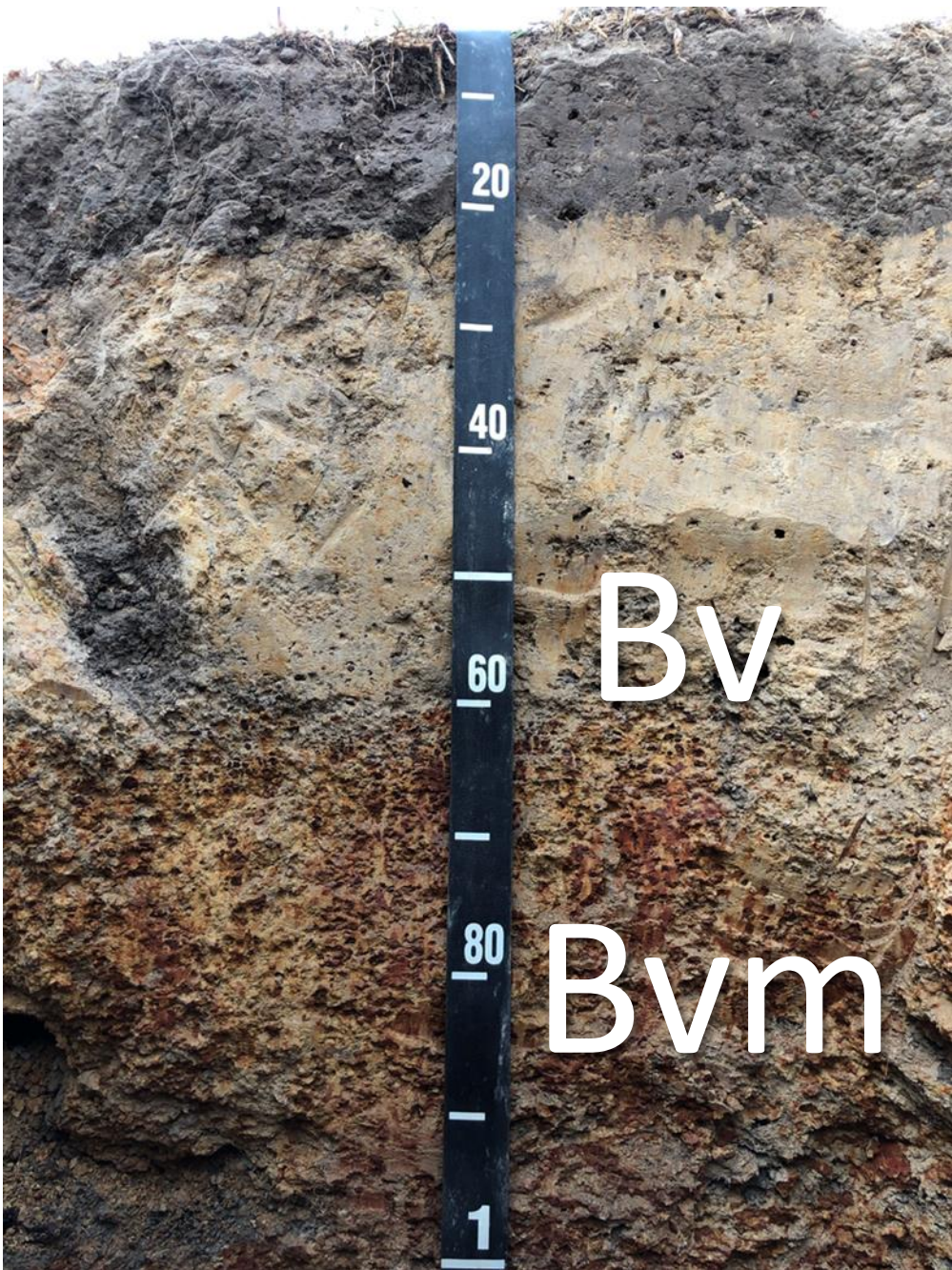
Liberia context

- mainly relevant in **coastal lowlands, estuaries, tidal flats, and mangrove zones**
- generally **not widespread inland**, because high rainfall usually leaches salts out

Key idea:

The suffix **z** indicates **salinity**, usually of **local coastal significance in Liberia**.





Suffix	Short description	Used for
v	Occurrence of plinthite	no restriction

The suffix **v** indicates the presence of **plinthite**:

- Fe-rich (often also Mn-rich) material
- humus-poor
- mixture of clay, quartz, and oxides
- soft when moist, but **hardens irreversibly when exposed**

Typical indicators:

- red mottles or nodules
- irregular aggregates
- zones that may harden over time

The suffix **m** indicates **strong cementation**:

- material already hardened
- forms a hardpan or indurated layer
- strongly restricts roots and water movement

Suffix	Short description	Used for
m	Strong cementation or induration	Mineral horizons

Summary

Environment → Process → Horizon designation

or, in field terms:

Observe the setting → infer the processes → name the horizons