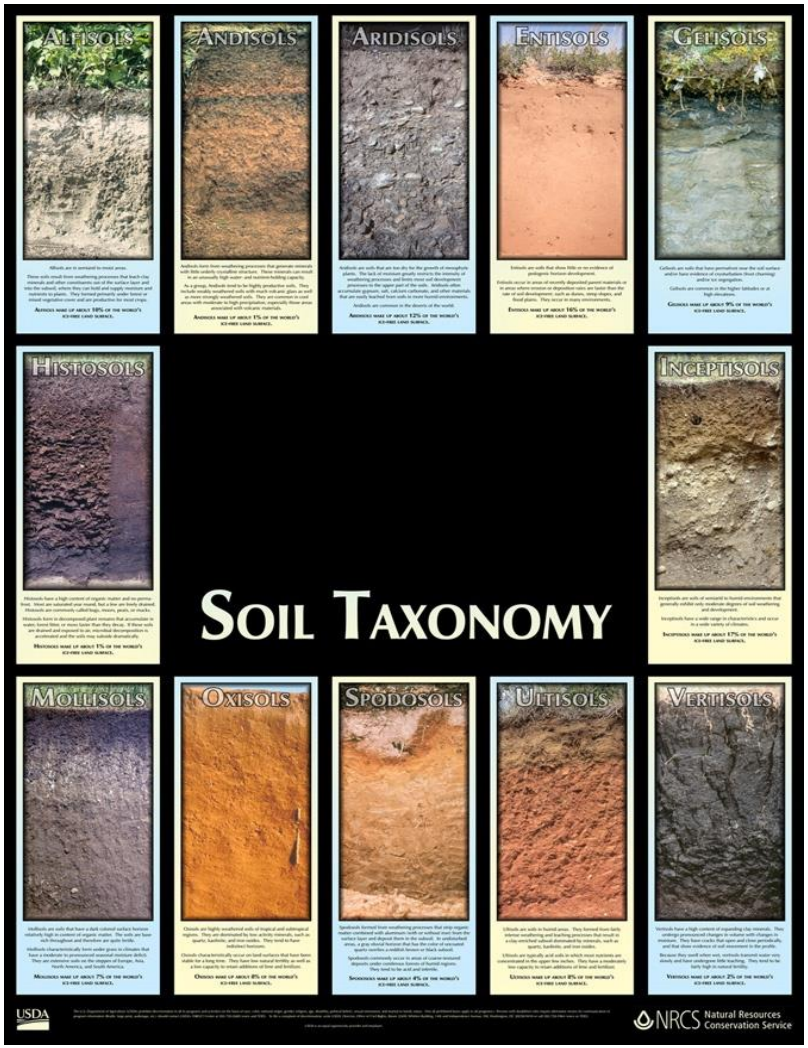
Soil Taxonomy
SS 1201 Introductory Soil Science



Dr S R Amarasinghe
Department of Soil Science
Faculty of Agriculture
University of Rhuna

- **Contents**

- USDA system of soil classification (soil Taxonomy)
- Bases of soil classification
- Diagnostic surface and sub-surface horizons
- Categories & nomenclature of soil Taxonomy
- Soil orders (USDA)

Learning objectives

- After this session you should have

1. Organize knowledge about soils and soil classification
2. Understand relationships among different soils
3. Knowledge of different soil orders

Soil Classification/Soil Taxonomy

- Soil classification is necessary because of the presence of a large number of soil types
- The word '**Taxonomy'** is derived from the word **'Taxis'** – arrangement or order
- Taxonomy deals with the systematic grouping of similar things
- V V Dokuchaev (known as the father of soil science) introduced a genetic taxonomy of soil and the concept of soil types in **1886**
- It was the first geographic genetic classification of soils

USDA system of soil classification (soil Taxonomy)

- This classification system has been used since 1975
- The system has 2 major features that makes it most useful

1. It is based on soil properties that are easily verified
2. A unique nomenclature is used which gives a meaning of the major characteristics of soils

The soil is classified according to several levels

Order

Suborder

Great Group

Subgroup

Family

Series

Example of classification of a soil type

Order: Alfisols

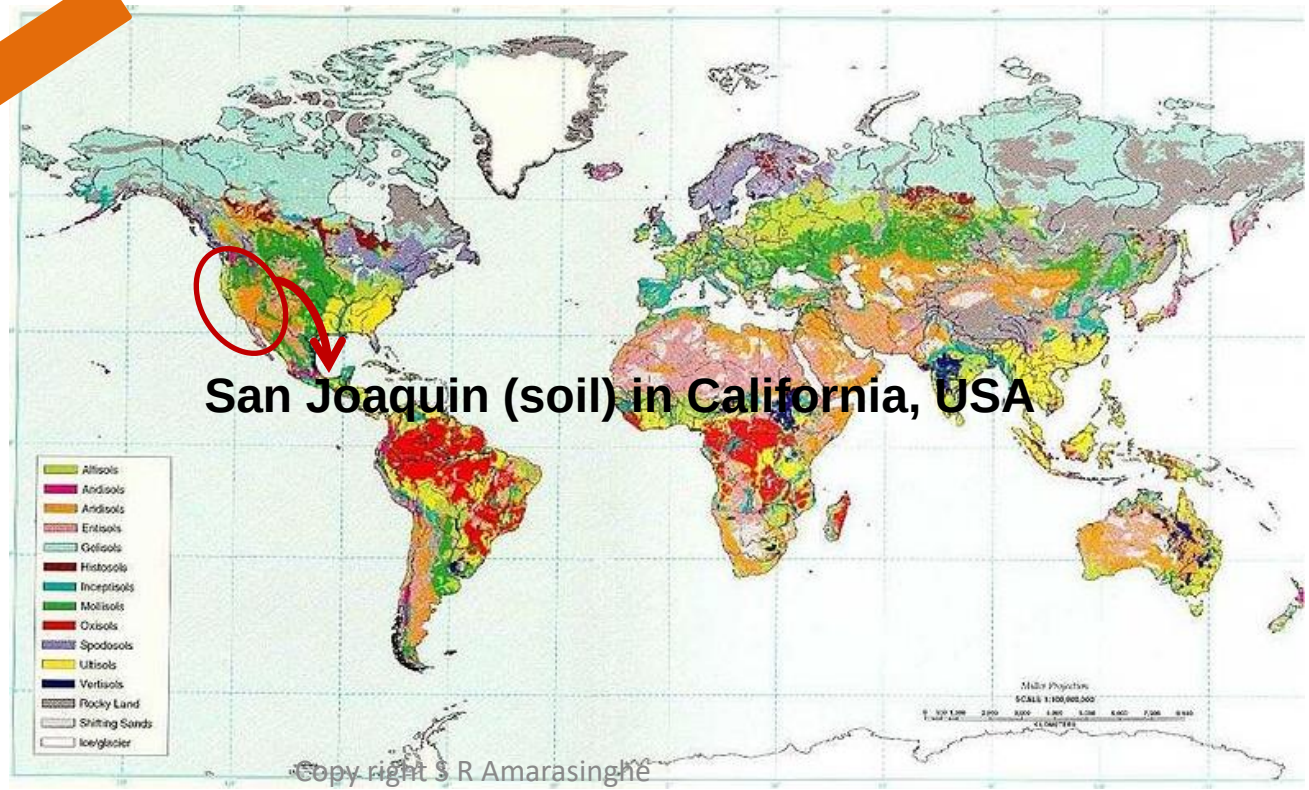
Suborder: Xeralfs (dry summers)

Great Group: Durixeralfs

Subgroup: Abruptic Durixeralfs

Family: Thermic Abruptic Durixeralfs (Fine, Mixed, Active)

Series: San Joaquin (soil) in California, USA



Global Soil Map according to the USDA classification

Base of soil classification

- Soil classification is based on the **properties of soils**

- The **moisture** and **temperature status**, **colour**, **texture**, **structure**, **chemical & mineralogical properties** (OM, Clay, CEC, % BS, pH) are some of the soil properties used for the classification

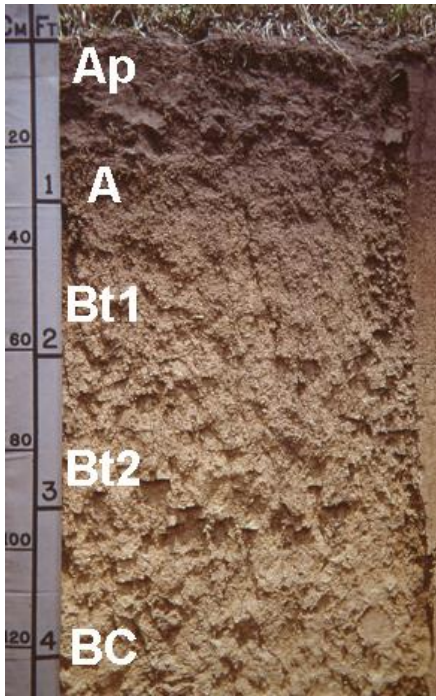
USDA Classification

- Orders (12)
- Suborders (54)
- Great Groups (211)
- Subgroups (1,100+)
- Family (7,000+)
- Series (a lot!)

- Orders- based on conditions under which the soil develops
- Sub orders-grouped by similarities in soil formation such as wetter/dryer soil, colder/warmer soil, etc.
- Great groups -Based on differences between soil horizons
- Sub groups- Describes a profile characteristic, wetness, sand, clay, etc.
- Family- Based on soil properties that affect management and root penetration, such as texture and depth
- Series - Named from the town or landscape feature near where the soil was first recognized

Orders

- Highest and most general of the soil classification system (similar to the phylum in plant taxonomy)
- Based on conditions under which the soil developed



EX: Fine-loamy mixed, superactive, mesic Aquic Argiud**olls**

Order

oll = Mollisols

Suborders

Fine-loamy mixed, superactive, mesic Aquic Argi**ud**o**lls**

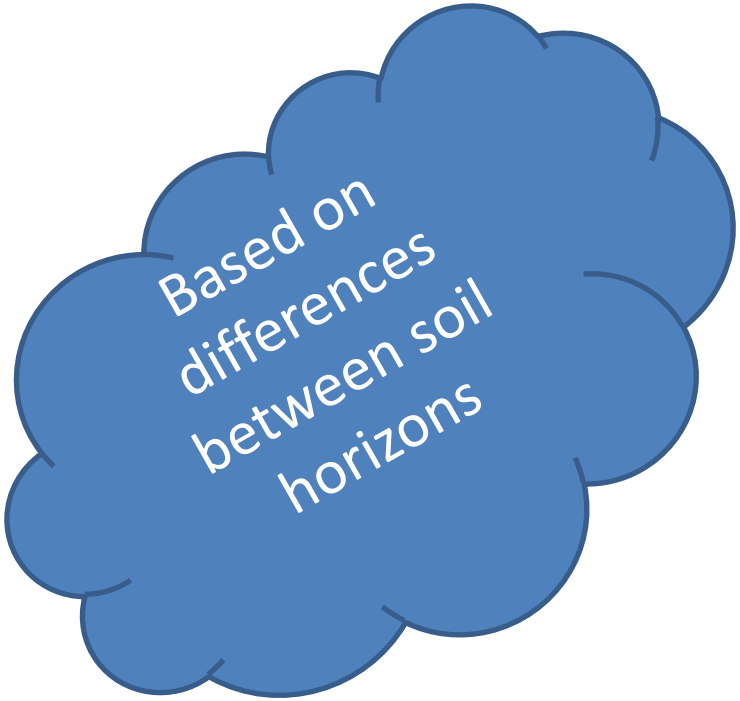
Sub Order

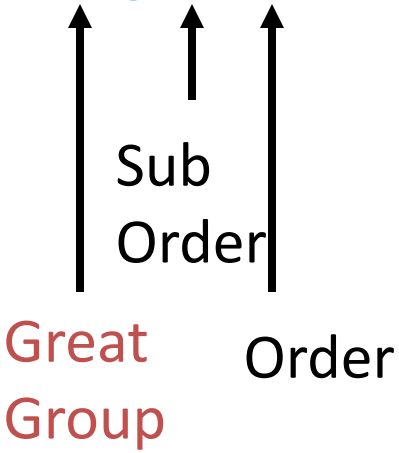
Order

Ud = Udic= Moisture/ humid

Great Groups

Fine-loamy mixed, superactive, mesic Aquic **Argiudolls**

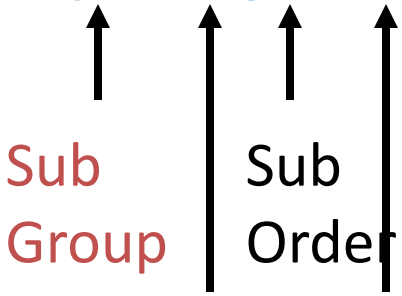




Argillic = Clay accumulation

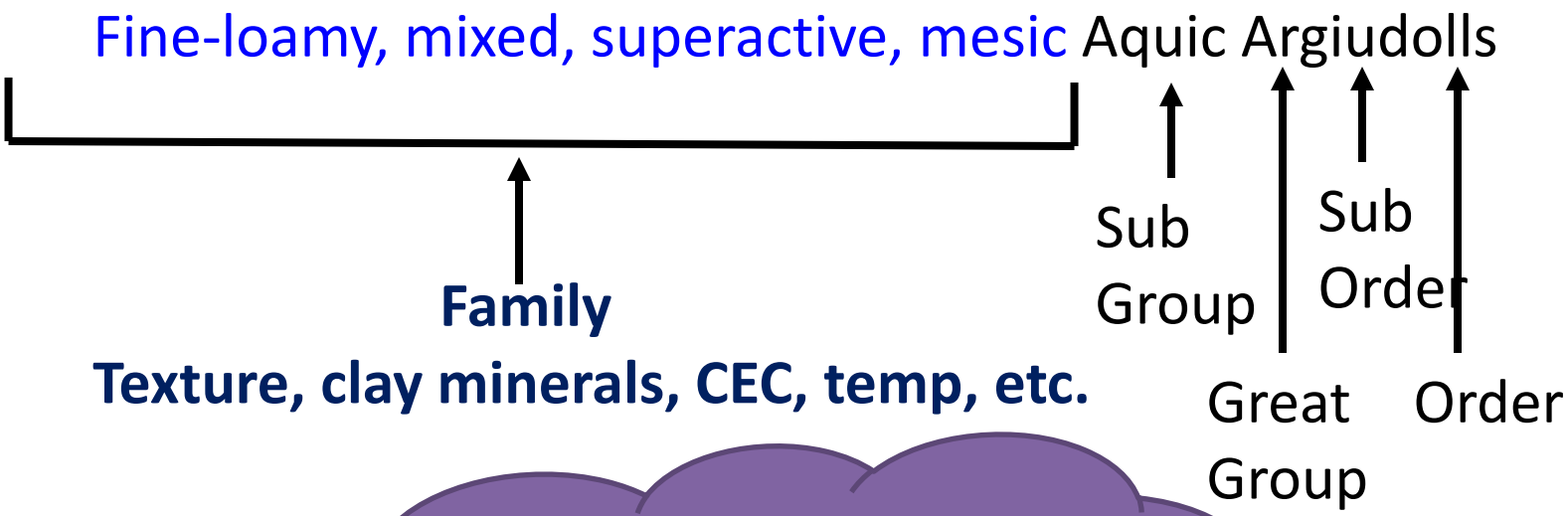
Sub Groups

Fine-loamy mixed, superactive, mesic **Aquic Argiudolls**



Aquic = wet soil

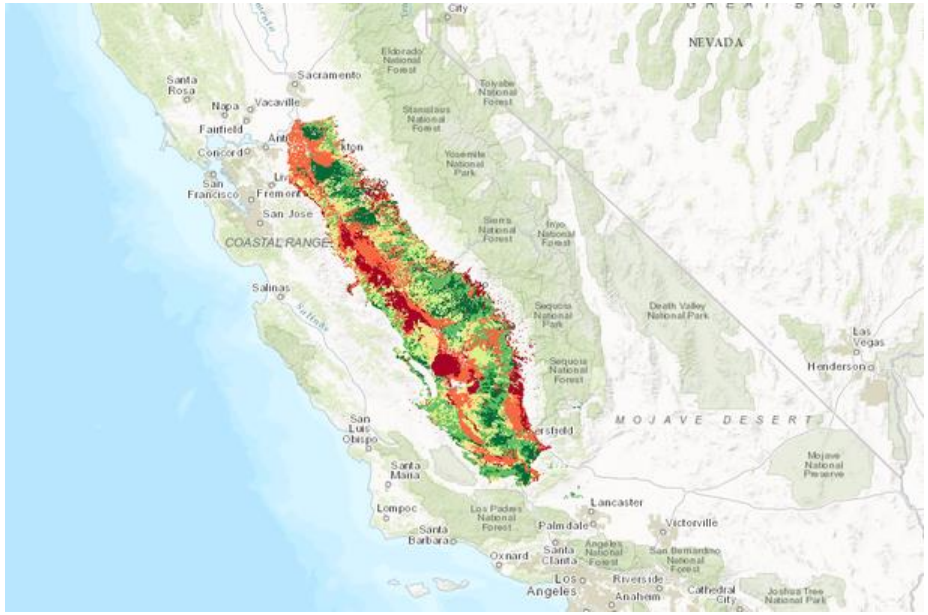
Family

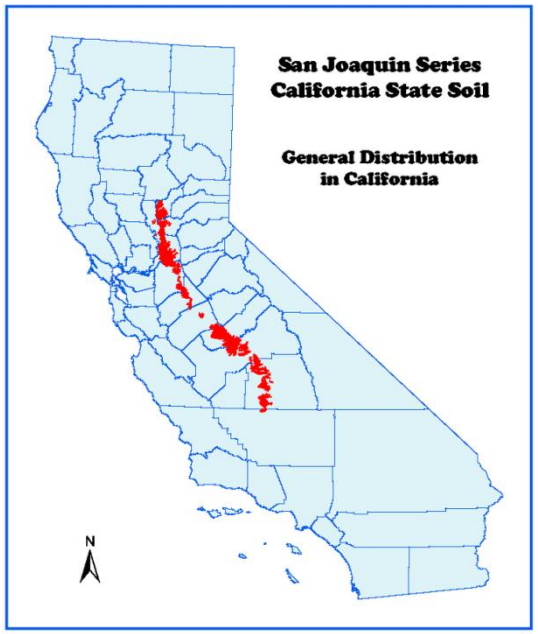


Based on soil properties that affect management and root penetration, such as texture, and depth

Series- Named from the town or landscape feature near where the soil was first recognized

Ex: San Joaquin in California, USA





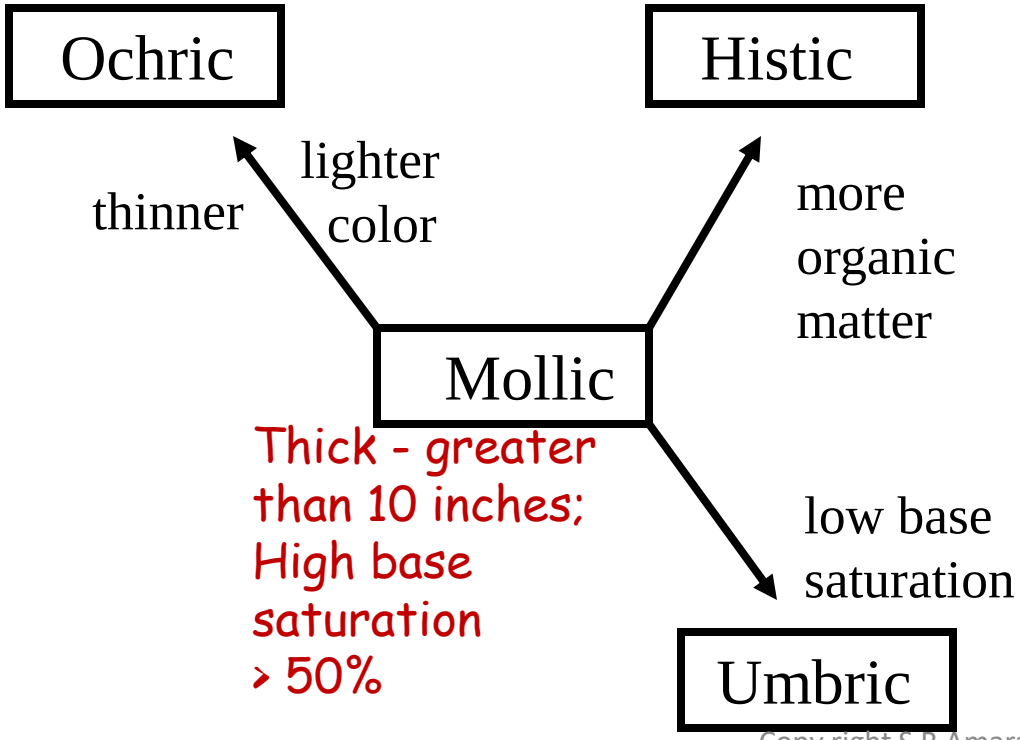
Diagnostic surface horizons

- The diagnostic horizons that occur at the soil surface are called epipedons (from Greek '**epi**'-over; and '**pedon**'- soil)
- The epipedon includes the upper part of the soil darkened by OM, or the upper elluvial horizons
- It may include part of the B horizon
- There are eight (08) epipedons recognized; however 06 occur naturally over wide areas
- The other 2 (Anthropic & Plaggen) are the result of intensive human use of soils

Major features of Diagnostic surface horizons (Epipedons)

	Epipedon	Soil Horizon	Major feature
Natural	1. Mollic	A	Thick, dark coloured, high % BS, strong structure (highly bounded), 0.6% organic Carbon
Natural	2. Umbric	A	Same as Mollic epipedon except low % BS
Natural	3. Ochric	A	Light coloured, low OM content, hard when dry
Natural	4. Melanic	A	Thick black (melanic in Greek-black), high in OM (> 6% organic C) common in volcanic ash, light in weight & soft
Natural	5. Histic	O	Very high in OM content, wet during some part of the year; peat; low density
Natural	6. Folistic	O	Cool humid areas, with OM, it is like the histic except it is **not saturated with water for more than 30 days**
Man Made	7. Anthropic	A	Human modified Mollic like epipedon in color, structure, and organic-carbon content, high in available P
Man Made	8. Plaggen	A	Human made, created by years of manuaring

Comparison of Epipedons (diagnostic surface horizons)



Base Saturation = relative amount of bases (Ca, Mg, K) in the soil,
Low %BS = few bases
high %BS = many bases

Diagnostic sub-surface horizons

- Many sub-surface horizons are used to characterize different soils in soil taxonomy
- There are **18 sub-surface** horizons to characterize different soils in soil taxonomy

1. Argillic (Bt)
2. Natric (Btn)
3. Spodic (Bhs)
4. Cambic (Bw, Bg)
5. Agric
6. Oxic (Bo)
7. Duripan (qm)
8. Fragipan (x)
9. Albic (E)
10. Calcic (k)
11. Gypsic (y)
12. Salic (z)
13. Kandic
14. Petrocalcic (km)
15. Petrogypsic (ym)
16. Sombric (bh)
17. Sulfuric
18. Placic

- The presence or absence of these horizons play a major role in determining in which class a soil falls in soil taxonomy
- These diagnostic sub-surface horizons are differentiate by characters like consist of silicate minerals, OM content, Fe, Al oxides, Ca compounds, cemented materials and highly acidified materials.

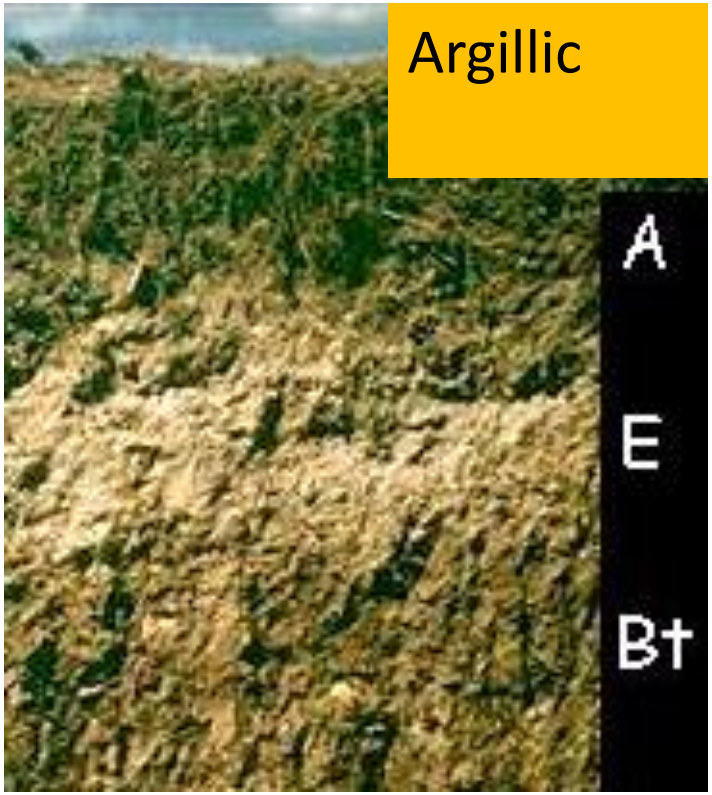
Major features of diagnostic subsurface horizons

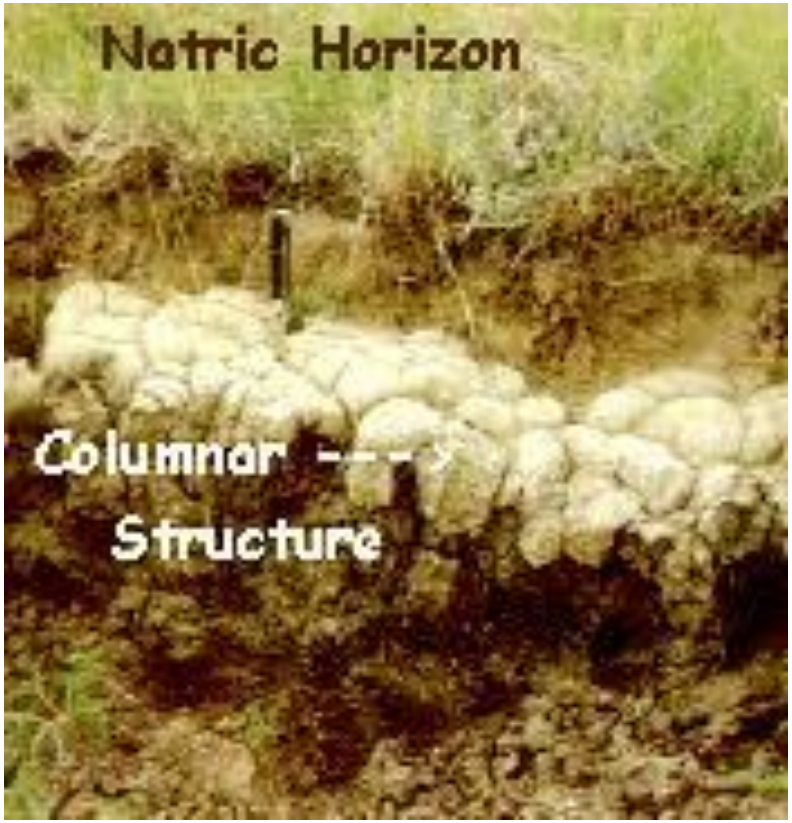
Sub-surface horizon	Major features
1. Argillic (Bt)	Sillicate clay accumulation
2. Natric (Btn)	Argillic with high in Na, columnar or prismatic structure
3. Spodic (Bhs)	Organic matter, Fe & Al oxides accumulation
4. Cambic (Bw, Bg)	Changed or altered by physical movement or by chemical reactions
5. Agric	OM and clay accumulation just below plough layer due to cultivation
6. Oxic (Bo)	Highly weathered, primary mixure of Fe, Al oxides and Silicate clays (non sticky type)
7. Duripan (qm)	Hardpan strongly cemented by silicates

Major features of diagnostic subsurface horizons contd.

Sub-surface horizon	Major features
8. Fragipan (x)	Brittle pan, usually loamy textured, weakly cemented
9. Albic (E)	Light coloured, clay & Fe & Al oxides mostly removed
10. Calcic (k)	Accumulation of Calcite ($CaCO_3$) or Dolamite ($CaMgCO_3$)
11. Gypsic (y)	Accumulation of Gypsum ($CaSO_4.2H_2O$)
12. Salic (z)	Accumulation of salts
13. Kandic	Accumulation of low activity clays
14. Petrocalcic (km)	Cemented calcic horizon
15. Petrogypsic (ym)	Cemented gypsic horizon
16. Sombric (bh)	OM accumulation
17. Sulfuric	Highly acidic with Jarrosite mottles (in acid sulfate soils)
18. Placic	Very hard pan, Fe, Mn cemented

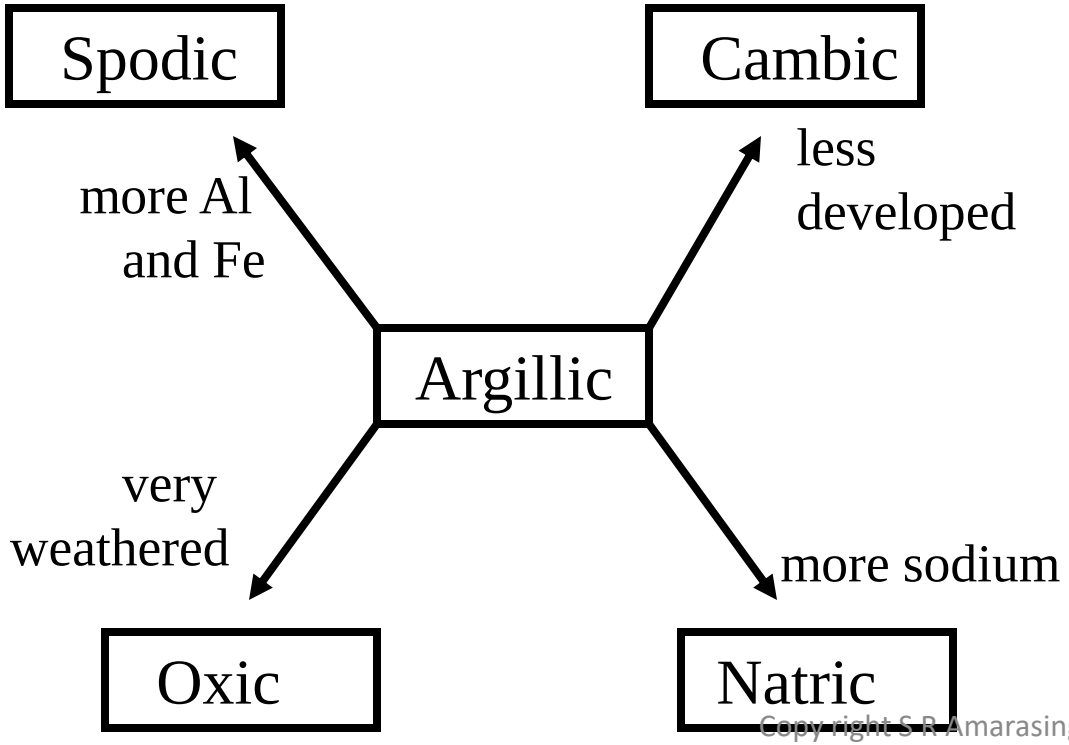
Examples of sub surface diagnostic horizons





- *Argillic* - <u>illuvial horizon</u> of clay accumulation -Bt
- *Natric* - same as argillic but with > 15% exchangeable sodium (Na) - Btn

Comparison of Subsurface Diagnostic Horizons



Further reading

USDA United States Department of Agriculture
Natural Resources Conservation Service

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051241.pdf

Keys to Soil Taxonomy

Eighth Edition, 1998

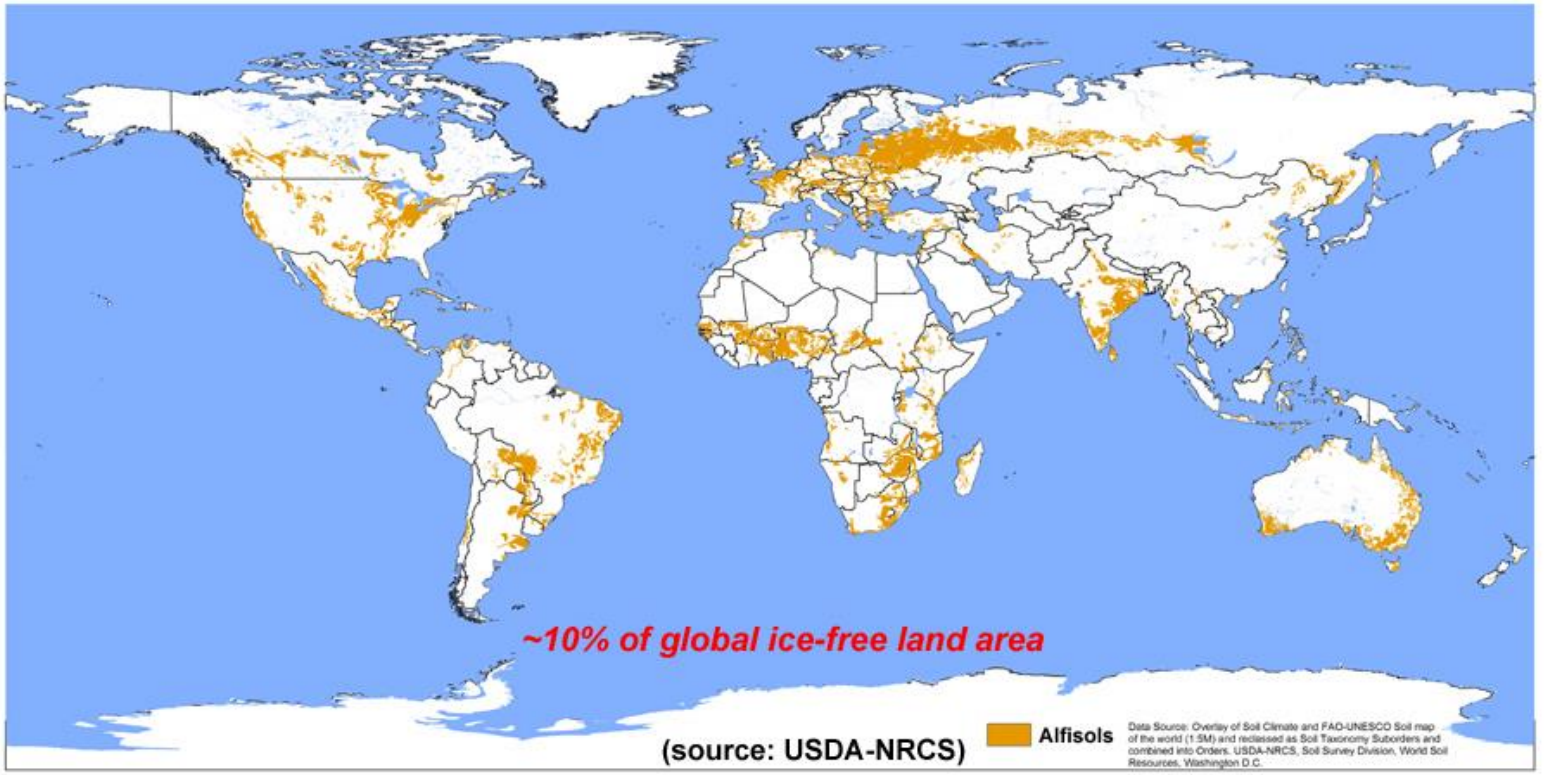
- There are **twelve (12) major soil orders** in the USDA soil classification system

1. Alfisols
2. Andisols (not found in SL)
3. Aridisols (not found in SL)
4. Entisols
5. Gelisols (not found in SL)
6. Histosols
7. Inceptisols
8. Mollisols (not found in SL)
9. Oxisols
10. Spodosols (not found in SL)
11. Ultisols
12. Vertisols

1. Alfisols

- Alfisols are moderately weathered soils
- Form under forests
- Rich in iron and aluminum
- Found in semi-arid to humid areas
- These soils result from weathering processes that leach clay minerals out of their surface layer into subsoil
- The sub soils can hold and supply moisture & nutrients to plants
- Alfisols make up about 10% of the world's ice-free land surface

Global Distribution of Alfisols



Sub orders of Alfisols

Aqualfs - Alfisols with a water table at or near the surface for much of the year

Cryalfs - Alfisols of cold climates

Ustalfs - Alfisols of semiarid and subhumid climates

Xeralfs - temperate Alfisols with very dry summers and moist winters

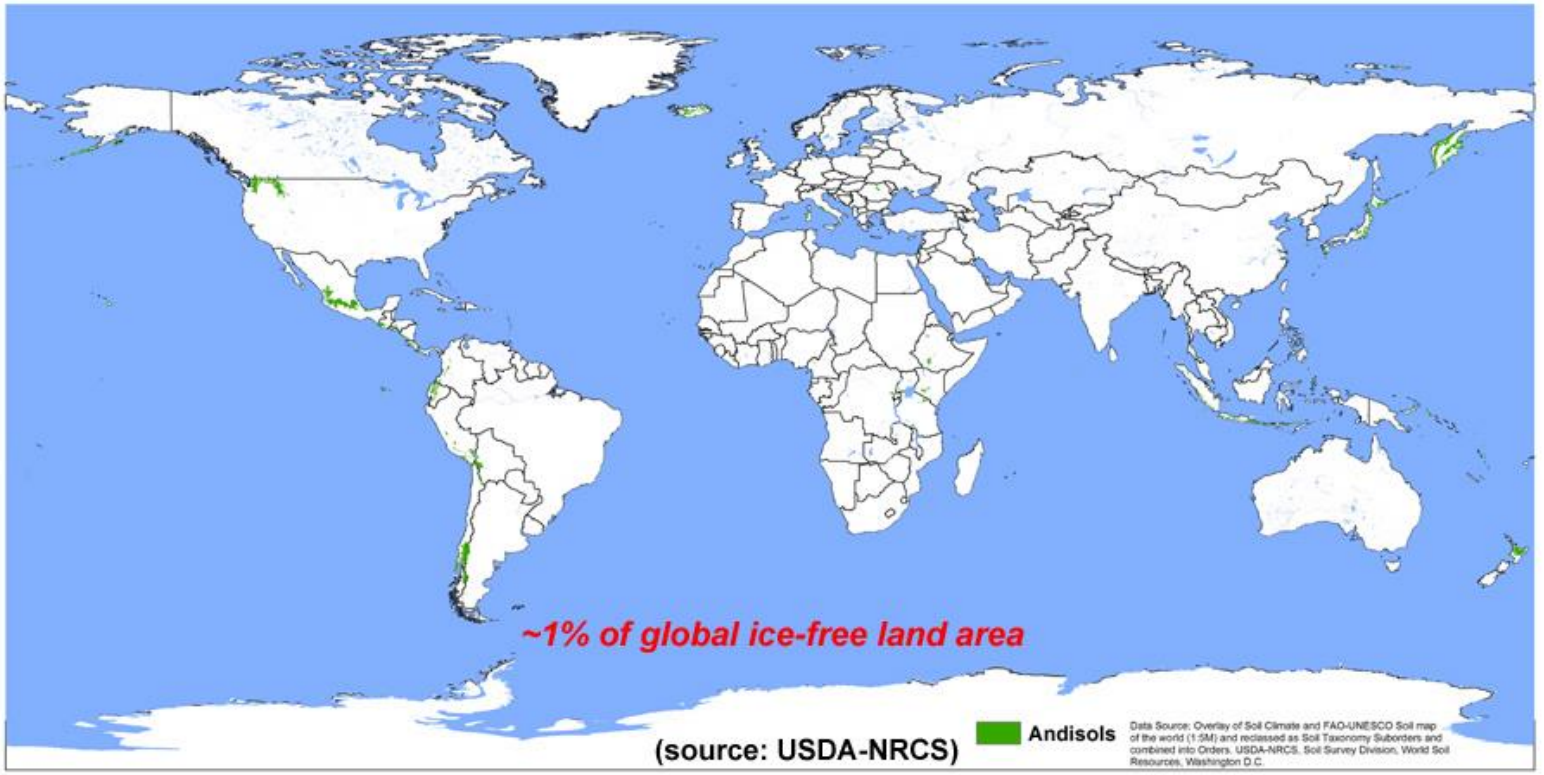
Udalfs - Alfisols of humid climates

- Aualfs (wet)
- Boralfs (cold)
- Udalfs – humid (most SL soils)
- Ustalfs (moist/dry-humid)
- Xeralfs (dry summers & wet winters)

2. Andisols

- Andisols form from the minerals of orderly crystalline structure; 'Ando' in japanese- black soil
- Contains high proportions of amorphous colloidal (non crystalline) materials, including **Allophane, Imogolite and Ferrihydrite**
- These minerals can result in as unusually high water & nutrient holding capacity
- Andisols tend to be highly productive soils
- They are common on cool areas with moderate to high precipitation, especially areas associated with volcanic minerals/volcanic ash
- Andisols make up about 1% of the world's ice-free land surface (not in SL)

Global Distribution of Andisols



Sub orders of Andisols

Aquands - Andisols with a water table at or near the surface for much of the year

Gelands - Andisols of very cold climates (mean annual soil temperature ≤0°C)

Cryands - Andisols of cold climates

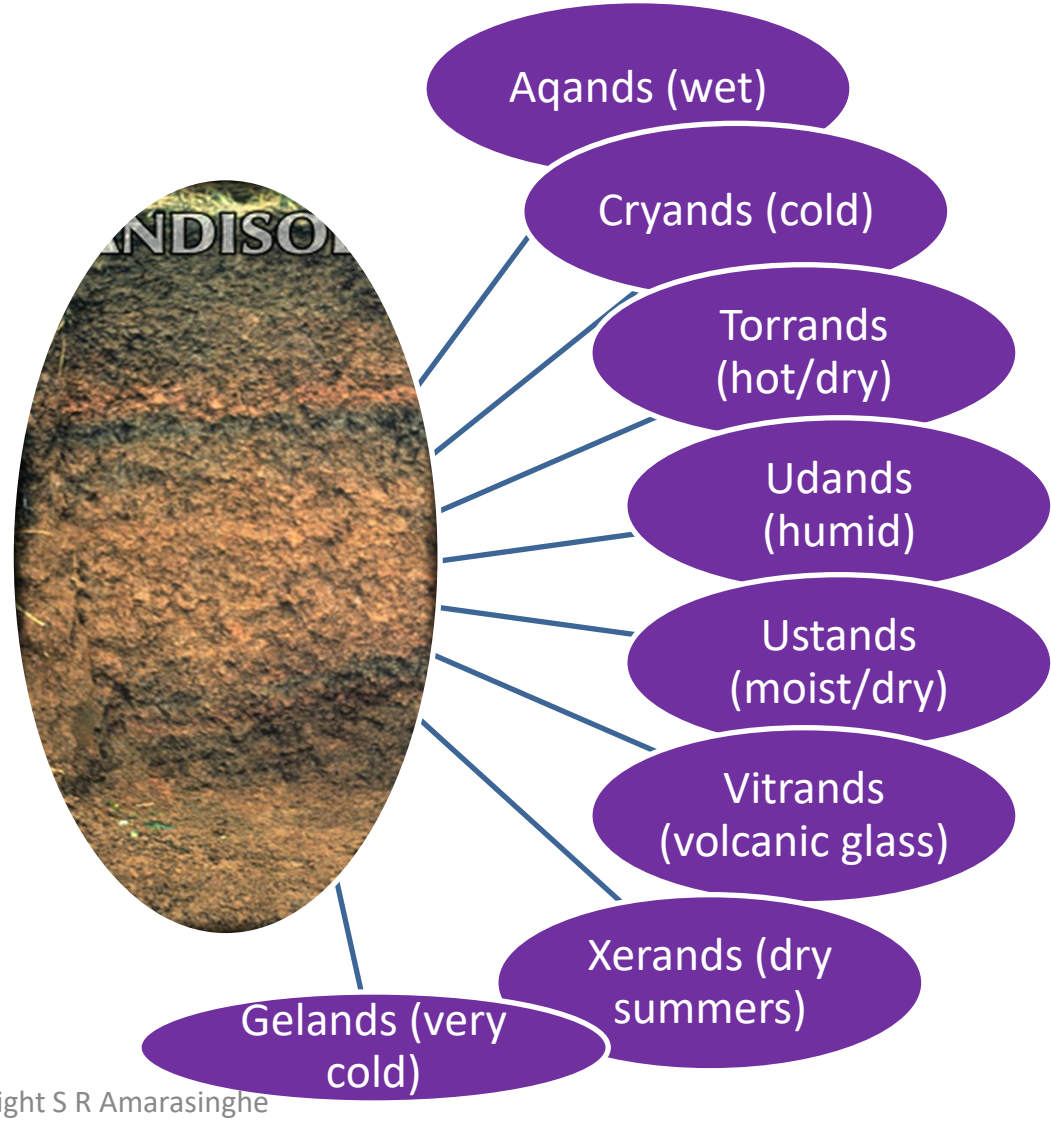
Torrands - Andisols of very dry climates

Xerands - temperate Andisols with very dry summers and moist winters

Vitrands - relatively young Andisols that are coarse-textured and dominated by glass

Ustands - Andisols of semiarid and subhumid climates

Udands - Andisols of humid climates



ANDISOLS (VOLCANIC ASH SOILS)

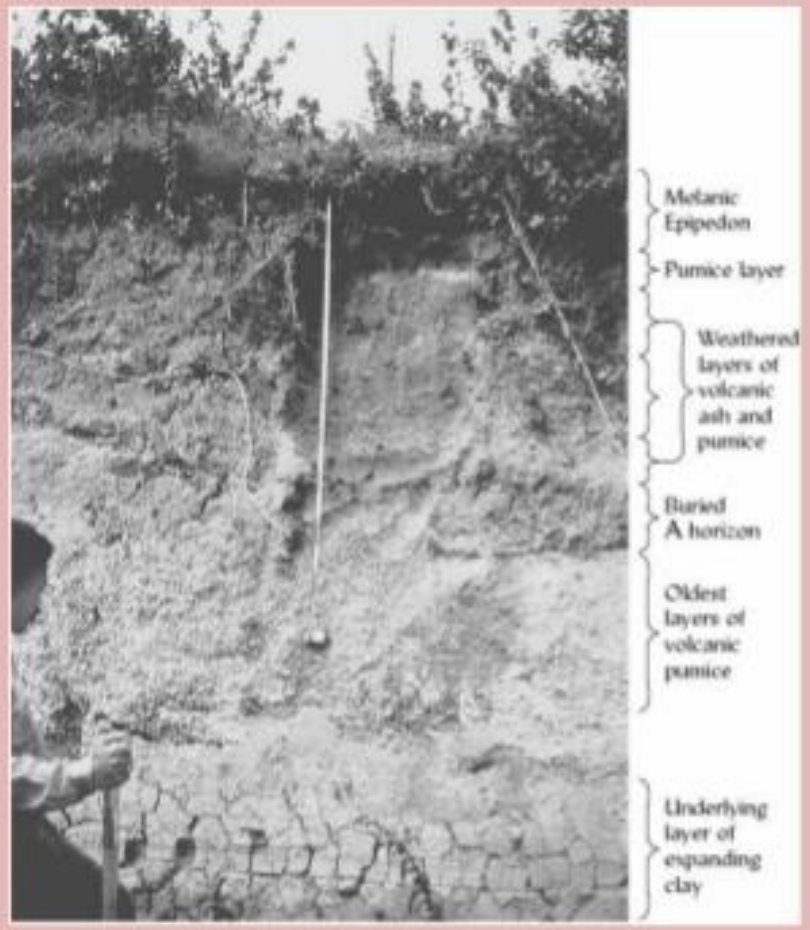


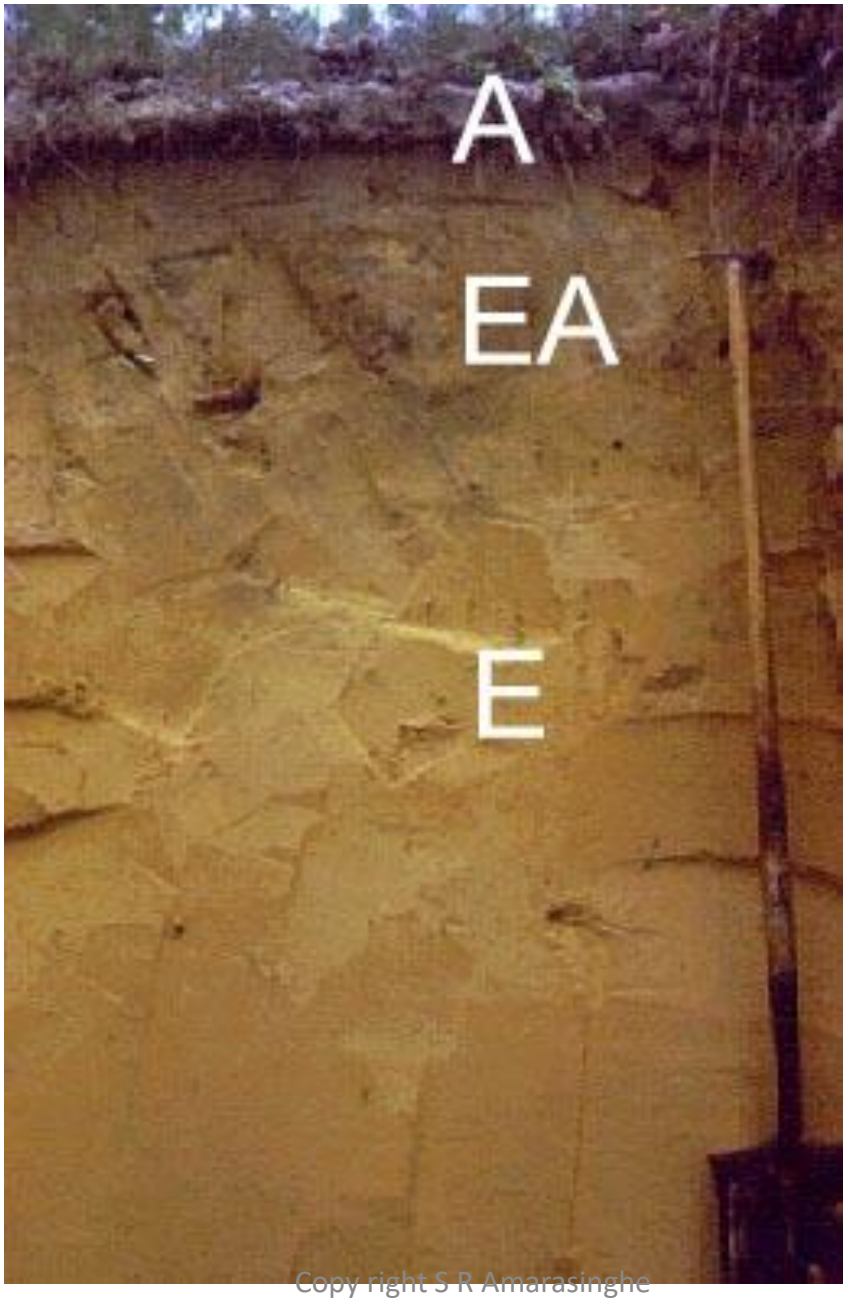
Figure 3.10 An Andisol developed in layers of volcanic ash and pumice in central Africa. (Photo courtesy of R. Weil)

3. Aridisols

- The Aridisols— (from the Latin 'Aridus', for 'dry') form in an **arid** or **semiarid** climate (common in deserts of the world)
- The lack of moisture greatly restricts the intensity of weathering processes
- Aridisols often accumulate Gypsum, Salt, Calcium Carbonate, and other minerals that are easily leached from soils in more humid environments
- **Aridisols make up about 12% of the world's ice-free land surface**

4. Entisols

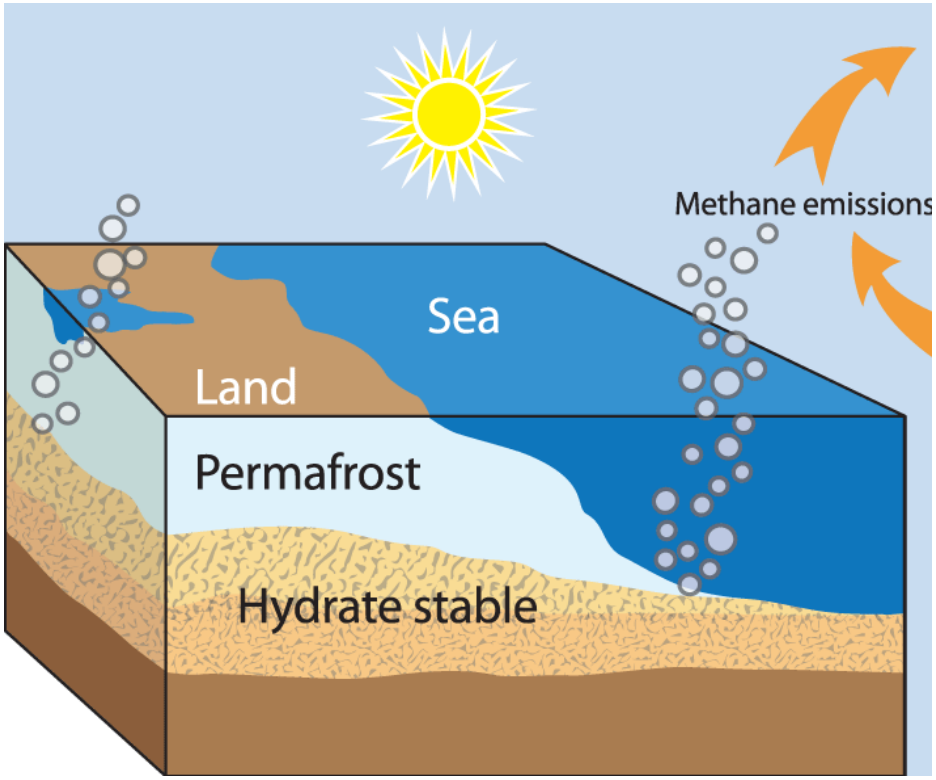
- Entisols **do not show any "significant" soil profile development**
- Minimal soil horizons; Only A horizon
- Occur in areas of recently deposited PM or areas where erosion or deposition rates are faster than the rate of soil development i.e dunes, steep slopes and flood planes
- Entisols make up about 16% of the world's ice-free land surface



5. Gelisols

- Gelisols are soils of very cold climates which are defined as containing permafrost within two meters of the soil surface
- 'gelare' in latin 'to freeze'.
- They have evidence of **cryoturbation** (frost churning) and/or ice segregation
- These are common in the higher latitudes or at higher elevations
- Gilisols make up about 9% of the world's ice-free land surface

permafrost



Permafrost is soil, rock or sediment that is frozen for more than two consecutive years. In areas not overlain by ice, it exists beneath a layer of soil, rock or sediment, which freezes and thaws annually and is called the "active layer". (Wikipedia)

cryoturbation (frost churning)

cryoturbation (frost churning) refers to the mixing of materials from various horizons of the soil down to the bedrock due to freezing and thawing. (Wikipedia)

6. Histosols

- Histosols consist primarily of organic materials
- From greek 'histos'=tissue
- Most of these soils are saturated year around, but a few are freely drained
- Histosols are commonly called **bogs, moors, peats, or mucks**
- Histosols form in decomposed plant remains that accumulate in water, forest litter or moss faster than they decay (20-30% OM and > 40cm thick)
- Histosols make up about 1% of the world's ice-free land surface

7. Inceptisols

- Inceptisols form quickly through alteration of parent material (beginning of the soil formation)
- These are soils of semiarid to humid environments that generally exhibit only moderate degrees of soil weathering and development
- Inceptisols have a wide range in characteristics and occur in a wide variety of climates
- Inceptisols make up about 17% of the world's ice-free land surface

8. Mollisols

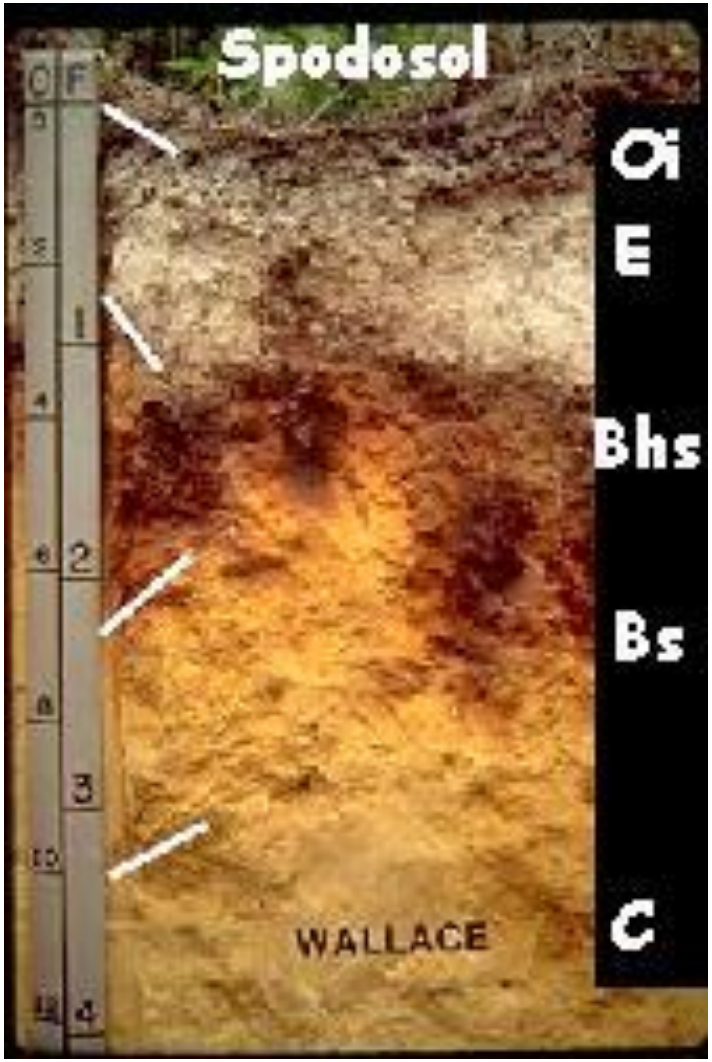
- Mollisols form in semiarid to semi humid areas, typically under **a grassland cover**
- They are soils with dark coloured surface horizon relatively high in OM
- These are base rich & are quite **fertile**
- They are extensive soils on the steppes of Europe, Asia, North America, and South America
- Mollisols make up about 7% of the world's ice free land surface

9. Oxisols

- Oxisols are best known for their occurrence in **tropical rain forest**
- These are **highly weathered soils** of tropical & subtropical regions
- They dominated by low activity minerals, such as **Quartz**, **Kaolinite**, and **Iron Oxides**
- They tend to have distinct horizons
- Oxizols have low natural fertility as well as a low capacity to retain additions of lime and fertilizer
- Oxisols make up about 8% of the world's ice-free land surface

10. Spodosols

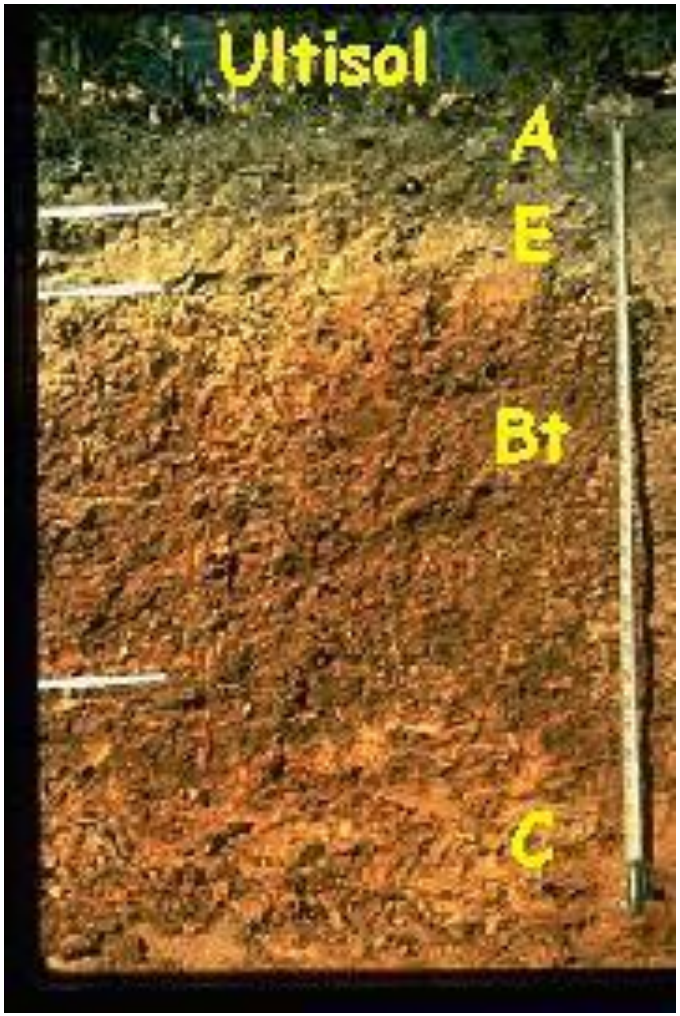
- Spodosols are typical soils of **coniferous or boreal forests**
- They formed from weathering processes that strip OM combined with Al (with or without iron) from the surface layer and deposit them in the subsoil
- In undisturbed area, a gray eluvial horizon that has the colour of uncoated Quartz overlies a reddish brown or black subsoil
- They tend to be acid & infertile
- **Spodosols make up about 4% of the world's ice free land surface**

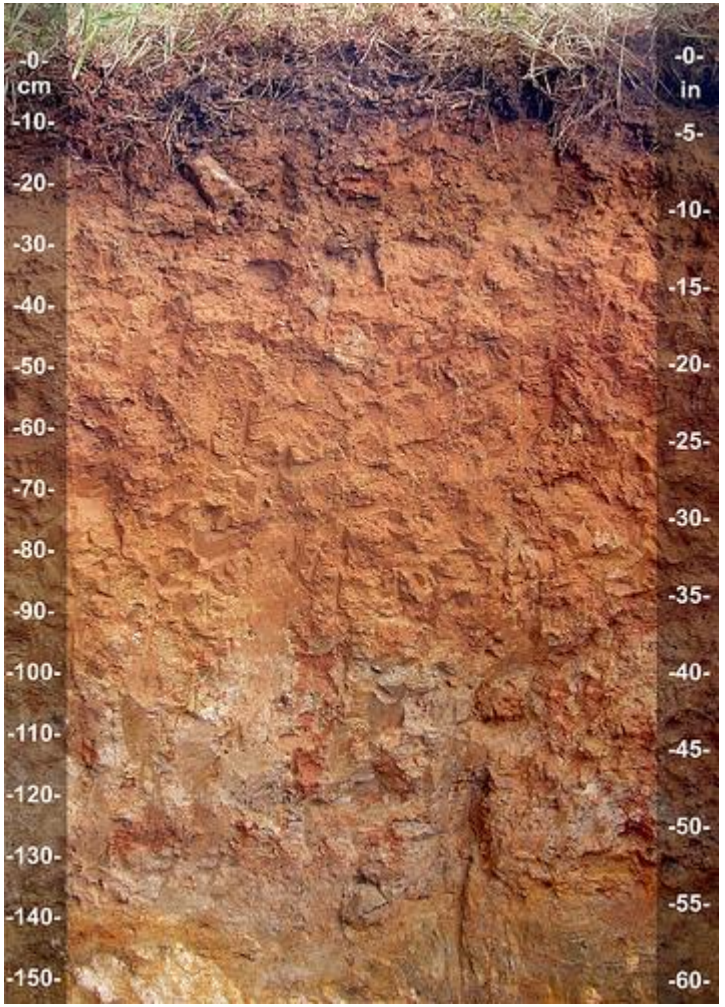


Organic matter, Fe & Al oxides accumulation

11. Ultisols

- Ultisols are commonly known as red clay soils
- Soils of humid areas
- They formed from fairly intense weathering and leaching processes that result in a **clay-enriched subsoil** dominated by minerals, such as **Quartz, Kaolinite**, & **Iron oxides**
- Ultisols are typically acid soils in which most nutrients are concentrated in the upper few inches
- They have moderately low capacity to retain additions of lime & fertilizer
- Ultisols make up about 8% of the world's ice-free land surface





Sub orders of Ultisols

SUBORDERS

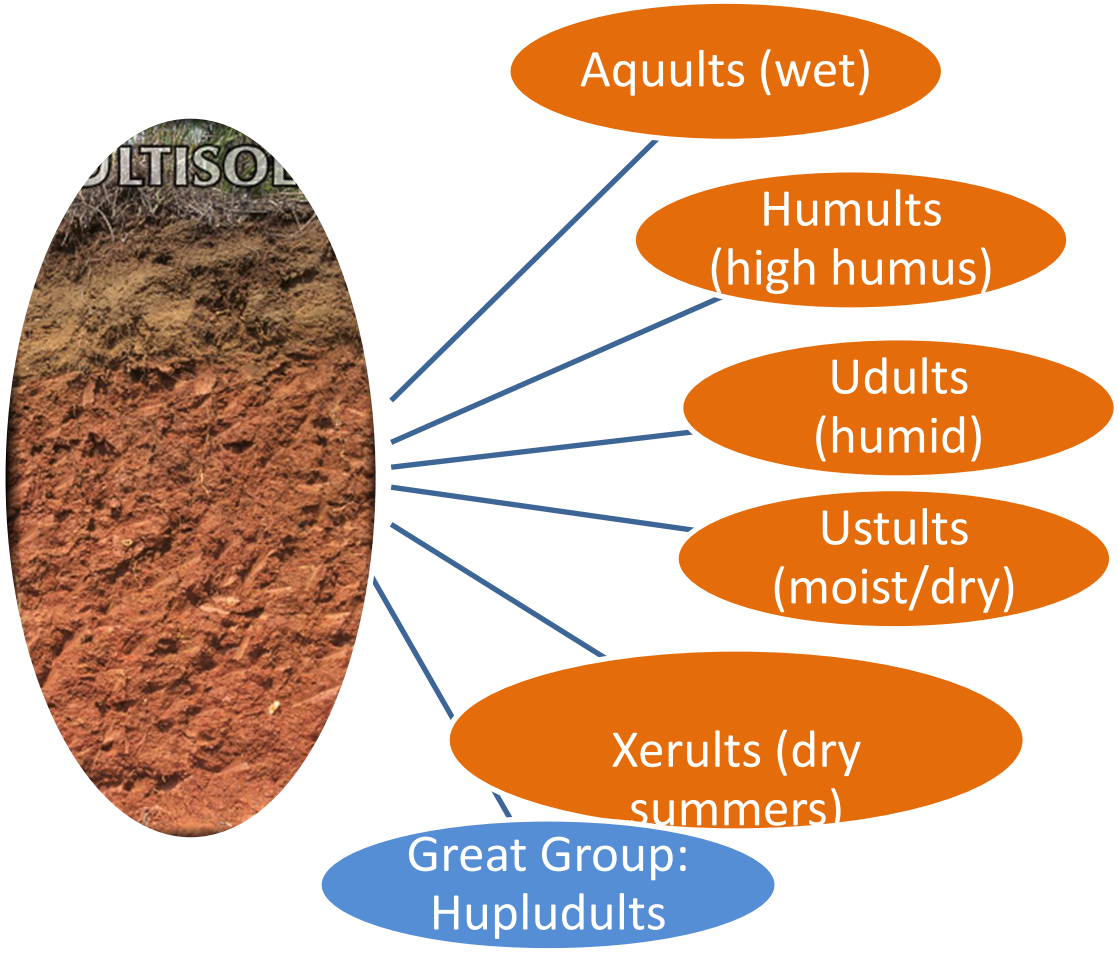
Aquults - Ultisols with a water table at or near the surface for much of the year

Humults - well-drained Ultisols that have high organic matter content

Udults - Ultisols of humid climates

Ustults - Ultisols of semiarid and sub-humid climates

Xerults - temperate Ultisols with very dry summers and moist winters



12. Vertisols

- Vertisols are high content of **expansive clay (shrinking/swelling)**
- They undergo pronounced changes in volume with changes in moisture
- They have cracks that open and close periodically and that show evidence of soil movement in the profile
- Because they swell and wet, vertisols **transmit water very slowly** and have undergo little leaching
- Vertisols make up about 2% of the world's ice free land surface

Soil Orders and General Descriptions

Type	Description	Type	Description
Entisols	Little or no horizon development	Inceptisols	Beginning of horizon development
Aridisols	Soils located in arid climates	Mollisols	Soft, grassland soils
Alfisols	Deciduous forest soils	Spodosols	Acidic, coniferous forest soils
Ultisols	Extensively weathered soils	Oxisols	Extremely weathered, tropical soils
Gelisols	Soils containing permafrost	Histosols	Soils formed in organic material
Andisols	Soil formed in volcanic material	Vertisols	Shrinking and swelling clay soils

Please refer notes and diagrams in

http://www4.schoolnet.lk/edusoft/agriculture/grade-12_13/more.php?main=main3

http://www.cals.uidaho.edu/soilorders.htm

Any Questions?