Bharathidasan University

Tiruchirappalli – 620 023, Tamil Nadu

6 Yr. Int. **M.Tech. Geological Technology and Geoinformatics**

Course Code *:* **MTIGT0707** *Optional Elective :* **14** *Credits* *:* **3**

GEOINFORMATICS IN SOIL SCIENCE

Unit–2 Soil Types

Prepared by

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Professor, Department of Remote Sensing

Course Objectives:

- To learn the importance, characters and types of soil and its relation with biotic systems
- To study the significance of soil nutrients and micronutrients
- To understand relevant aspects like soil organic matter, water holding property and landscape
- To learn the application of Geological Technology and Geoinformatics in soil resources mapping and management
- To learn the application of Geoinformatics in mitigating soil erosion and reservoir siltation.

SEMESTER – VII ELECTIVE PAPER-14 MTIGT0707 GEOINFORMATICS IN SOIL SCIENCE

3 Credits

1. **Introduction to Soil Science :** Nature and Importance of Soil, Soil formation, Soil survey, Physical, chemical and biological characters of soil, Relationship between Soil, plants and animal. **9 Hrs**

2. **Soil Types :** Soil types and classification, Soil genesis, Soil mineralogy and geochemistry of soil types: Laterites, Bauxites, Aridisols, Vertisols, Camborthids. Application of soil micromorphology and landscape evolution. Radiometric age determination of soils. **12 Hrs**

3. **Soil Nutrients and Crop Production :** Elements essential for plants and animals, Soil nutrients - Nitrogen, Phosphorous, Potassium, Calcium, Magnesium and Sulphur in soil and its significance in plant growth, Micronutrients. **9 Hrs**

4. **Soil Quality and Landscape :** Soil and water relations, organic matter in soil, functions of organic matter, organic matter and soil structure, organic matter and essential elements, tillage, cropping systems and fertility and case studies. **12 Hrs**

5. **Soil Management and Conservation :** Introduction, irrigation, drainage and soil management for field crops, gardens, lawns, pastures, rangelands and forests. Problem Soils - Soil surface crusting - Salinity - Erosion - Contamination. Soil conservation factors and implementation methods. **6 Hrs**

6. **Current Contours: (Not for Final Exam; only for Discussion):** Environmentally safe and sustainable methods of mitigating soil erosion and reservoir siltation using Geological Technology and Geoinformatics; Development of suitable and pragmatic methods to protect soil from fertility loss, soil pollution and degradation.

References:

1. Nyle, C. Brady, Ray R. Weil, The Nature and Properties of Soils (13th Edition) Prentice Hall, 2002.
2. Donald, L. Sparks, Environmental Soil Chemistry, 2002.
3. Raymond B. Daniels, Richard D. Hammer., Soil Geomorphology, John Wiley & Sons, 2000.
4. M.E. Sumner, Hand book of soil Science, 1992.
5. Donald Sparks, Donald L. Sparks D, Environmental Geochemistry, Academic Press, 2002.

Course Outcomes:

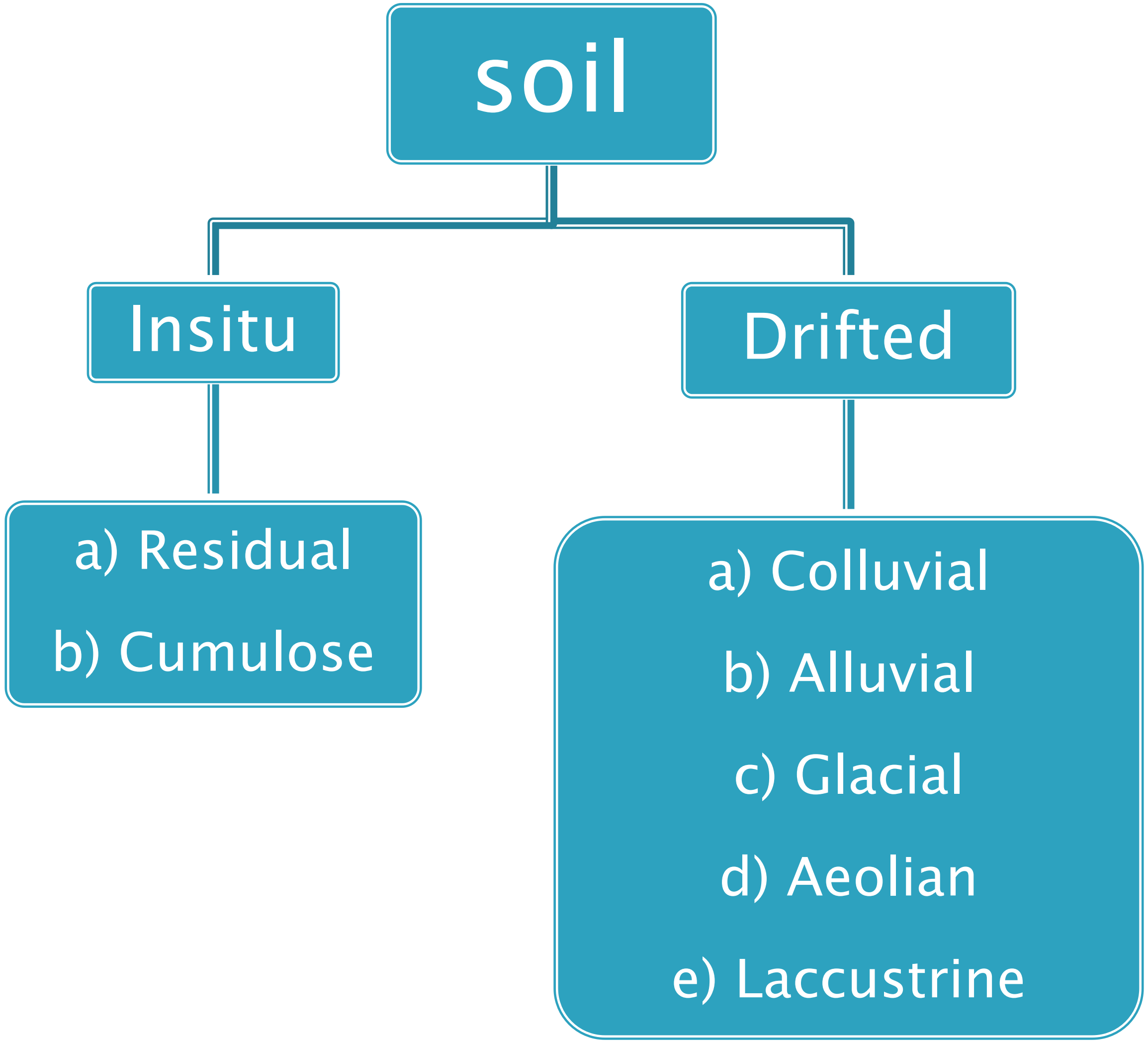
After the successful completion of this course, the students are able to:

- *Understand the importance and the physical, chemical and biological properties of soils*
- *Know the different types of soils and classification*
- *Differentiate the reflectance properties of soils and mapping them using satellite data*
- *Understand the problems to soils using Remote Sensing, field surveys in GIS platform through modeling.*
- *Suggest pragmatic soil management and conservation practices using Remote Sensing, field surveys in GIS platform through modeling and*
- *Understand the importance of soil nutrients, quality and relation with landscape.*

Unit – 2 Soil Types

Soil types and classification, Soil genesis, Soil mineralogy and geochemistry of soil types: Laterites, Bauxites, Aridisols, Vertisols, Camborthids. Application of soil micromorphology and landscape evolution. Radiometric age determination of soils. **12 Hrs.**

Soils can be classified in many ways.
Based on its location / occurrence, soils are classified as follows:



DIFFERENT TYPES OF SOIL

- Clayey Soil
- Silty Soil
- Sandy Soil
- Loamy Soil
- Peat Soil
- Chalky Soil

Clayey Soil

- Clay soils contain very fine, flat particles which tend to stick together. They feel heavy and sticky and form a little ball when you rub a small amount between finger and thumb. A handful of damp clay will retain the impression of your fingers and may appear shiny on the surface.


Silty Soil

- Silty soils fall between clay and sand in terms of particle size, and feel smooth, silky or soapy when rubbed between your fingers.

Sandy Soil

- Consists of small particles of weathered rock.
- Sandy soil is usually formed by the breakdown or fragmentation of rocks like granite, granite gneiss, which consists of quartz and feldspar
- This type of soil is very good for the drainage system.
- it has very low nutrients and poor water holding capacity.

Loamy Soil

- Loam is one of the ideal soil types for plant growing purposes. It comprises proportionate amounts of **sand, silt** and **clay** in the ratio . Generally, loam soil is fertile (unlike sandy soil) and has no water drainage problems like clayey soil and silty soil.

Chalk

- Chalk soils were described by Geoff Hamilton as 'pale and hungry looking' which sums them up really well! They feel dry and crumbly in your hand, are usually greyish white in colour, and contain fragments of white chalk.

Peat Soil

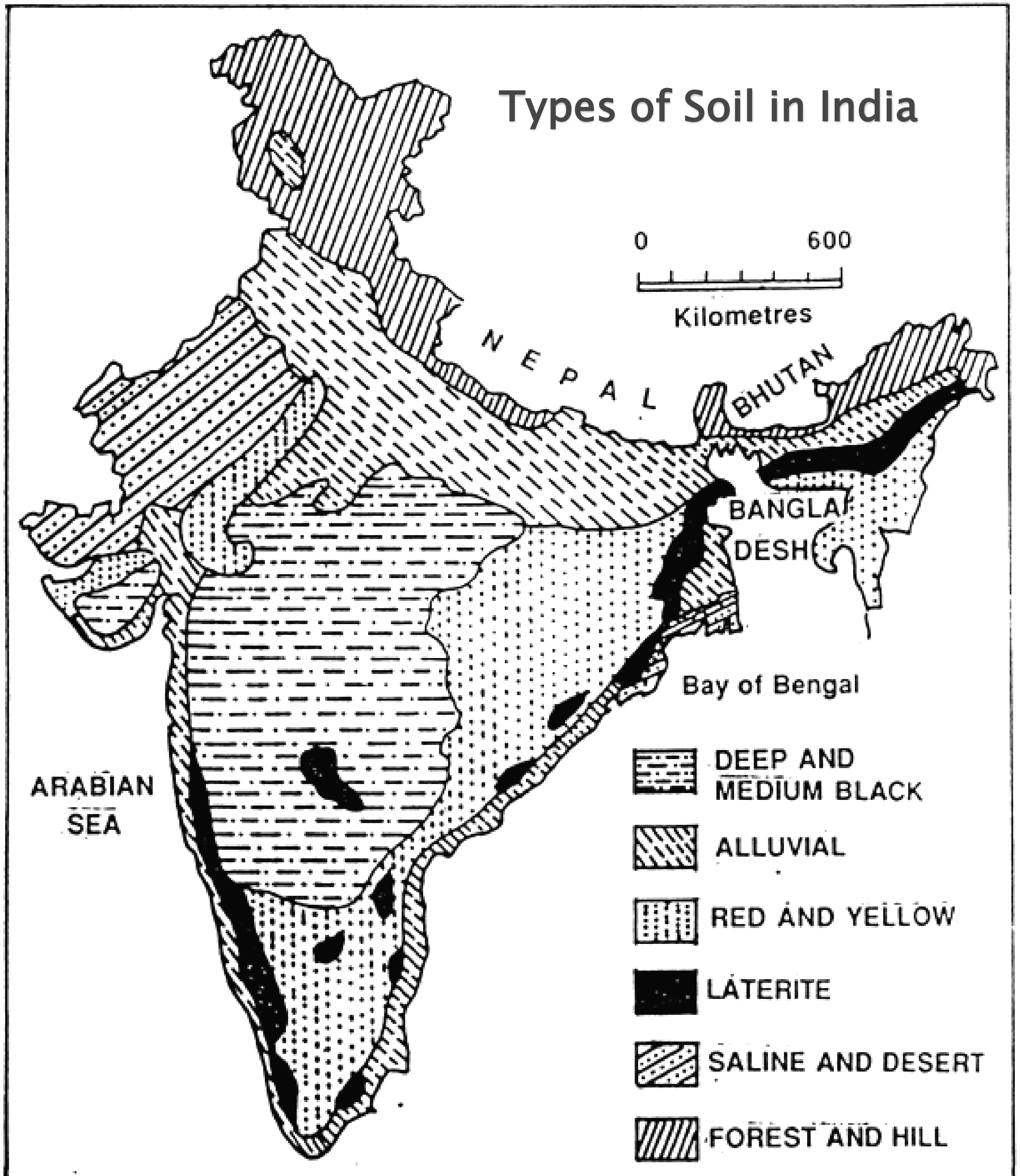
- Peat soils have a very high organic content so are very dark, almost black, in colour. In your hand they feel moist and spongy and are hard to roll into a ball.

Types of Soil in India

- In India diverse natural environment has engaged various types of soil.
- Number of soil classifications has been adopted for soils of India.
- Based on physiography, climatic conditions, and Geological formations soil has been grouped into

  - **Alluvial Soils**
  - **Mountain Soils**
  - **Red and Yellow Soils**
  - **Black soils**
  - **Lateritic soils**
  - **Saline Soils** &
  - **Desert Soils**

Types of Soil in India



Red Soil

- **Red soils**, one of twelve soil orders in USDA classification known as Ultisols.
- The red and yellow colors result from the accumulation of iron oxide (rust) which is highly insoluble in water.
- Major nutrients, such as calcium and potassium, are typically deficient.
- They generally cannot be used for sedentary agriculture (repeated cultivation of same crop again and again in an year), without the aid of lime and other fertilizers such as superphosphate.
- Crops grown in Red soil includes Groundnuts, Millet, Ragi, Rice, Potatto, Sugarcane, Wheat, etc.

Red and Yellow Soils

- They are less clayey and sandier and are poor in important minerals like lime, phosphorous and nitrogen. Red soil is acidic like that of the Lateritic soil. This soil is mainly cultivated during the monsoon rainy season. Red soils also develop in Manipur, Shillong Plateau and Mizoram.

Black Soil

- The colour of the soil is black because of the presence of certain salts. However, in some places, presence of humus in the soil imparts its black colour.
- Black soils, also called **regur** or **black-cotton soil**,
- This soil becomes sticky when is wet owing to the high quantity of clay deposition. Black soils are generally thin and sandy in the hilly regions of the country.
- It does not contain adequate nitrogen but it contains sufficient phosphorous required for the growth of the plants.
- These soils are spread mostly across the Deccan Lava Plateau, the Malwa Plateau, and interior Gujarat, where there is both moderate rainfall and underlying basaltic rock.
- Black soils are highly argillaceous, very fine-grained and dark and contain a high proportion of calcium and magnesium carbonates.
- These soils have high plasticity and stickiness.
- their iron-rich granular structure makes them resistant to wind and water erosion.
- They are also highly moisture-retentive, thus responding well to irrigation.

Black Cotton soil

Red Soil

Black Soil

ALLUVIAL SOILS

- alluvial soils are mainly found in the plains of northern India. These soils have low phosphorous and nitrogen content. These soils are sandier in their composition. Even in the north western regions of the country which are drier these soils are found.

Lateritic Soil

- Lateritic soil formed due to seasonal variations in tropical temperature and humidity.
- The color of the soil indicates the soils fertility.
- Despite a typically dense vegetation, little decomposed plant material (humus) passes into the soil due to its rapid decay.
- Lateritic soils are rich in Iron and aluminium and poor in potash, nitrogen, phosporic acid and lime.
- Laterite soils are mainly found in capings of flat uplands.

Lateritic soil

Alluvial soil

Desert Soils

- Desert soils are basically sandy texture, poor clay content and lacks in moisture.
- They are saline soils and evaporation is quite rapid.
- Desert soils are generally brown or reddish color
- These soils are favourable for vegetation if there is water content.
- These soils contain an important mineral that is nitrogen.
- They are regions of extremely low rainfall and level of precipitation is below 250 mm per Year.

Desert Soils




Desert Soils

SALINE SOILS

- Saline soils develop in the coastal plains of Kerala and Orissa. In some regions of the country, salt content is in toxic doses. Saline soils are basically black in colour. They are highly acidic.

Mountain soils

- Mountain soils are considered as a significant variety of soil in the Himalayan region of the country. They are mainly found in dry and cold district in the northern region of India.
-

Mountain soil

Textural Classification of Soils

Name of soil separate	*Diameter limits (mm) (USDA classification)*
Clay	less than 0.002
Silt	0.002–0.05
Very fine sand	0.05–0.10
Fine sand	0.10–0.25
Medium sand	0.25–0.50
Coarse sand	0.50–1.00
Very coarse sand	1.00–2.00

Sediment Classification Systems: MNCR, Wentworth and Folk						
phi value	mm	Size Class				
		MNCR		Wentworth		Folk
		Boulder		Boulder		
-8	256					
		Cobble		Cobble		
-6	64					
		Pebble				Gravel
				Pebble		
-4	16					
		Gravel				
-2	4					
				Granule		
-1	2					
		Coarse				
				Very coarse		
-0.5	1.41					
0	1					
				Coarse		
0.5	0.71					
		Medium				
1	0.5					
			Sand			
				Medium	Sand	Sand
1.5	0.35					
2	0.25					
				Fine		
2.5	0.17					
		Fine				
3	0.125					
				Very Fine		
3.5	0.088					
4	0.0625					
		Mud		Silt		Mud

MNCR - Marine Nature Conservation Review,

Soil Texture Triangle

Source: USDA Soil Survey Manual Chapter 3

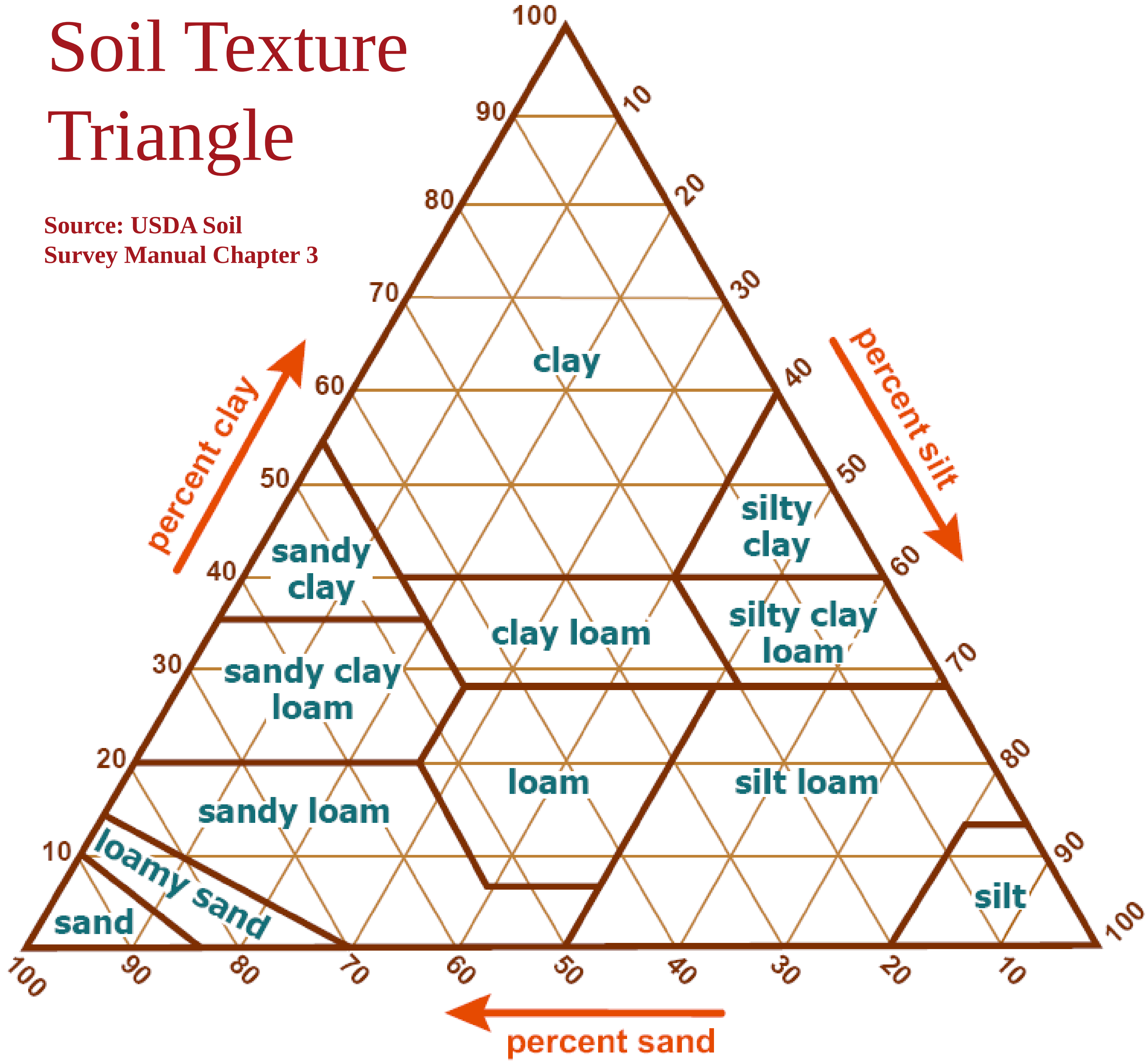


TABLE 2-2 Textural and Other Characteristics of Soils (Holtz and Kovacs, 1981)

Soil name:	Gravels, Sands	Silts	Clays
Grain size:	Coarse grained Can see individual grains by eye	Fine grained Cannot see individual grains	Fine grained Cannot see individual grains
Characteristics:	Nonplastic Granular	Nonplastic Granular	Plastic —
Effect of water on engineering behavior:	Relatively unimportant (exception: loose saturated granular materials and dynamic loadings)	Important	Very important
Effect of grain size distribution on engineering behavior:	Important	Relatively unimportant	Relatively unimportant

It is important to understand the soil units used for general classification of soils

Soil Units

Pedon – smallest three-dimensional unit /volume of soil; natural aggregates; that displays the full range of properties characteristic of a given soil. (1-10 m^2 of area) - the fundamental unit of soil classification

Polypedon – collective of such pedons; group of closely associated pedons in the field

Soil Series – class of soils world-wide which share a common suite of soil profile properties

Pedology - study of soil profiles

Horizon - a layer of soil that can be differentiated from below and up above

Profile - a vertical section of soil through all its horizon down to rock

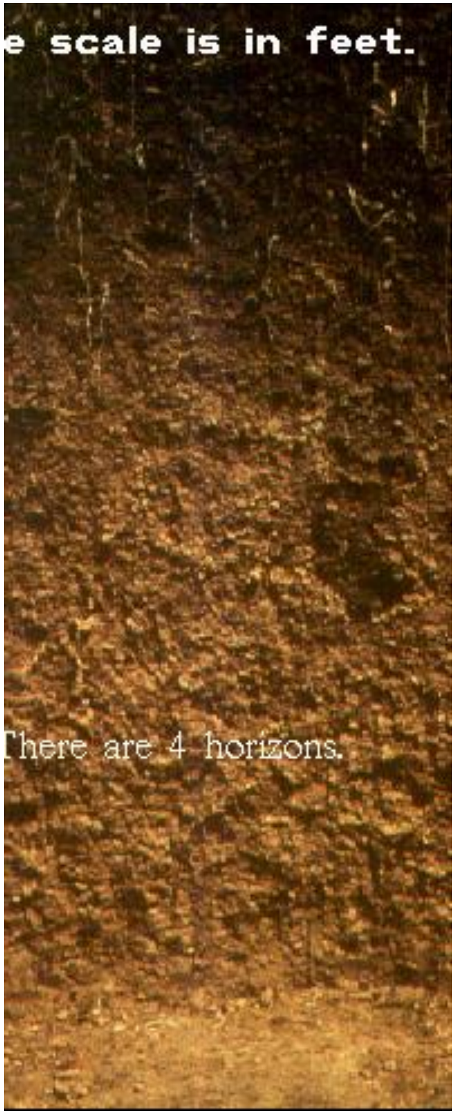
Diagnostic Soil Horizons

Epipedons	Subsurface Soils (Endopedon)
Mollic	Albic
Umbric	Kandic
Ochric	Argillic
Histic	Spodic
Melanic	Oxic
Plaggen	
Anthropic	

Epipedons

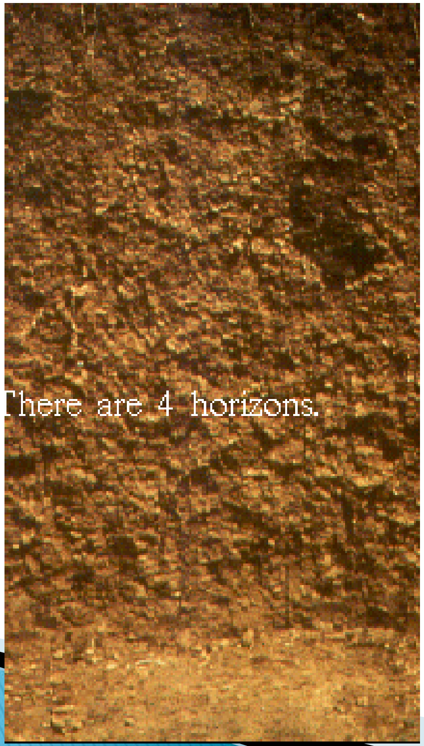
Mollic Epipedon

Thickness	> 18-25 cm
Color	value < 3.5 moist
	chroma < 3.5 moist
Organic Carbon	> 0.6 %
Base Saturation	> 50 %
Structure	strongly developed



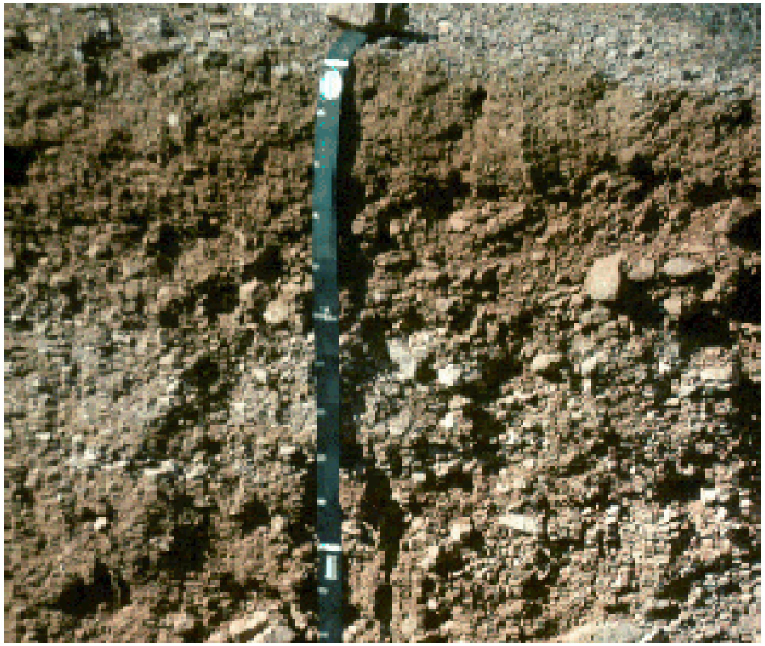
- Umbric Epipedon

- Meets all criteria of the Mollic epipedon, except base saturation < 50%.
- Chemically different than Mollic



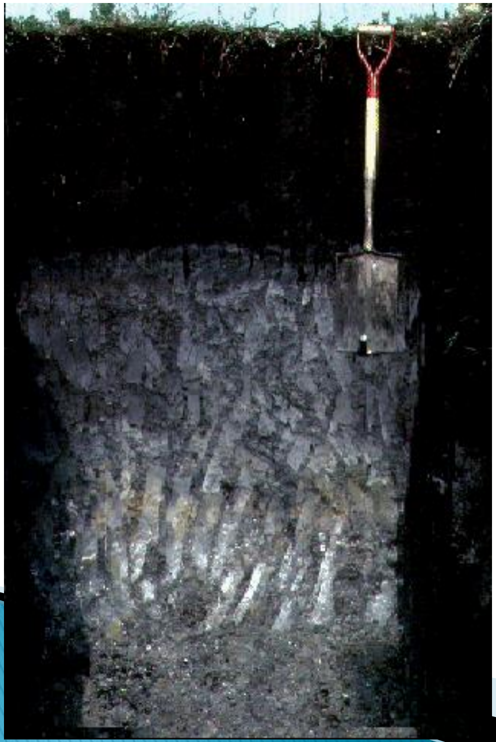
- Ochric Epipedon

- Too thin light low in Organic Matter.
- Ochric = pale
- Extremely common



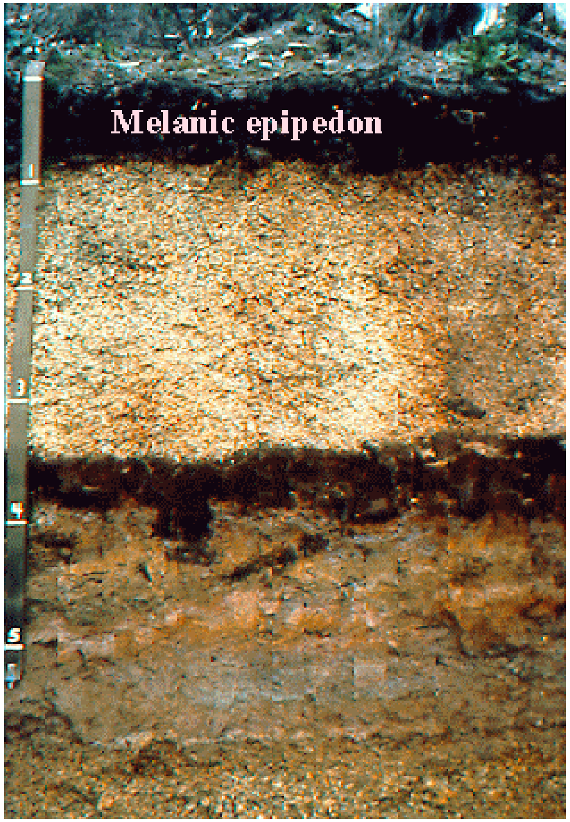
- Histic Epipedon

- Organic horizon Formed in wet areas Black to dark brown Low bulk density = 20-30 cm thick.
- Organic = > 20% - 35% Organic Matter.



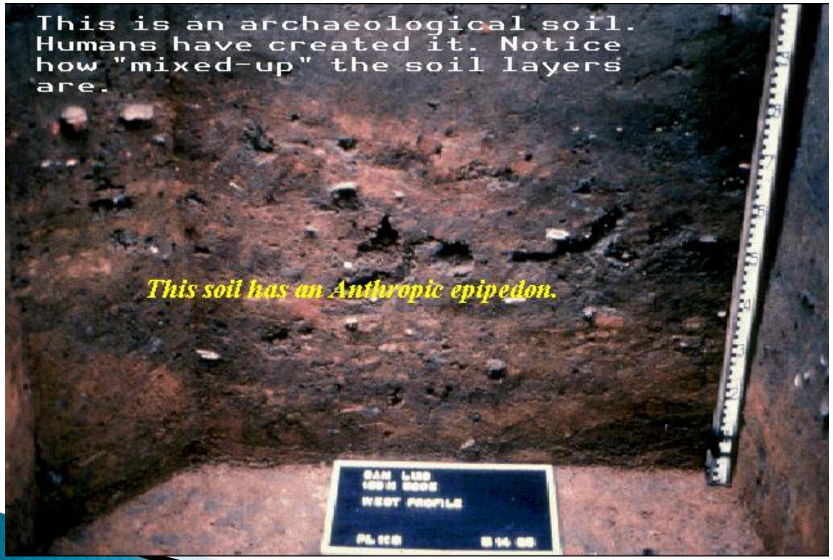
- Melanic Epipedon

- Similar in properties to Mollic
- Formed in volcanic ash
- Lightweight, Fluffy.



Anthropic Horizon

- Resembles mollic (color, organic matter.)
- Use by humans as well as Shells



Plaggen Epipedon

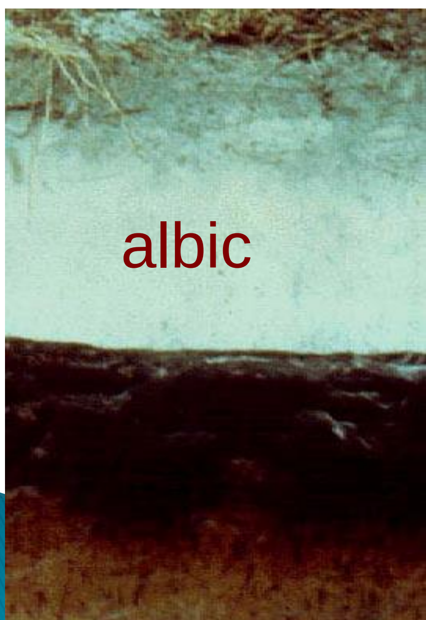
- Produced by long-term (100s yrs.) manuring Old, human-made surface horizon
- > 50 cm thick

Subsurface Pedons

Horizon	Description of detailed soil horizons
O	consists mainly of organic matter from the vegetation, which accumulates under conditions of free aeration.
A	eluvial (outwash) horizon consisting mainly of mineral matter mixed with some humified (decomposed) organic matter.
E	strongly eluviated horizons having much less organic matter and/or iron and/or clay than the horizons underneath. Usually pale coloured and high in quartz.
B	illuvial (inwashed) horizon characterised by concentrations in clay, iron or organic matter. Some lime may accumulate, but if the accumulation is excessive, the horizon is named K.
K	horizon containing appreciable carbonate, usually mainly lime or calcium carbonate.
G	gleyed (wetland / hydric soil) horizons which form under reducing (anoxic) conditions with impeded aeration, reflected in bluish, greenish or greyish colour.
C	weathered parent material lacking the properties of the solum and resembling more the fresh parent material.
R	regolith, the unconsolidated bedrock or parent material.

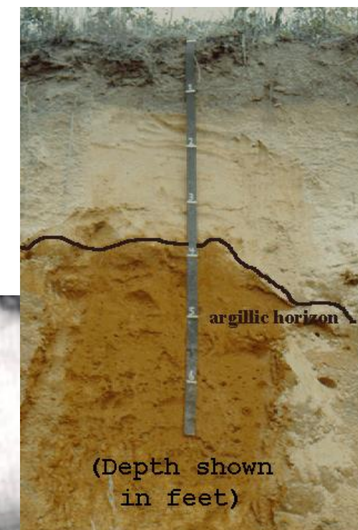
Albic (white) Horizon

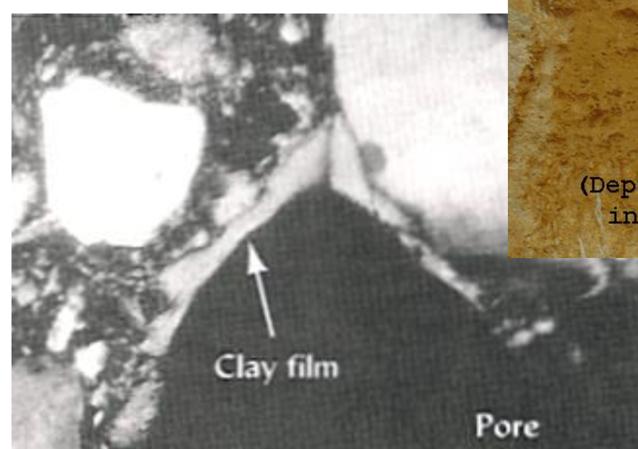
Light-colored (Value > 6 moist) Elluvial (E master horizon*) Low in clay, Fe and Al oxides Generally sandy textured Low chemical reactivity (low CEC) Typically overlies Bh or Bt horizons



Argillic Horizon

Illuvial accumulation of silicate clay Illuvial based on overlying horizon Clay bridges Clay coatings





Spodic Horizon

- Illuvial accumulation of organic matter and aluminum (+/- iron)
- Dark colored (value, chroma < 3)
- Low base saturation (acidic)
- Formed under humid acid conditions

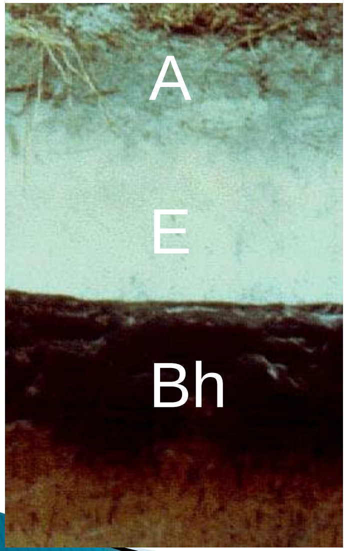
Oxic horizon

- Highly weathered (high temperatures, high rainfall)
  - High in Fe, Al oxides
  - High in low-activity clays

activity

(kaolinite < smectite < vermiculite)

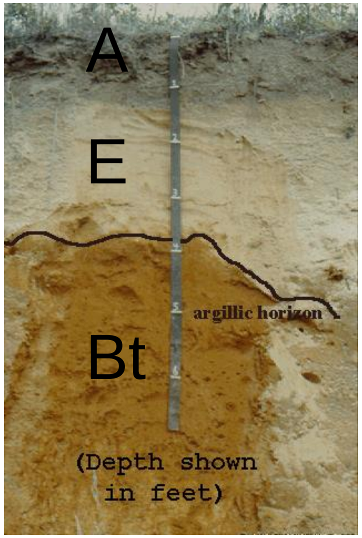
Elluviation and Illuviation



Elluviation (E horizon)

Organic matter → Bh horizon → Spodic horizon

Clays → Bt horizon → Argillic horizon



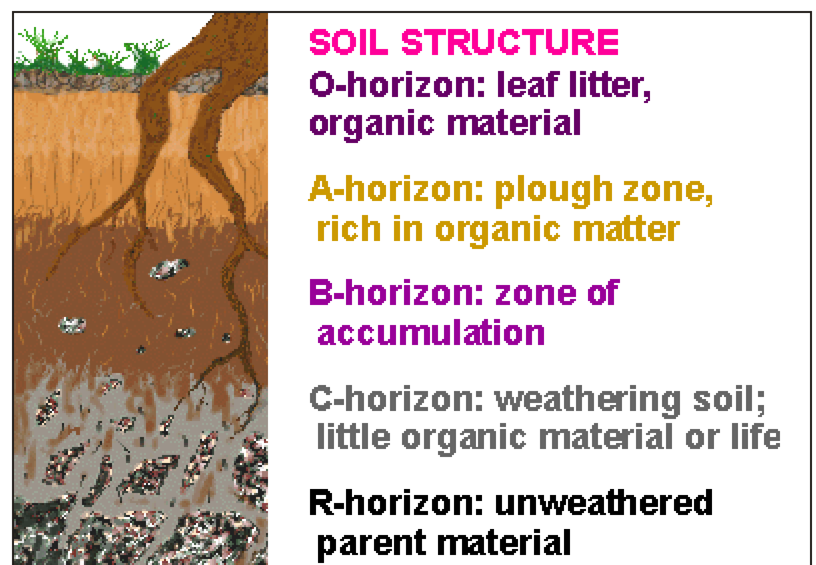
O - Organic horizon

A - elluvial horizon

B - illuvial horizon

C - weathered gneiss

R - rock



Soil profile

- This solid rock give rise to the number of horizons.
- Soil profiles look different in diffe ... the world.

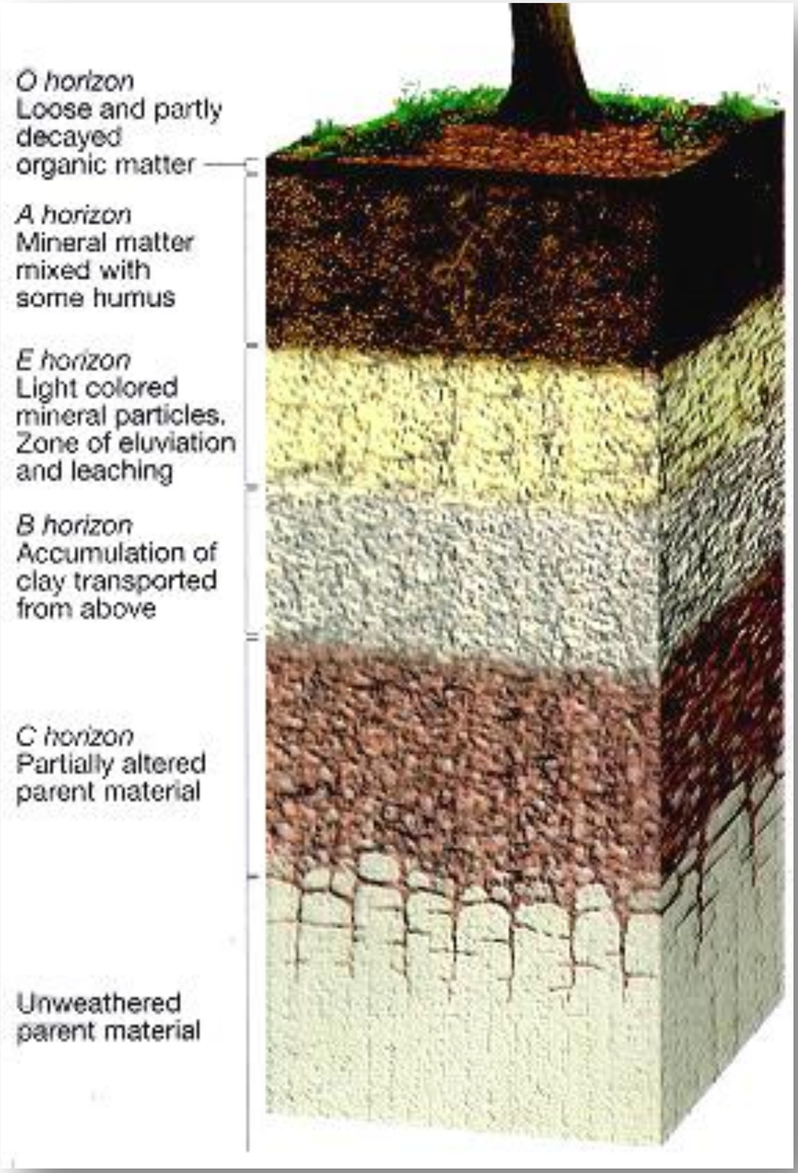
Desert

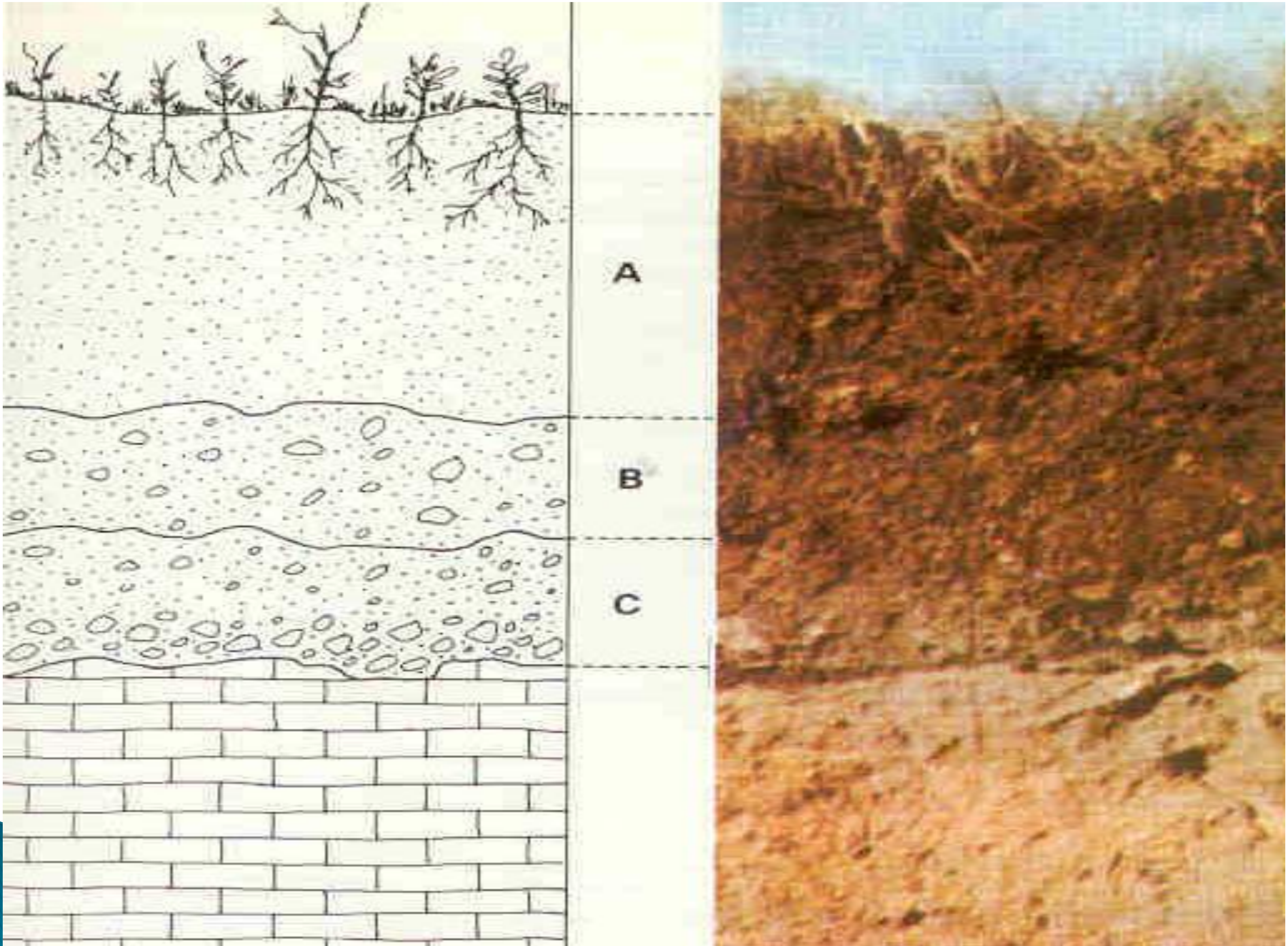
Prairie

Temperate

Soil Profile

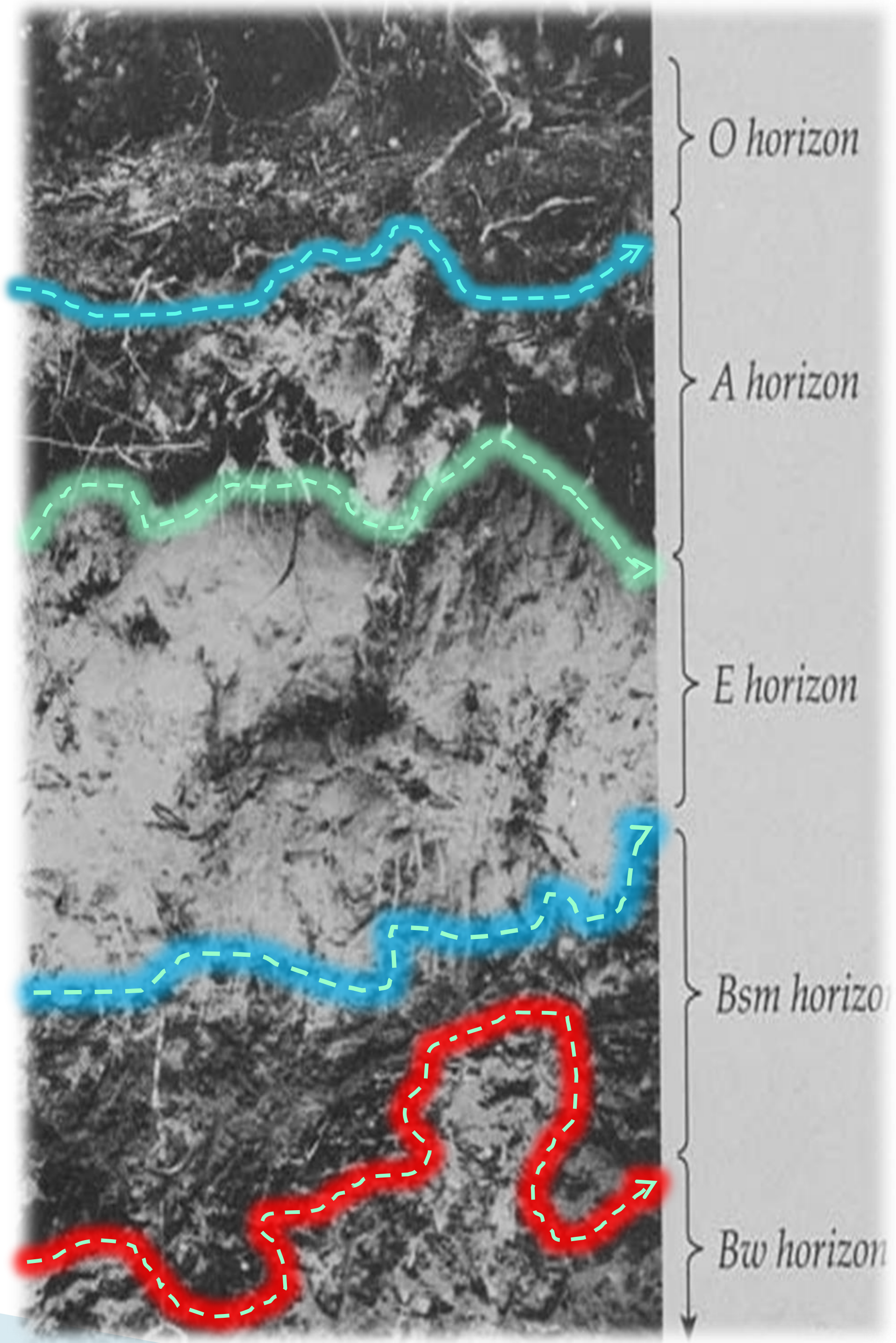
The soil profile is an important tool in nutrient management. By examining a soil profile, we can gain valuable insight into soil fertility. As the soil weathers and/or organic matter decomposes, the profile of the soil changes.




A
B
C

SOIL HORIZONS

- **O - organic horizons.**
- **A - predominatly mineral horizon that is mixed with humified organic** material (an eluvial horizon, i.e. a source of organic material, clay, and cations to lower horizons).
- **E - light colored, bleached mineral horizon underlying the A horizon that** occurs only in highly leached acidic soils.
- **B - mineral horizon that shows little or no evidence of the original rock** structure and which has been altered by oxidation, and illuviation (addition of minerals, clays, and organic matter from the A horizon).
- **K - a subsurface horizon that is characterized by accumulation of calcium** carbonate. Occurs mostly in desert and dry areas.
- **C - a subsurface horizon that is basically the material from which the soil** formed (loess, alluvium, till, etc.). It lacks most of the properties of the A or B horizon, but can be somewhat oxidized (Cox horizon).
- **R - regolith (consolidated bedrock**.



US COMPREHENSIVE SOIL CLASSIFICATION SYSTEM

CATEGORY	DIFFERENTIATING CHARACTER
ORDER	PRESENCE OR ABSENCE OF MAJOR DIAGNOSTIC HORIZON
SUBORDER	GENETIC HOMOGENITY, SOIL MOISTURE REGIMES AND TYPE OF PARENT MATTERIAL
GREATGROUP	SOIL COLOR, SOIL MOISTURE,TEMPERATURE AND DIAGNOSTIC LAYERS
SUBGROUP	***TYPIC*** – REPRESENT CENTRAL CONCEPT ***INTERGRADE*** – HAS PROPERTY THAT TEND TOWARDS OTHER GREAT GROUP OR SUBORDER ***EXTRAGRADE*** – HAS PROPERTY THAT TEND TOWARDS OTHER ORDER
FAMILY	TEXTURE, MINERALOGY AND SOIL TEMPERATURE
SERIES	PLACE NAME

Soil Taxonomy - Scientific grouping of similar soils

U.S. Soil Classification System

The US System classification scheme contains 6 categories:

1. Order – the most general grouping – 10 – 12 orders
2. Suborder – defined by moisture, temp, dominating chemical or textural features – 47 nos.
3. Great Group – by differentiating horizons – 185 nos.
4. Subgroup – three types: typical (typic), intergrade, not one of the other two – 970 nos.
5. Family – plant growth or engineering properties – 4500 nos.
6. Series – common name / local area name – 10,500 nos.

Soil orders are categorised by the nature of the developed pedogenic horizons they contain,

- by the degree of weathering (Oxisols and to some extent ultisols),
- by the importance of swelling clay contents (Vertisols) and
- by being organic soils (Histosols).

Formative elements of the names of soil orders

Table 17-7 Formative elements in the names of soil orders. Modified from *National Soil Survey Handbook 1997*, http://www.statlab.iastate.edu/soils/nssh/. Courtesy of the U.S. Department of Agriculture, Natural Resource Conservation Service.

Name of order	Formative element in name of order	Derivation of formative element	Pronunciation of formative element	Typical vegetation on soils of order
Alfisol	Alf	Al and Fe, symbols for aluminum and iron	Ped*alf*er	Deciduous forest
Andisol	And	J. *ando*, "dark"[a]	*And*esite	Many types
Aridosol	Id	L. *aridus*, "dry"	*Arid*	Desert scrub
Entisol	Ent	Meaningless syllable	Rec*ent*	Many types
Gelisol[b]	El	L. *gelid*, "cold"	G*el*atine	Tundra
Histosol	Ist	Gr. *histos*, "tissue"	H*ist*ology	Marsh
Inceptisol	Ept	L. *inceptum*, "beginning"	Inc*ept*ion	Cool grassland
Mollisol	Oll	L. *mollis*, "soft"	M*oll*ify	Grasslands
Oxisol	Ox	F. *oxide*, "oxide"	*Ox*ide	Tropical rain forest
Spodosol	Od	Gr. *spodos*, "wood ash"	*Od*d	Coniferous forest
Ultisol	Ult	L. *ultimus*, "last"	*Ult*imate	Forest
Vertisol	Ert	L. *verto*, "turn"	Inv*ert*	Many types

[a]J. meaning Japanese

[b]Gelisols, a new order (soils with permafrost), added in 1998.

SIMPLIFIED KEY TO SOIL ORDERS

SOILS WITH >30% OM; HISTIC EPI-PEDON	**HISTOSOLS (ist)**
SOILS WITH A SPODIC HORIZON	**SPODOSOLS (od)**
SOILS WITH AN OXIC HORIZON AND NO ARGILLIC	**OXISOLS (ox)**
SOILS WITH >30% CRACKING CLAY	**VERTISOLS (ert)**
SOILS THAT ARE DRY FOR >6 MONTHS A YEAR	**ARIDISOLS (id)**
SOILS THAT HAVE ARGILLIC HORIZON BUT B.S <50% (Base Saturation)	**ULTISOLS (ult)**
SOILS THAT HAVE MOLLIC EPI-PEDON	**MOLLISOLS (oll)**
SOILS THAT HAVE ARGILLIC (clay) HORIZON	**ALFISOLS (alf)**
SOILS THAT HAVE CAMBIC HORIZON	**INCEPTISOLS (ept)**
SOILS THAT HAVE HISTIC EPI-PEDON WITH <25% OC (Organic Carbon)	**ANDISOLS (and)**
SOILS THAT HAVE PERMAFROST WITHIN 2M OF SURFACE	**GELISOLS (els)**
SOILS THAT HAVE NO DIAGNOSTIC HORIZON	**ENTISOLS (ent)**

SOIL ORDERS (12 major units of classification)

- Alfisols: Relatively high base saturation; not organic rich; evidence of clay transport.
- Andisols: Soils derived major properties from volcanic parent material. High P fixation.
- Aridisols: Arid soils; Low in organic matter; high in salts and pH.
- Entisols: Leftovers; Not well-developed even after long periods (can occur anywhere)

- **Gelisols:** derived from permafrost/glacial regions.

- **Histosols:** Soils formed from organic matter (peats and mucks).

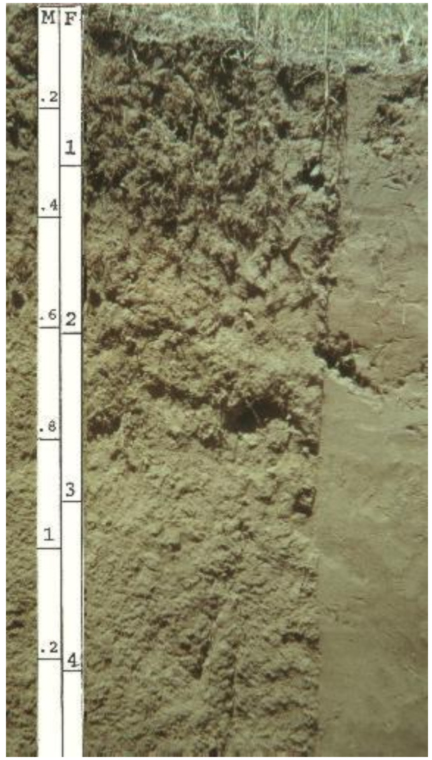
- **Inceptisols:** Still forming; Water is available for soil formation (e.g., glaciated soils).

- **Mollisols:** Brown-black surface horizons; High in organic matter, Vermiculite or Smectite clays; Base saturation usually > 50% (e.g., Iowa farm soils) Most extensive in the US (25%).

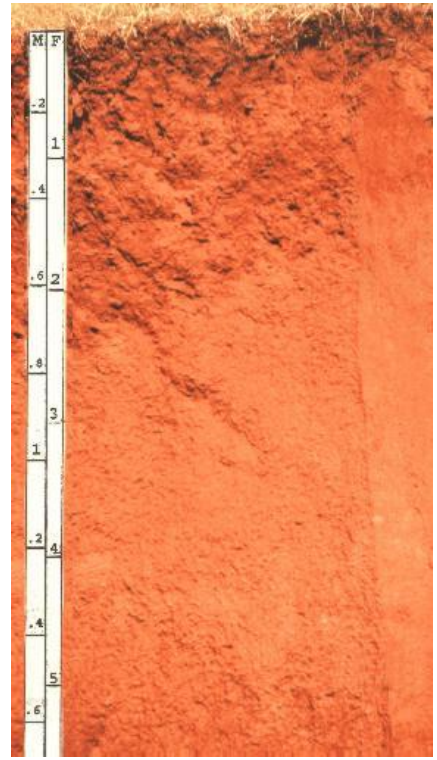
- Oxisols: Highly-weathered; Only quartz, kaolinite, and Fe and Al oxides left (e.g., tropical rainforest).
- Spodosols: Evidence of Fe, Al, and organic matter transport; Often a whitish E Horizon (e.g., boreal forest – with deciduous trees and conifers).
- Ultisols: Clay transport like Alfisols, but much more acidic. Higher temperature; Often highly weathered.
- Vertisols: Mixed soils; Swelling clays, frost, etc cause lower horizons to mix with upper horizons; Often characterized by cracks.

- Entisol - recently formed soils that lack well-developed horizons. Commonly found on unconsolidated sediments like sand, some have an A horizon on top of bedrock.
- Vertisol - inverted soils. They tend to swell when wet and shrink upon drying, often forming deep cracks that surface layers can fall into.
- Inceptisol - young soils. They have subsurface horizon formation but show little eluviation and illuviation.
- Aridisol - dry soils forming under desert conditions. They include nearly 20% of soils on Earth. Soil formation is slow, and accumulated organic matter is scarce. They may have subsurface zones (calcic horizons) where calcium carbonates have accumulated from percolating water. Many aridiso soils have well-developed Bt horizons showing clay movement from past periods of greater moisture.
- Mollisol - soft soils with very thick A horizons.
- Spodosol - soils produced by podsolization. They are typical soils of coniferous and deciduous forests in cooler climates.
- Alfisol - soils with aluminium and iron. They have horizons of clay accumulation, and form where there is enough moisture and warmth for at least three months of plant growth.
- Ultisol - soils that are heavily leached.
- Oxisol - soil with heavy oxide content.
- Histosol - organic soils.
- Andisols - volcanic soils, which tend to be high in glass content.
- Gelisols - permafrost soils.

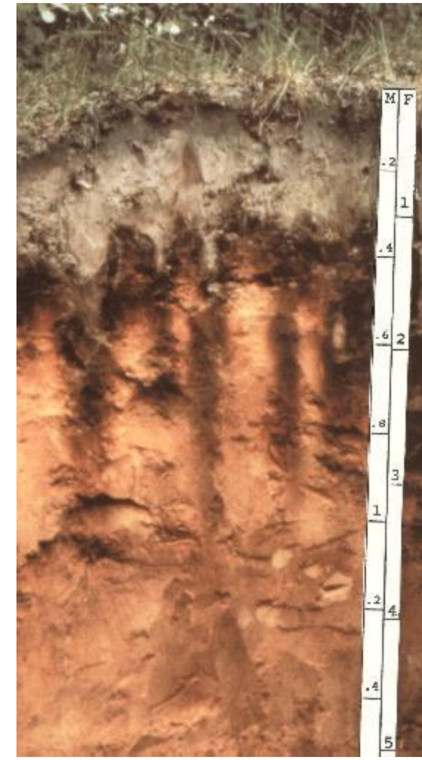
Aridisol



Entisol



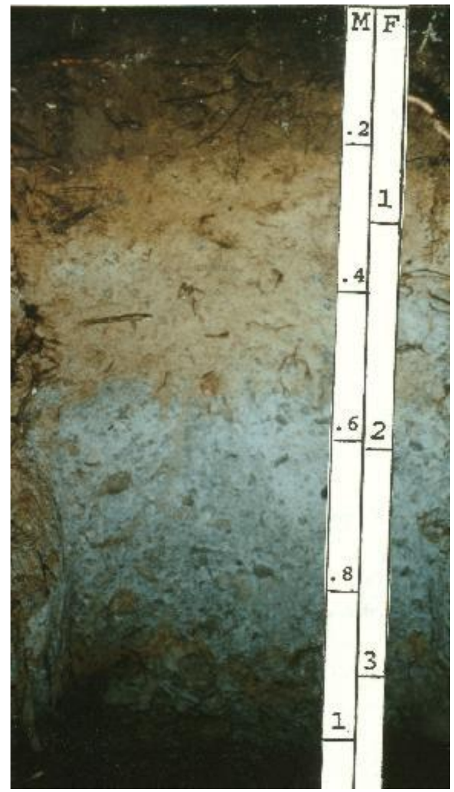
Oxisol



Spodosol

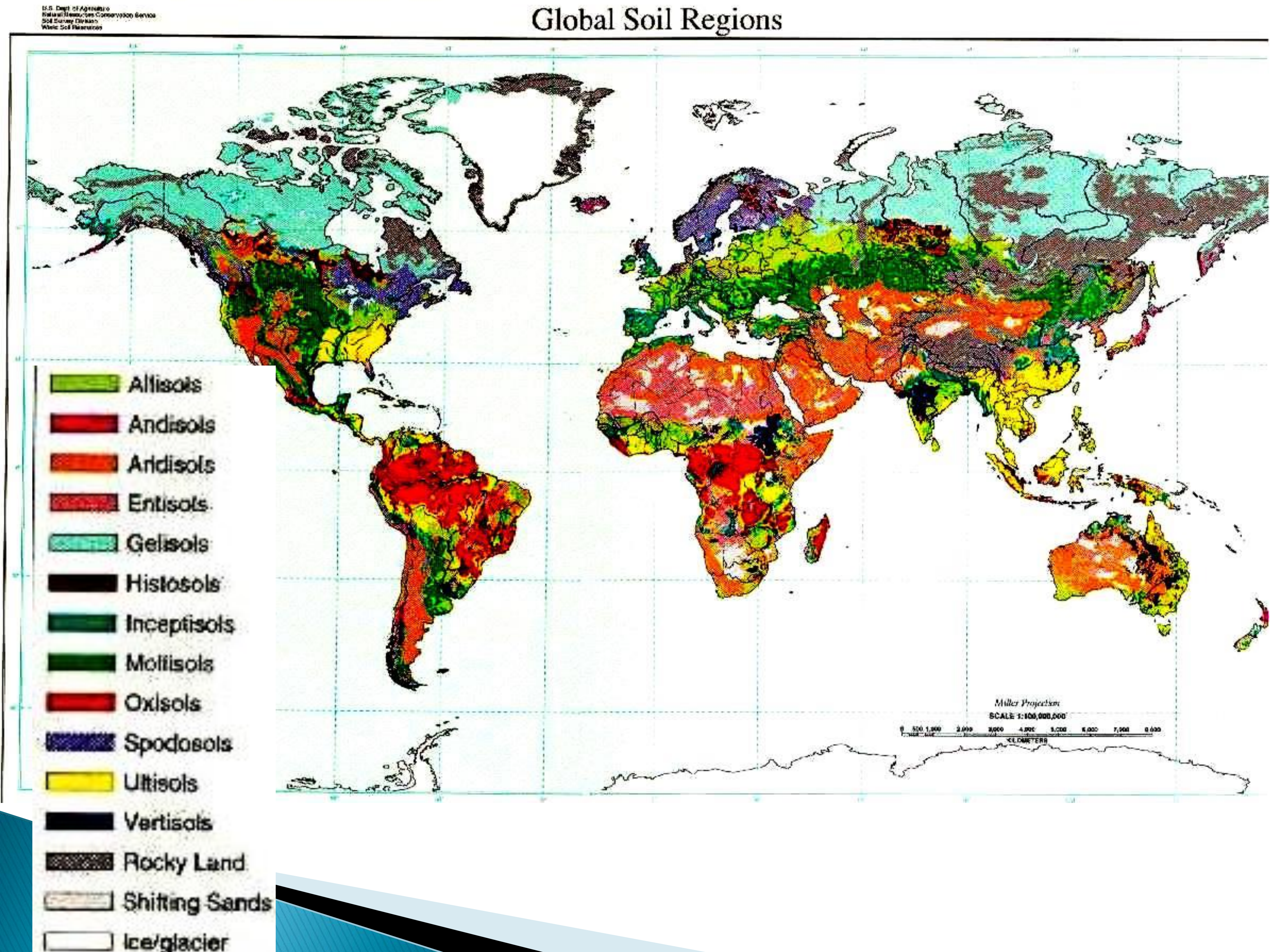
Gelisol

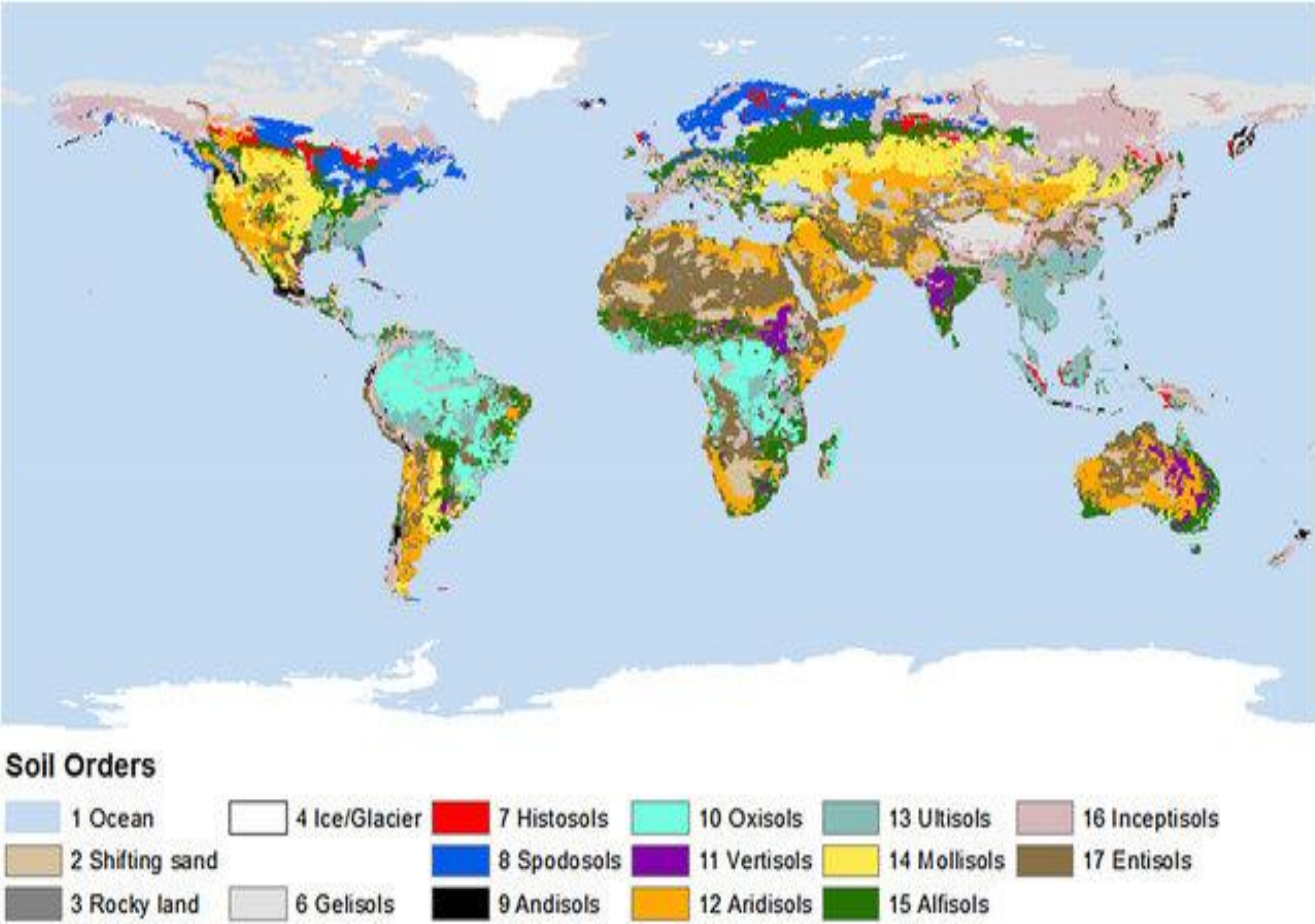
Histosol



Inceptisol

Mollisol


Global Soil Regions
Alfisols
Andisols
Aridisols
Entisols
Gelisols
Histosols
Inceptisols
Mollisols
Oxisols
Spodosols
Ultisols
Vertisols
Rocky Land
Shifting Sands
Ice/glacier
Miller Projection
SCALE 1:100,000,000
KILOMETERS


Soil Orders
1 Ocean
2 Shifting sand
3 Rocky land
4 Ice/Glacier
6 Gelisols
7 Histosols
8 Spodosols
9 Andisols
10 Oxisols
11 Vertisols
12 Aridisols
13 Ultisols
14 Mollisols
15 Alfisols
16 Inceptisols
17 Entisols

Criteria for Hydrological Soil Grouping

CHARACTER	HYDROLOGICAL SOIL GROUPS			
	A	B	C	D
Infilteration rate	High	Moderate	Slow	Very Slow
Texture	Sand or Gravel	Moderately Coarse to fine	Moderately fine to fine	Clay
Depth	Deep	Moderately Deep	Deep	Shallow over an impervious layer / clay
Drainage	Slow	Moderately slow	Moderately well drained	Well to excess
Water Transmission	High	Moderate	Slow	Very Slow
Soil List	Entisols	Inceptisols	Alfisols	Vertisols
Remarks : Runoff Recharge	Low High	- Moderate - - Moderate -		High Low

Soil Genesis

: Evolution of soil from rock

Rock —— Weathering ——→ **Parent Material** —— Soil Forming Factors ——→ **Soil**

physical,
chemical
biological

Climate, topography, time,
Micro organism and
Nature of parent material

Soil Formation

- **Major Soil forming factors (**Jenny 1941**)are :**

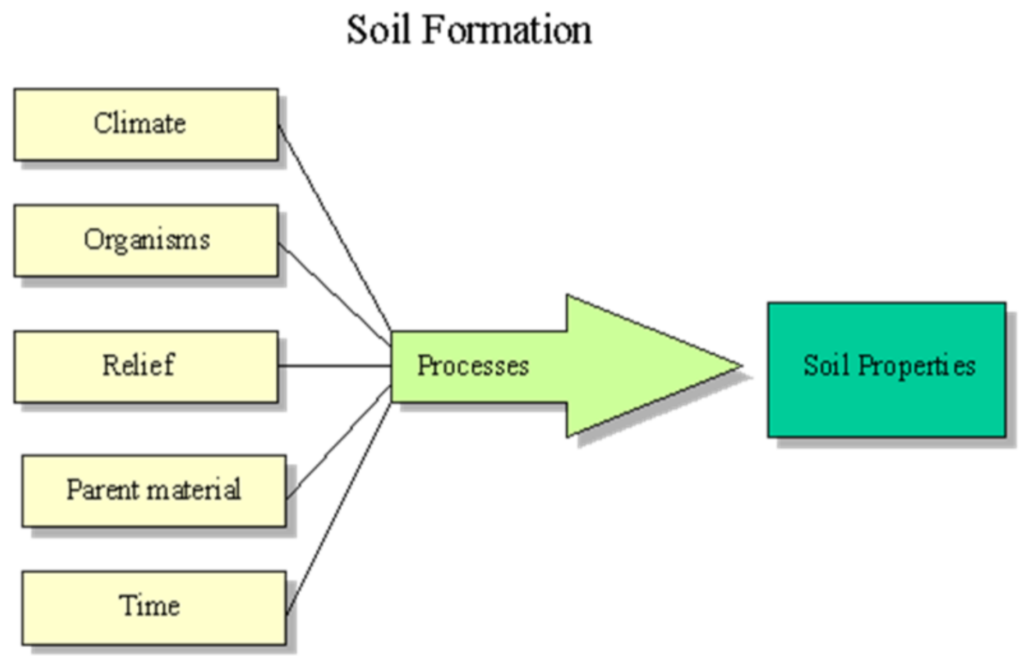
Climatic effects

Biological factors

Shape of the landscape – Topography

Geologic factors

Chronological factors



⁂ $$s = f\,(cl, o, r, p, t, \ldots\ldots)$$

The dots indicate that factors of lesser importance such as mineral accession from the atmosphere, or fire, might need to be taken into account.

The above equation assumes a casual relationship between S and the 5 factors. Jenny has redefined the factors during 1980, as ‘state’ variables and included ecosystem properties, vegetation and animal as well as soil properties.

Parent material and relief define the initial state for soil development, climate and organisms determine the rate at which chemical and biological reactions occur in the soil (the pedogenic processes), and time measures the extent to which a reaction will have proceeded. There is a logical progression: of environment (i.e. the soil forming factors) -> processes -> soil properties underlying the soil formation.

To simplify the application of the above equation, it has been practice to solve it for changes in a soil property **s** when only one of the control variable (e.g. climate) varies, the others being constant or nearly so. The relationship is then called a climofuntion (climate = control variable):

$$\mathbf{s} = f\,(cl)_{\,o,\ r,\ p,\ t,\ \ldots}$$

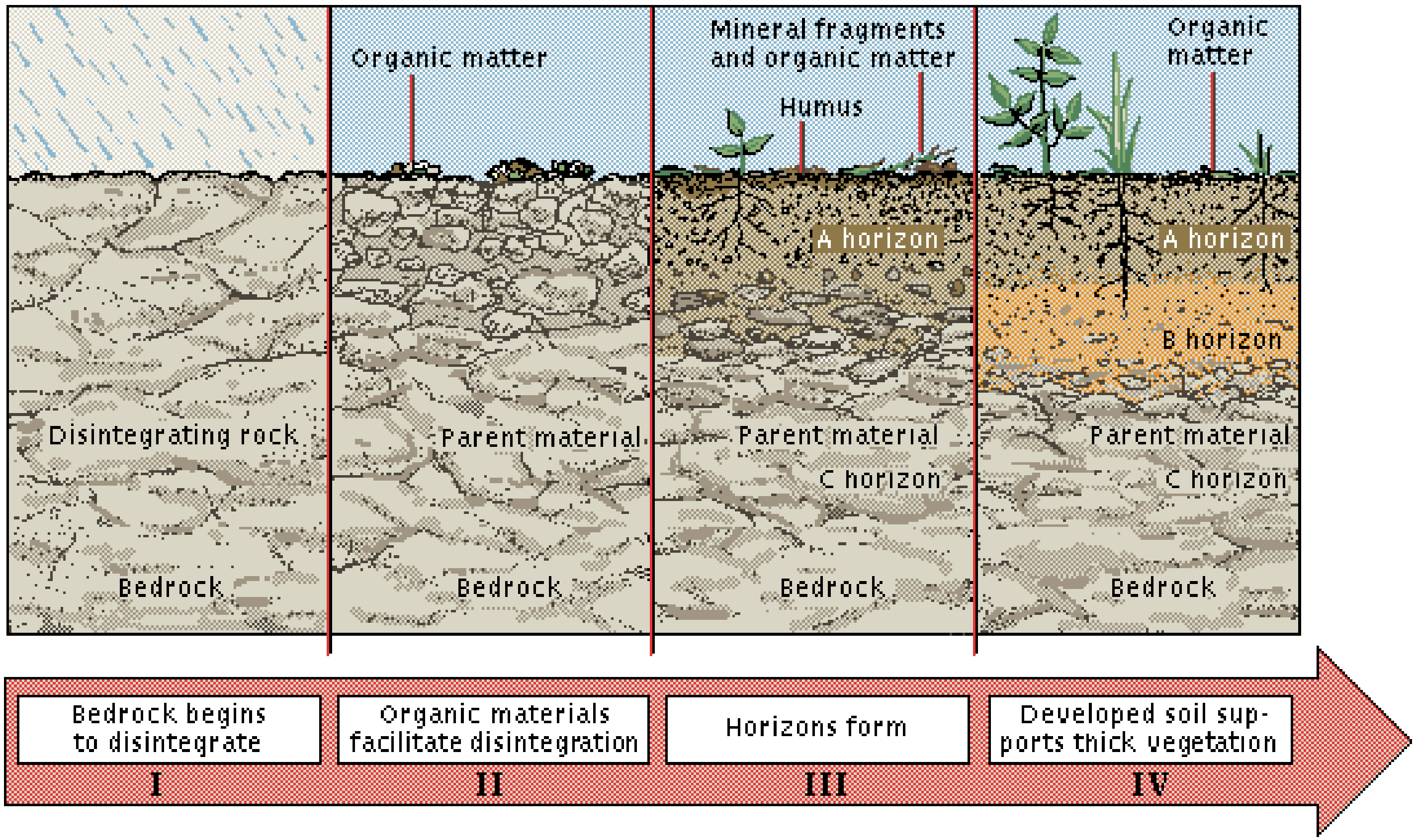
and the range of soils formed is called a climosequence.

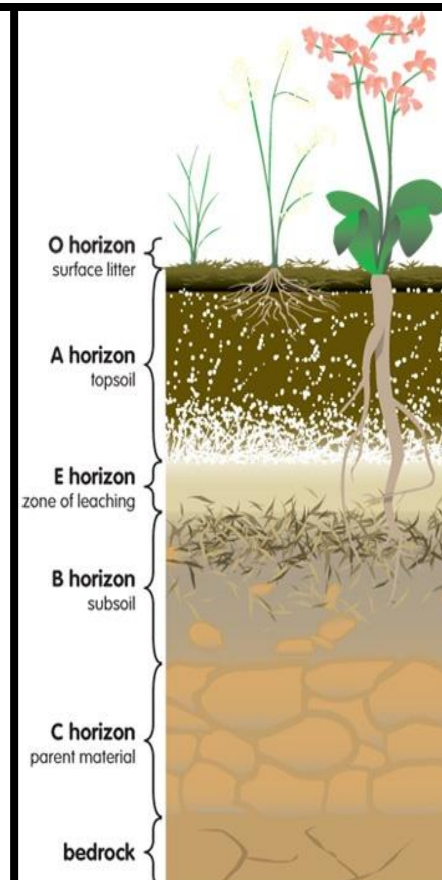
Biosequences, toposequences, lithosequences and chronosequences of soils have been recognized in various parts of the world.

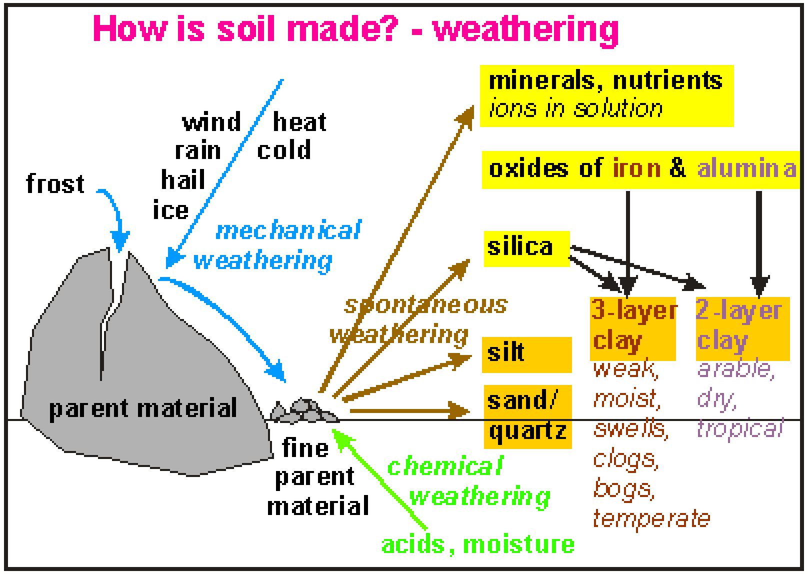
The term toposequence is synonymous with Milne's catena concept (Milne, 1935).

Indeed, the main virtue of Jenny's attempt to quantify the relationship between soil properties and soil forming factors lies not in the prediction of exact values of **s** at a particular site, but rather in identifying **trends** in **properties** and soil groups that are associated with **readily observable changes** in climate, parent material, etc.

STAGES IN FORMATION OF SOIL







During the weathering process, four components are released:

- minerals in solution (cations and anions), the basis of plant nutrition.
- oxides of iron and alumina (sesquioxides Al_2O_3, Fe_2O_3).
- various forms of silica (silicon-oxide compounds).
- stable wastes as very fine silt (mostly fine quartz) and coarser quartz (sand). These have no nutritious value for plants.

(1) It can be created because of the **shape of the landscape**. That shape is called the **topography**. When you have mountains, the sides of the mountains are said to have a slope. When you have a slope and it rains, there will be drainage. The runoff carries away small rocks and minerals. This runoff winds up in valleys or in the ocean. It slowly builds up and the small pieces make soil.

(2) There are **climatic effects** that create soil. Moisture and rain combine with the temperature to do amazing things to rocks. We just explained that when it rains you have runoff and erosion. Those physical activities break down the rocks and hard surfaces. Temperature plays a role when you move below and above the freezing point. When water freezes, it expands. Rocks and soil that hold water can be cracked when the water freezes and expands. They pop open with a cracking sound!

(3) What's in the soil is dependent on **geologic factors**. The type of soil under your feet is dependent on the bedrock deep below the surface. As the bedrock breaks down, smaller pieces move to the surface and mix with the existing soil.

(4) In the same way that there are large geologic factors, **chronological factors** play an important part in the process. Chronological means time. You need time to make soil. That's it. Sediment can move around quickly but it takes a long time to break down bedrock. We can't just sit and watch this process happen. We have to study it over many years. Also, if we pollute our soil we can't renew it in our lifetime. It takes hundreds to thousands of years.

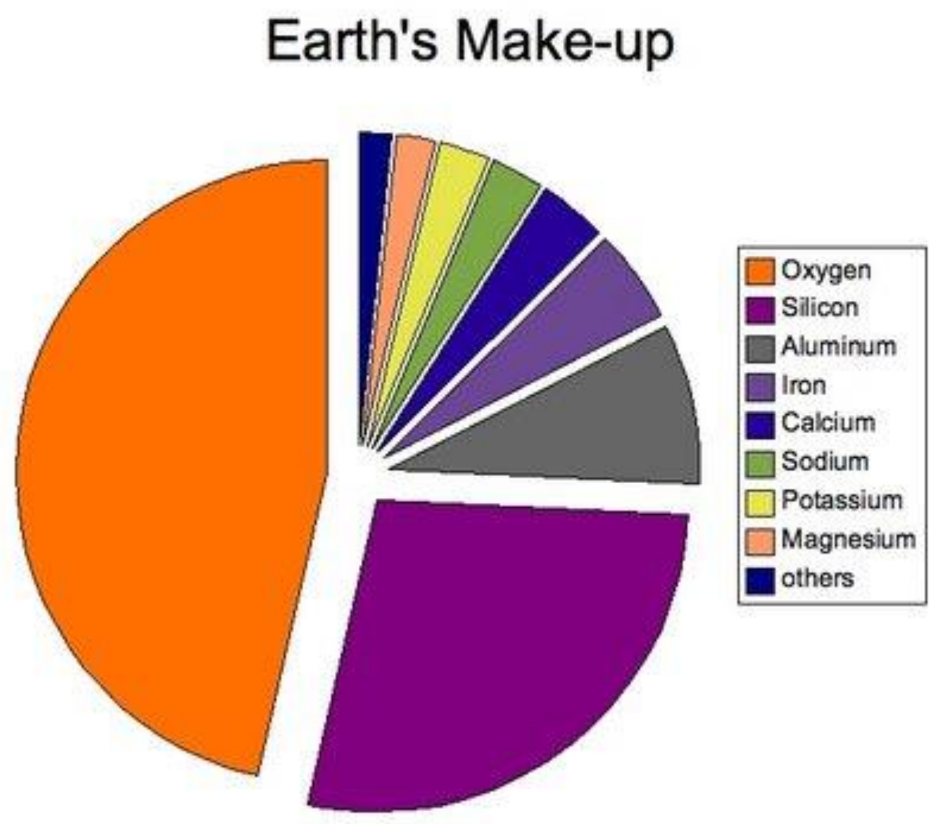
(5) Soil is also created by **biological factors**. You'll find that soil is half minerals/rocks and half air/water. All sorts of biological things are happening in the air/water space. The organic material is most important. There are tiny living organisms (like bacteria) that break down organic stuff. The "stuff" could be dead leaves or dead animals. The organic stuff is called humus. There are also roots and tunneling creatures that work like the microbes. They turn the soil around and move it. They churn the pieces of soil.

Geochemistry and Mineralogy of Soil

- Geochemistry is defined as the study of “the distribution and amount of the chemical elements in minerals, ores, rocks, soil, water, and the atmosphere and the circulation of the elements in nature, on basis of the properties of their atoms and ions.
- Soil development is initiated by the weathering of the bedrock and the incorporation of organic matter.
- These processes produce:
- dissolved matter (bases, silicic acid, Fe, Al, etc.);
- dispersed colloidal particles (e.g. silica, etc.):
- hydroxyls (Fe, Al, etc.):
- organic complexes; and,
- fine particulate matter (clay, clay-sized particles, etc.)

SOIL COMPOSITION

Oxygen (O_2) –46.6%
Silicon (Si) –27.7%
Aluminum (Al) – 8.1%
Iron (Fe) –5.0%
Calcium (Ca) –3.6%
Sodium (Na) –2.8%
Potassium (K) – 2.6%
Magnesium (Mg) –2.1%
others –1.6%



Geochemistry of soil types

- **Laterites** – Residual Deposits – in hot semi-arid regions, where evaporation from the ground is rapid and nearly equal to the rainfall and where there is little frost action, chemical decomposition of the rocks proceeds to great lengths and a hard, superficial crust is formed by the deposition of mineral matter just below the soil. The water from the occasional rains carries dissolved salts only a short distance below the surface, where they are retained by capillarity, with the result that as evaporation proceeds a mineral deposit is built up.
- If the solutions are saturated with calcium carbonate the deposit will be a calcareous one, like **Kankar.**
- If the solutions are ferruginous, such as would result from decomposition of basic igneous rocks, a red concretionary deposit called **laterite** may be formed. Laterite is **hydrated ferric oxide**, generally with some **alumina and silica**; its composition varies according to the nature of the underlying rock and the amount of chemical breakdown that has gone on. "Iron Pan" is the hard variety of laterite – used as rough building stone.

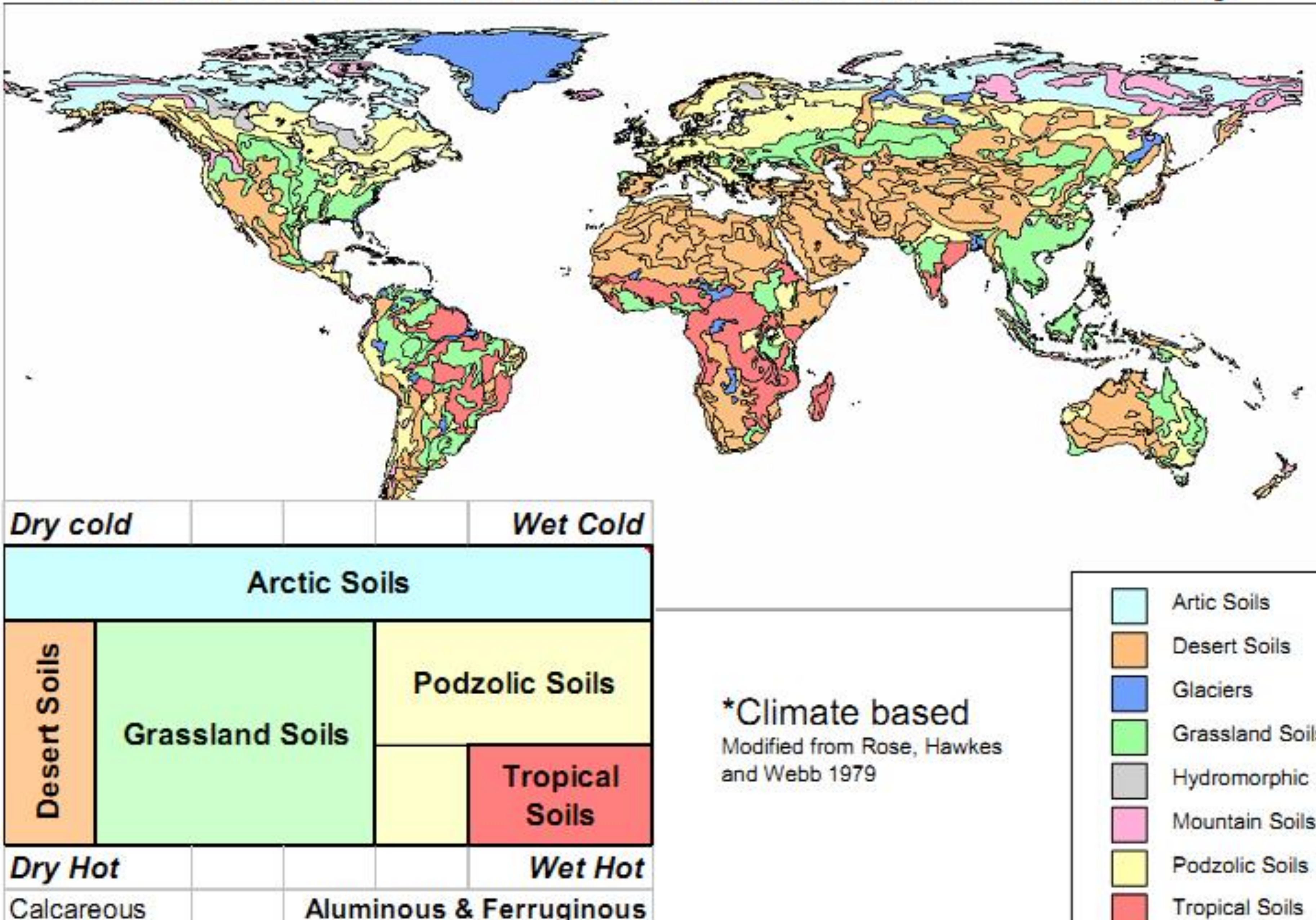
Geochemistry of soils...........

- **Bauxites** – Residual deposit – consists essentially of **hydrated alumina**, forms residual deposits resulting from the weathering, under tropical conditions, of igneous and other rocks containing aluminium.

- **Aridisols** – Develop in areas of low rainfall and from almost any kind of parent material; their characteristics are, therefore, extremely variable. Because of the absence (or low incidence) of leaching, in one or more horizons there is usually a concentration of **calcium carbonate, gypsum and/or soluble salts**.

Vertisols – develop from parent materials high in limestones, marls or basic rocks such as basalt. Because of their high clay content (more than 30% clay – mostly Montmorillonitic), they expand and contract (shrink and swell) highly. Occur in humid to semiarid climates. Light coloured horizon below 3ft may contain more than **50% of CaCO3.**

Geochemical Version on the FAO Soil Map*



*Climate based
Modified from Rose, Hawkes and Webb 1979

Soil Mineralogy

- Clay minerals – <2 micrometers–microns
- Mostly newly formed crystals reformed from the soluble products of primary minerals and may be considered as secondary minerals.
- **Montmorillonite** and **Vermiculite** – have expanding layers, have **high CEC** (cation exchange capacities) and **high swelling**
- **Illite, Chlorite** and **Kaolinite** – have **low CEC** and **low swelling**
- **Sesquioxides** – Iron and Aluminium oxides and **hydrous oxides** – have **still lower values of CEC** and **swelling**
- **Amorphous** – O, Al, Si
- **Crystalline clays** – like a partial deck of cards.

SOIL COMPONENTS

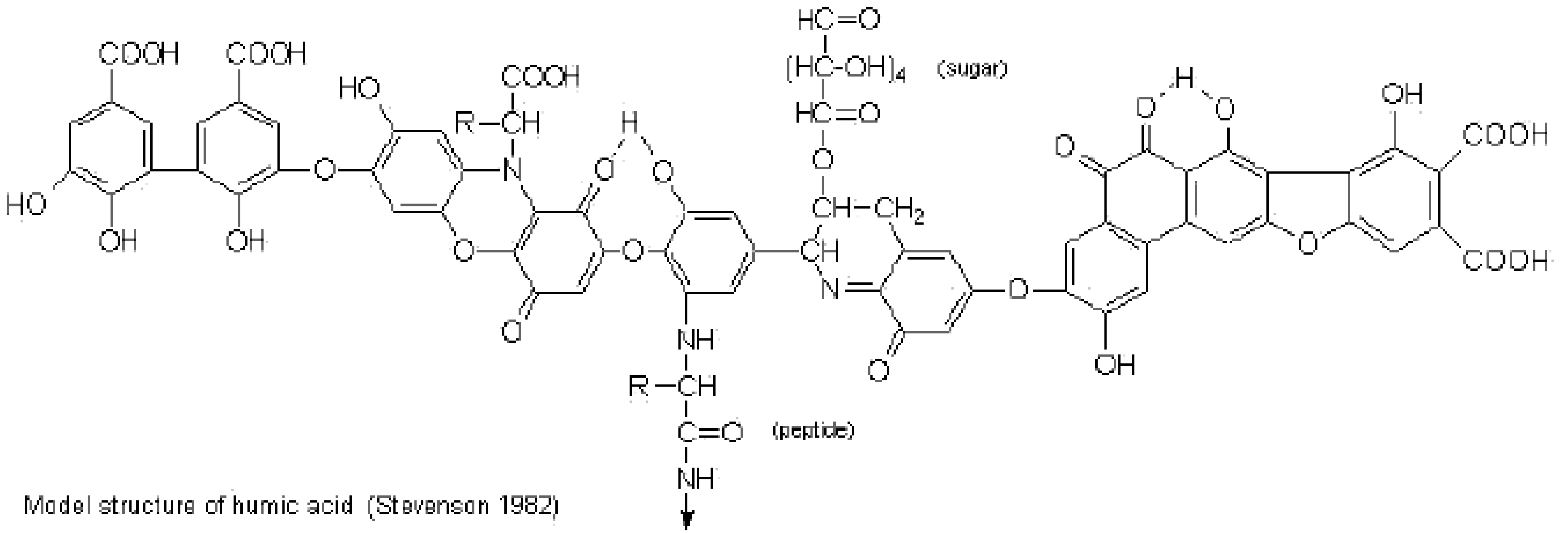
- **Resistate phases** – Zircon, Cassiterite, Quartz
- **Clay minerals** – Kaolinites, Smectites
- **Fe** and **Mn oxides**
- **Organic matter** (humic and fulvic acid)
- **Carbonates**
- **Amorphous material**

➢ Via - Mechanisms

- Structural presence, Adsorption, Complexation, Coprecipitation & Chelation.

HUMIC AND FULVIC ACID

- A substantial fraction of the mass of the humic acids is in carboxylic acid functional groups, which endow these molecules with the ability to chelate (bind) positively charged multivalent ions (Mg++, Ca++,Fe++, Cd++ and Pb++.)



Model structure of humic acid (Stevenson 1982)

Soil Mineralogy classes for family groupings

- Mineralogy classes that apply to any particle-size class: **Carbonatic, Ferritic, Gibbsitic, Serpentinitic, Gypsic** or **Glauconitic** – named to those have over 40% of that mineral in sand / silt / clay accordingly.
- **Oxidic** – has less than 90% quartz and also has other limitations.
- Mineralogy classes that apply to soils having a sandy, sandy-skeletal, loamy or loamy-skeletal particle-size class: **Micaceous** (0ver40% mica), **Siliceous** (0ver90% of silica) or **Mixed** (less than 40% of any one mineral).
- Mineralogy classes that apply to clayey or clayey-skeletal particle sizes (each with over 50% of the clay mineral indicated by adjective name): **Halloysitic, Kaolinitic, Montmorillonitic, Illitic, Vermiculitic** or **Chloritic**. The term "**Mixed**" is used for other soils.
- Modifiers that substitute in some soil family names for other adjective that connote particle-size and mineralogy class: **Cindery** (60% volcanic ash or cinders), **Ashy, Ashy-skeletal, Medial** (loamy feel), **Medial-skeletal, thixotropic** (becomes gel like on standing), or **Thixotropic skeletal**.

Soil Mineralogy

- Primary minerals—
  - inherited from parent material
  - igneous and metamorphic
  - sand and silt fraction (mostly)
- Secondary minerals—
  - formed under "normal" temperature and pressure
  - formed in the soil environment or inherited from sedimentary parent material
  - clay fraction (mostly)

Pauling's Rules

- Linus Pauling studied crystal structures and the types of bonding and coordination that occurs within them. These are useful for Soil Mineralogy studies. The geometry of these rigid spheres is governed by Pauling's Rules

Rule 1

- ***Around every cation, a coordination polyhedron of anions forms, in which the cation–anion distance is determined by the radius sums and the coordination number is determined by the radius ratio.***

Rule 2, The Electrostatic Valency Principle

- *An ionic structure will be stable to the extent that the sum of the strengths of the electrostatic bonds that reach an ion equal the charge on that ion.*

Rule 3

- *Shared edges, and particularly faces of two anion polyhedra in a crystal structure decreases its stability.*

Rule 4

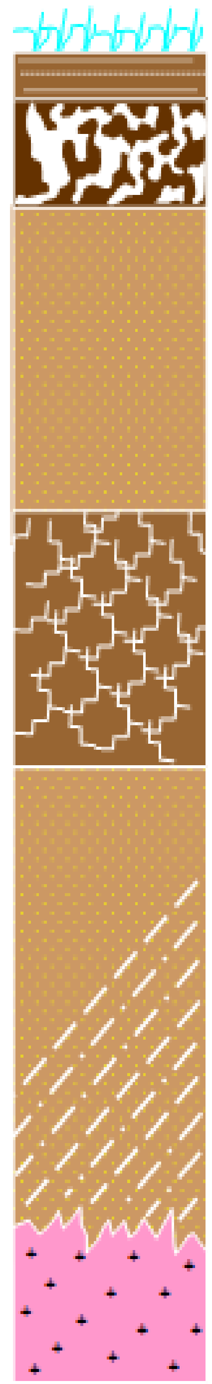
- *In a crystal structure containing several cations, those of high valency and small coordination number tend <u>not</u> to share polyhedral elements.*

Rule 5, The Principle of Parsimony

- *The number of different kinds of constituents in a crystal tends to be small.*

The Solum (the generic soil developed by soil-forming processes)

- Horizons of maximum biological activity, of eluviation (removal of materials suspended or dissolved in water), or both.
- Horizons of illuviation (accumulation of material by deposition or precipitation from percolating water).



O — Organic debris only partially decomposed

A1 — Dark-colored horizon, organic (humus) rich; mixed with mineral matter.

A2 — Light-colored horizon of maximum eluviation. Prominent in some soils, faint or absent in others. Generally loose structure.

B — Brown to orange-brown horizons. Accumulation of clay minerals or of iron and organic matter; compact blocky, prismatic structure.

C — Parent material derived by weathering. Some soils show intensely gleyed layers (Horizon G of hydromorphic soils; G may appear directly beneath A), or layers of calcium carbonate (Horizon C Ca of calcareous soils).

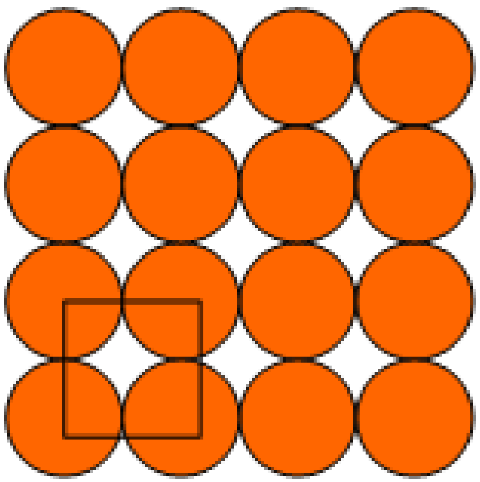
R — Bedrock

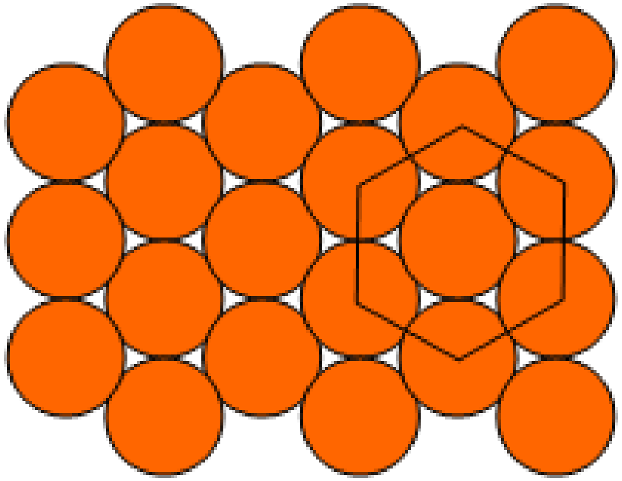
Modified from Rose, Hawkes and Webb 1979

Types of silicate minerals :

- The different minerals are a results of differences in the sharing of O and the presence or absence of different cations.
- Range from no sharing (Nesosilicates) to sharing of each O with 2 Si (tectosilicates)
- Zeolites are an interesting form of Tectosilicates.

- Basic Structural Concepts
- Cubic Close Packing (CCP).
- Hexagonal Close Packing (HCP).





- (A) (B)

HCP

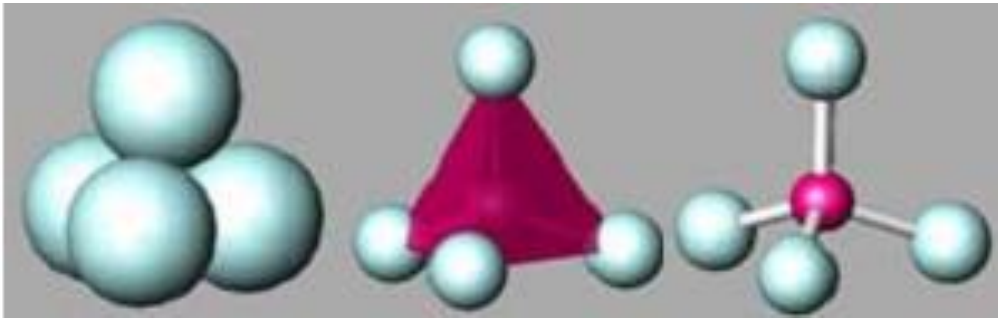
Two types of voids:

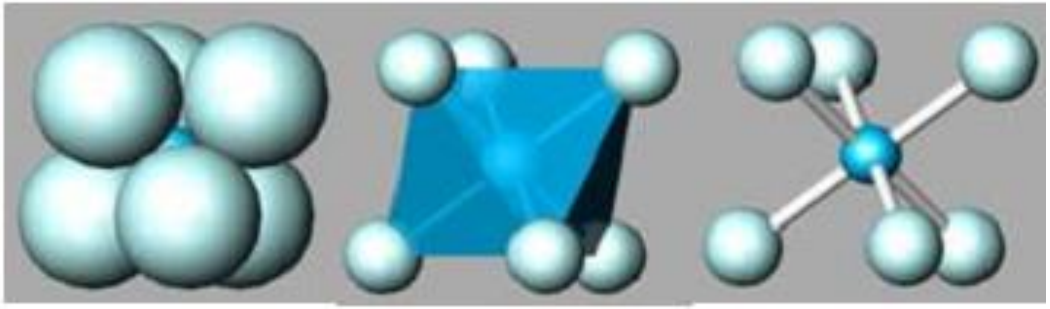
A – void constrained by 4 spheres

- Tetrahedral coordination

B – void constrained by 6 spheres

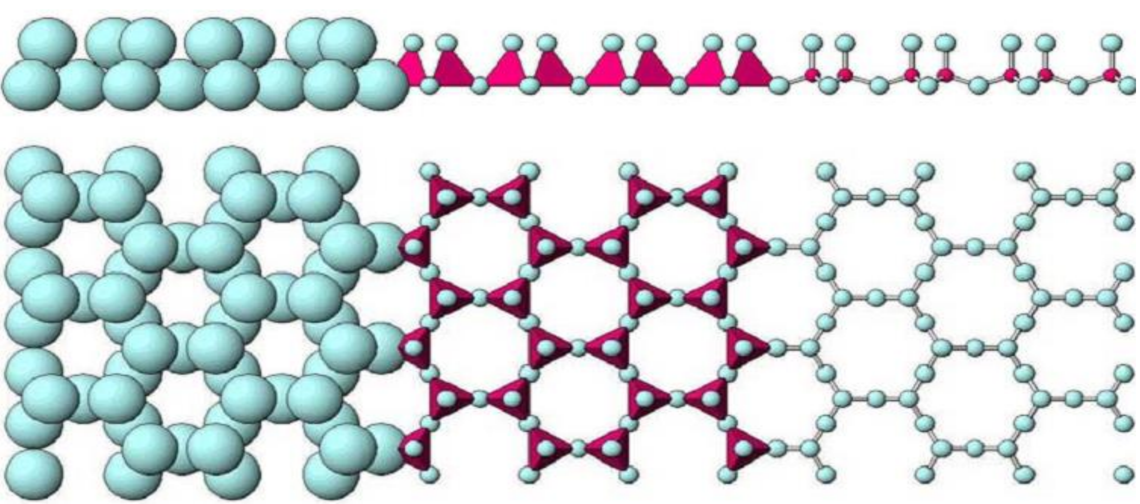
- Octahedral coordination

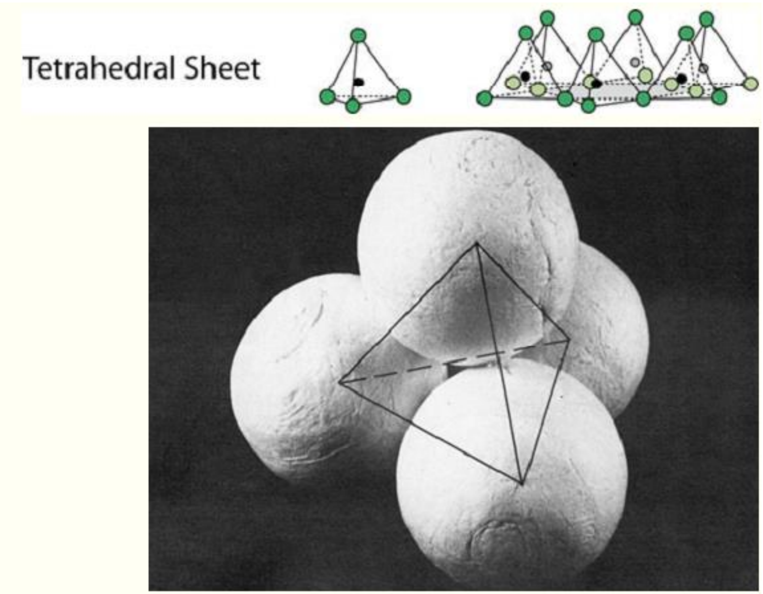




TETRAHEDRAL SHEET

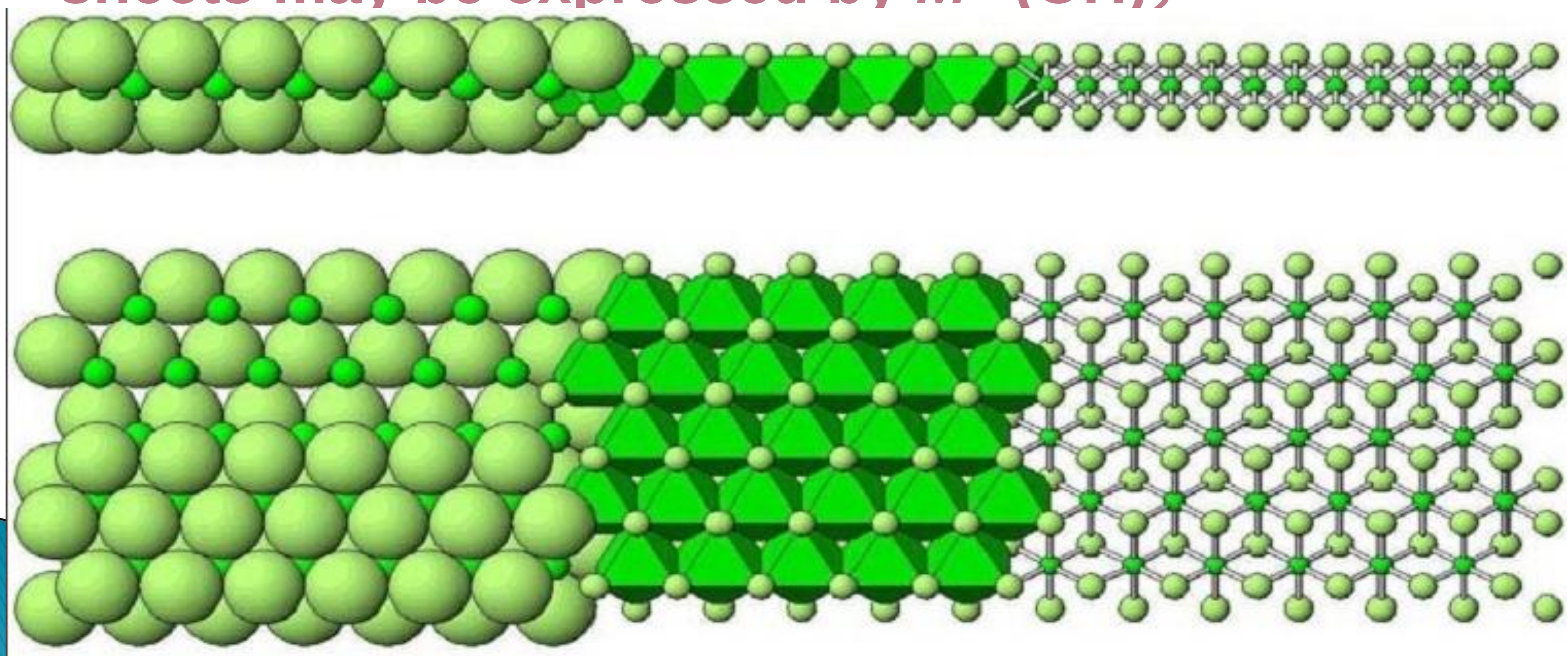
- Sheet of horizontally linked, tetrahedral-shaped units that serve as one of the basic structural components of silicate clay minerals.
- Each unit consists of a central four-coordinated atom (e.g. Si, Al, or Fe) surrounded by four oxygen atoms that, in turn, are linked with other nearby atoms (e.g. Si, Al, or Fe), thereby serving as inter-unit linkages to hold the sheet together.



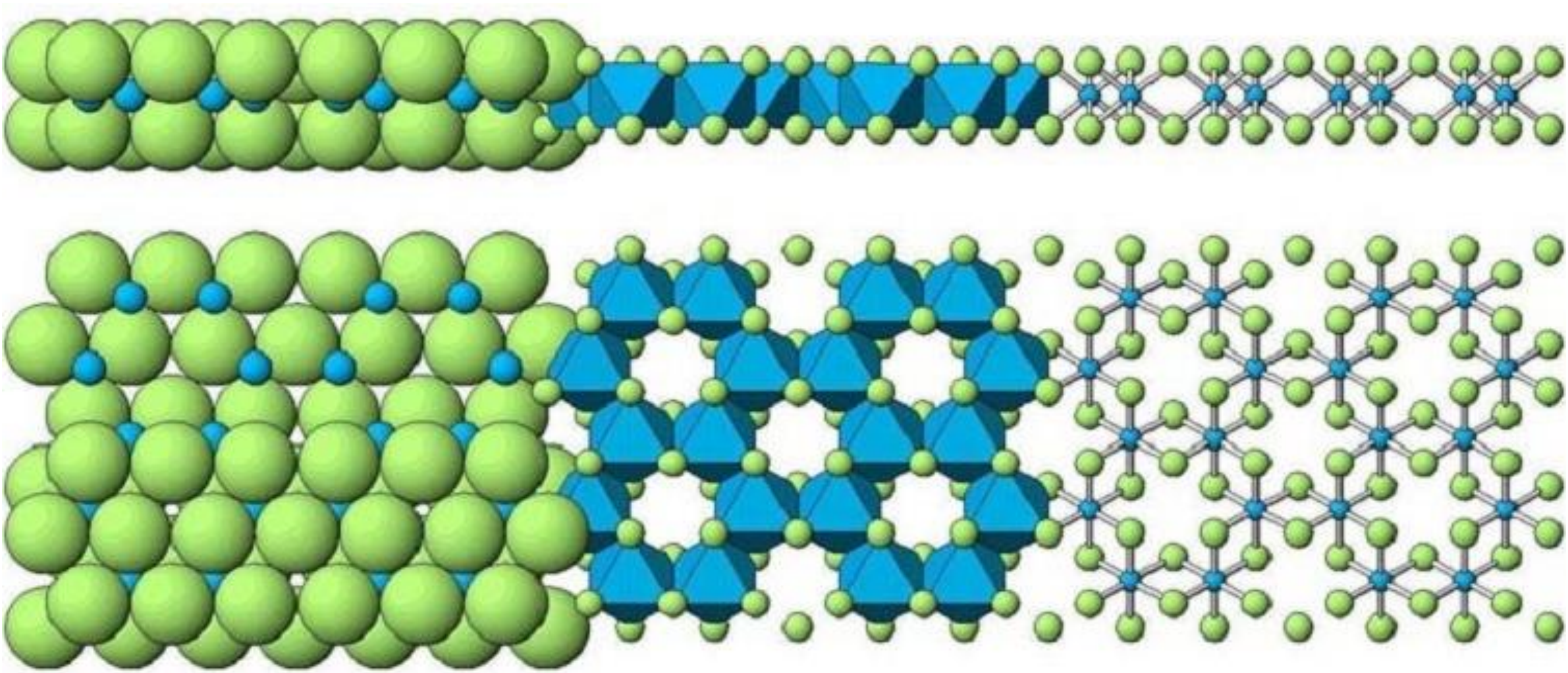


TRIOCTAHEDRAL SHEET

- **Two-thirds of the octahedrons are occupied, with the absence of the third octahedron.**
- **The former type of octahedral sheet is called trioctahedral, and the latter dioctahedral.**
- **If all the anion groups are hydroxyl ions in the compositions of octahedral sheets, the resulting sheets may be expressed by $M^{2+}(OH)_2$**



DIOCTAHEDRAL SHEET



Common Minerals-SILICATES

Mineral (Phase)	Component	Component Formula
Olivine	Forsterite	Mg_2SiO_4
	Fayalite	$Fe_2^{2+}SiO_4$
Garnet	Pyrope	$Mg_3Al_2Si_3O_{12}$
	Almandine	$Fe_3^{2+}Al_2Si_3O_{12}$
	Spessartine	$Mn_3Al_2Si_3O_{12}$
	Grossular	$Ca_3Al_2Si_3O_{12}$
	Andradite	$Ca_3Fe_2^{3+}Si_3O_{12}$
	Uvarovite	$Ca_3Cr_2^{3+}Si_3O_{12}$
Sillimanite	Sillimanite	Al_2SiO_5
Kyanite	Kyanite	Al_2SiO_5
Andalusite	Andalusite	Al_2SiO_5

Mineral (Phase)	Component	Component Formula
Zircon	Zircon	ZrSiO4
Orthopyroxene	Enstatite	$Mg_2Si_2O_6$ ($MgSiO_3$)
	Ferrosilite	$Fe_2{}^{2+}Si_2O_6$ (Fe_2+SiO_3)
	Diopside	$CaMgSi_2O_6$
	Hedenbergite	$CaFe^{2+}Si_2O_6$
Clinopyroxene	Diopside	$CaMgSi_2O_6$
	Hedenbergite	$CaFe^{2+}Si_2O_6$
	Enstatite	$Mg_2Si_2O_6$ ($MgSiO_3$)
	Ferrosilite	$Fe_2{}^{2+}Si_2O_6$ ($Fe^{2+}SiO_3$)
	Jadeite	$NaAlSi_2O_6$
Wollastonite	Wollastonite	$CaSiO_3$

Mineral (Phase)	Component	Component Formula
Amphiboles (only Mg end –members, Fe end –members also exist)		
Cummingtonite	Cummingtonite	$Mg_2Mg_5Si_8O_{22}(OH)_2$
Gedrite	Gedrite	$Mg_2Mg_3Al_2Si_6Al_2O_{22}(OH)_2$
Tremolite	Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$
Hornblende	Hornblende	$Ca_2Mg_4AlSi_7AlO_{22}(OH)_2$
Pargasite	Pargasite	$NaCa_2Mg_4AlSi_6Al_2O_{22}(OH)_2$
Muscovite	Muscovite	$K_2Al_4Si_6Al_2O_{20}(OH)_4$
Biotite	Phlogopite	$K_2Mg_6Si_6Al_2O_{20}(OH)_4$
	Annite	$K_2Fe_6^{2+}Si_6Al_2O_{20}(OH)_4$
Talc	Talc	$Mg_6Si_8O_{20}(OH)_4$
Kaolinite	Kaolinite	$Al_2Si_2O_5(OH)_4$

NON-SILICATES

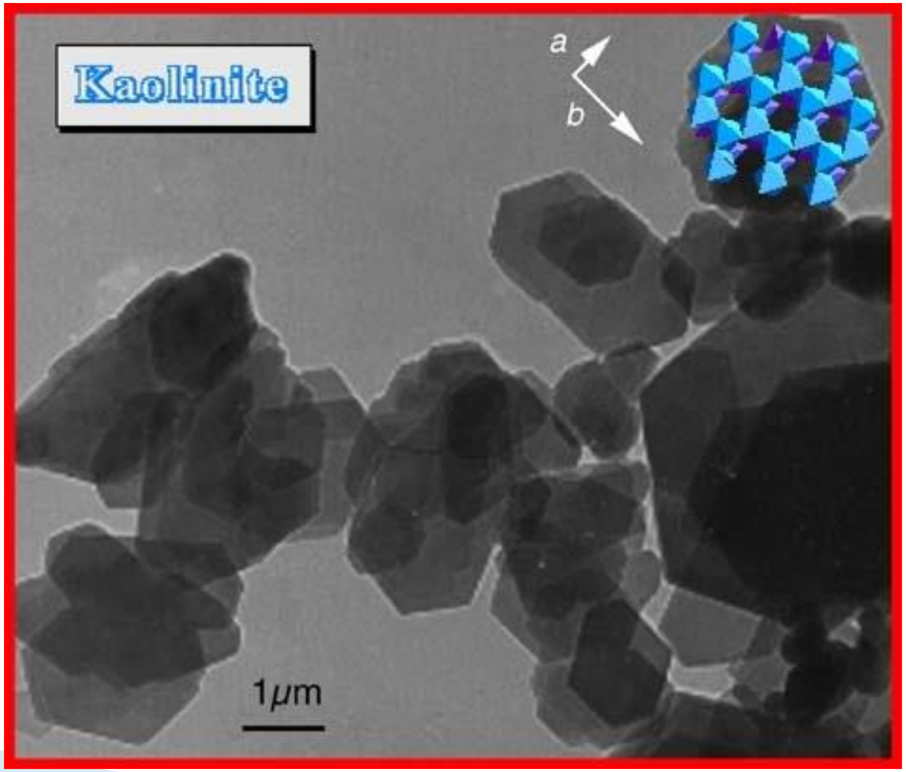
Mineral (Phase)	Component	Component Formula
Ilmenite and Hematite	Ilmenite	$FeTiO_3$
	Hematite	$Fe_2^{3+}O_3$
Magnetite	Magnetite	$Fe^{2+}Fe_2^{3+}O_4$
	Ulvospinel	$Fe_2^{2+}TiO_4$
Rutile	Rutile	TiO_2
Spinel	Spinel	$MgAl_2O_4$
Brucite	Brucite	$Mg(OH)_2$
Gibbsite	Gibbsite	$Al(OH)_3$
Pyrite	Pyrite	FeS_2

Mineral (Phase)	Component	Component Formula
Pyrrhotite	Pyrrhotite	$Fe_{(1\ x)}S$
Chalcopyrite	Chalcopyrite	$CuFeS_2$
Sphalerite	Sphalerite	ZnS
Galena	Galena	PbS
Barite	Barite	$BaSO_4$
Gypsum	Gypsum	$CaSO_4 \bullet 2\ H_2\ O$
Anhydrite	Anhydrite	$CaSO_4$
Calcite	Calcite	$CaCO_3$
Dolomite	Dolomite	$CaMg(CO_3\ )\ _2$
Apatite	Apatite	$Ca\ _5(PO_4\ )_3\ (OH)$
Fluorite	Fluorite	CaF_2
Halite	Halite	$NaCl$

Clay Minerals

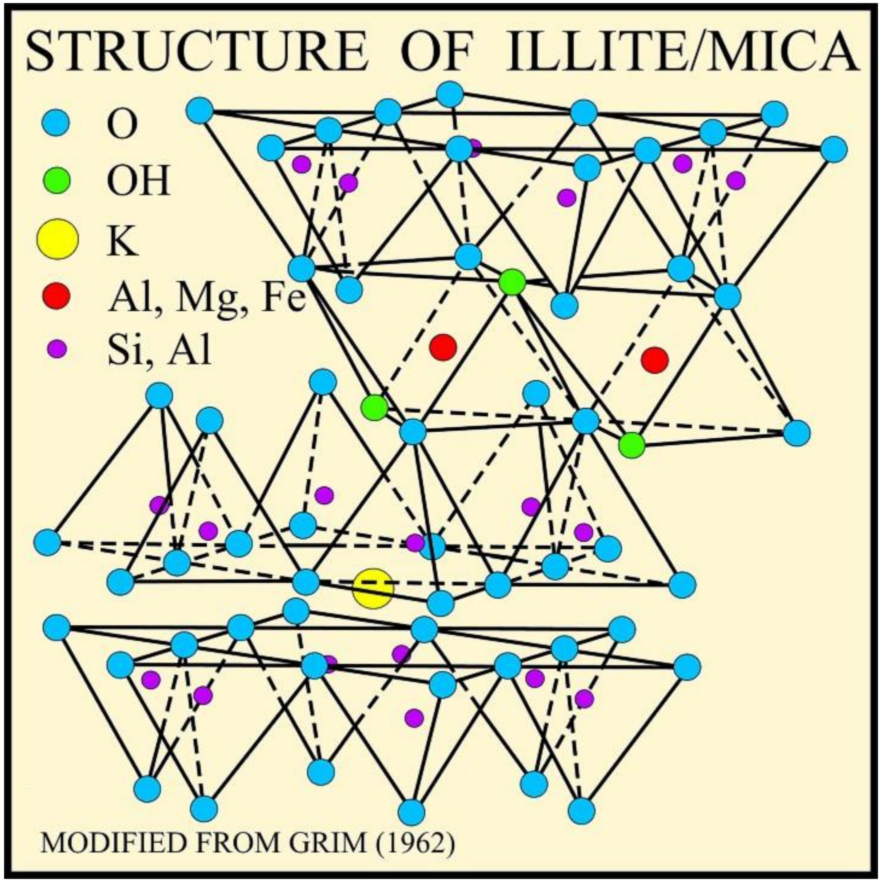
- Clay minerals are produced mainly from the chemical weathering and decomposition of feldspars, such as Orthoclase and Plagioclase, and some Mica.
- They are small in size and very flaky in shape.
- The key to some of the properties of clay soils, e.g. plasticity, compressibility, swelling / shrinkage potential, lies in the structure of clay minerals.
- There are three main groups of clay minerals:

- **KAOLINITES:**
  (include kaolinite, dickite and nacrite) formed by the decomposition of orthoclase feldspar (e.g. in granite); kaolin is the principal constituent in china clay and ball clay.

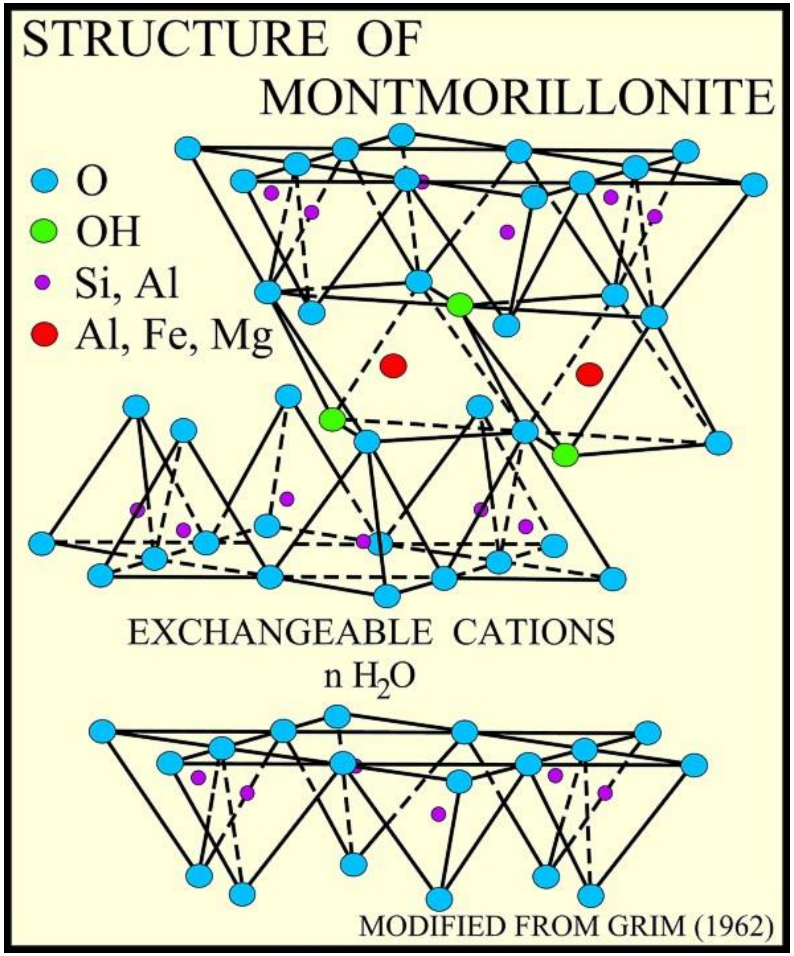


ILLITES:

(include illite and glauconite) are the commonest clay minerals; formed by the decomposition of some micas and feldspars; predominant in marine clays and shales (e.g. London clay, Oxford clay).



MONTMORILLONITES: (also called smectites or fullers' earth minerals) (include calcium and sodium montmorillonites, bentonite and vermiculite) formed by the alteration of basic igneous rocks containing silicates rich in Ca and Mg; weak linkage by cations (e.g. Na+, Ca++) results in high swelling/shrinking potential.



Clay mineralogy reflects weathering processes:

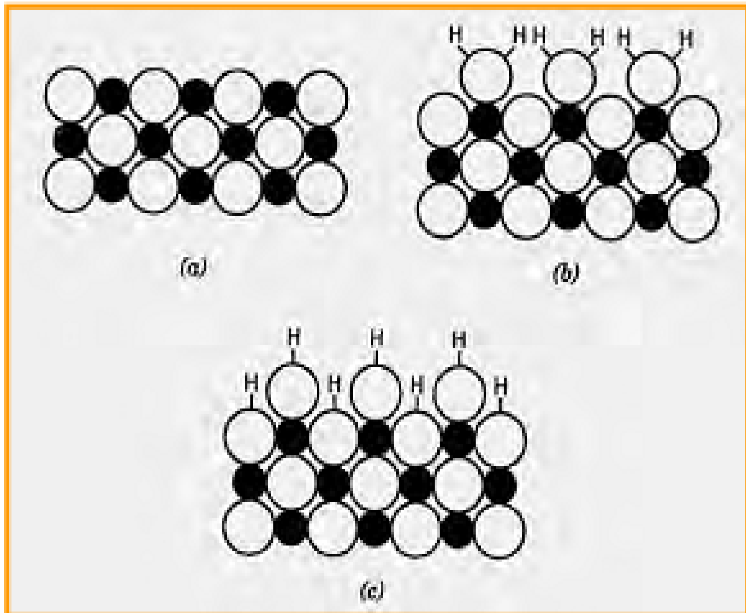
Micas → Vermiculite → Smectite, Kaolinite → Al,Fe-Oxides

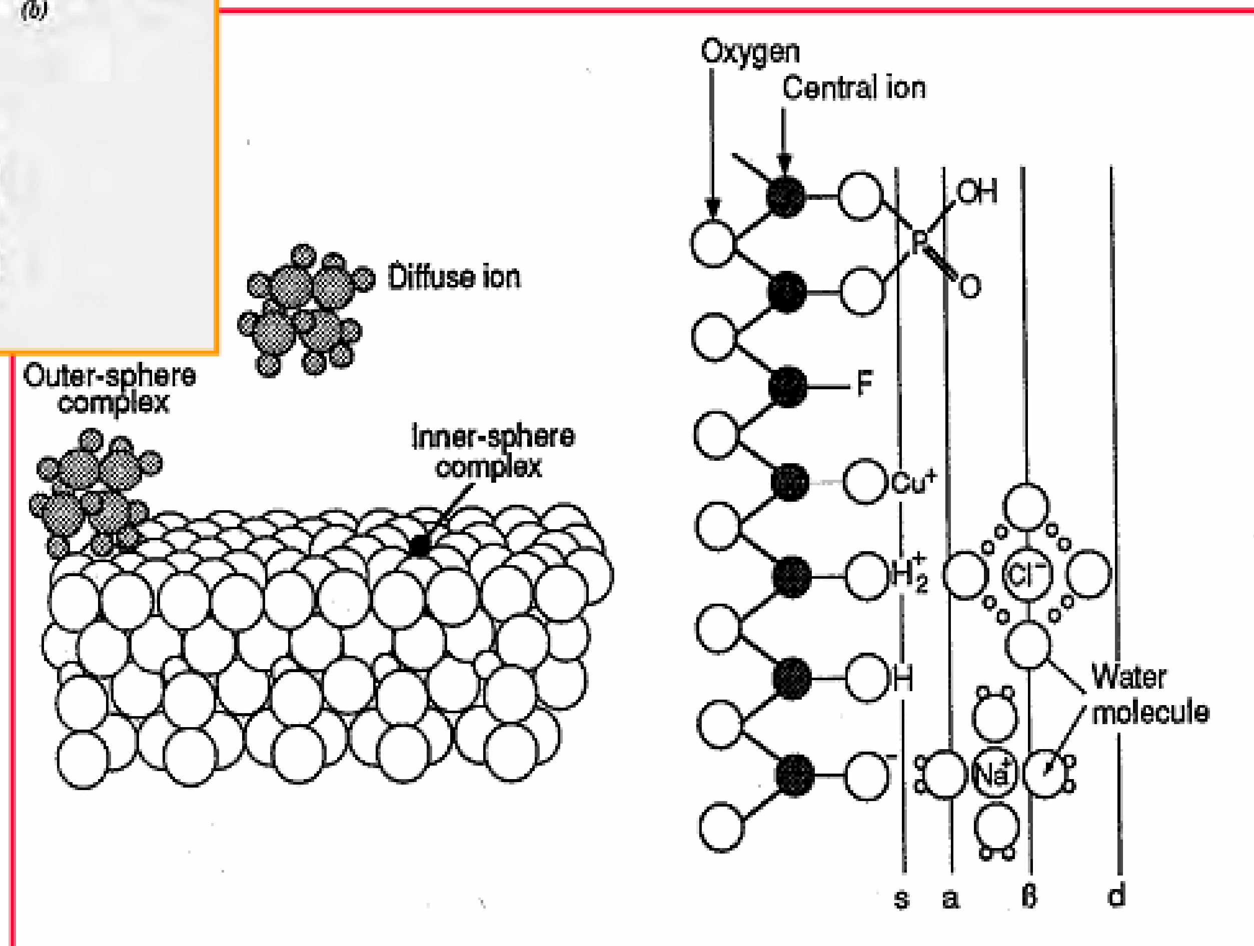
- Young, weakly weathered soils
  = fine-grained Mica, Chlorite, Vermiculite
  (Entisol, Inceptisol)

- Intermediate weathering
  = Vermiculite, Smectite, Kaolinite
  (Mollisol, Alfisol, Ultisol)

- Strong weathering
  = Kaolinite, Hydrous Oxides
  (Ultisol--> Oxisol)

Hosting Anomalies Within Soils





Soil Micromorphology and Landscape Evolution

- Soil micromorphology is concerned with the description, measurement of soil components and pedological features at a microscopic to sub-macroscopic scale.
- soil micromorphology begins in the field with the routine and careful use of a 10x hand lens,
- But, much more can be described by careful description of thin sections made of the soil
- with the aid of a petrographic polarizing light microscope.
- The soil can be impregnated with an epoxy resin,
- but more commonly with a polyester resin and sliced and ground to 0.03 millimeter thickness and examined by passing light through the thin soil plasma.
- **Soil micromorphology is the study of size, shape, aggregation, etching, coating, accumulation, and depletion of minerals associated with various soil processes.**

Application of soil micromorphology and landscape evolution.

Soil formation is a dynamic process with material continually being added, removed, and transformed. For example, water moving through a soil profile will pick up fine-textured material and deposit it as a coating along channels formed by the faces of adjacent peds.

Human activity can interrupt these processes and result in subtle differences in morphology. Water infiltration in the soil around a structure would be less than that in adjacent soil, because the structure would divert water away from it and compact the soil beneath it.
Consequently, coatings on soil peds beneath the structure would be thinner, less well oriented, and have a different ratio of fine to coarse material than in the adjacent undisturbed soil.

Some features occur within peds, such as manganese concretions, and others occur on ped surfaces, such as clay films

For features within peds, record the percent (or class) of the volume of the ped occupied by the feature. Illustrations of silt coats, clay films, carbonate coats, Mn concretions, and depletions and concentrations associated with a root channel are **to be studied in detail,** along with their form description. These kinds of additional features are common in Indiana soils.

Determination

Examine ped surfaces or near surfaces to learn if they differ from the adjacent material in the interior of the peds in texture, color, orientation of particles, or reaction to various tests. A **hand lens** to magnify the feature is helpful. Cut a ped to observe features within the ped.

Table 14. Abundance classes for additional features. Report either the class or the percentage of the matrix or of ped surface occupied by the feature. (see fig. 20, page 35)

Classes	On ped surfaces, % of surface area	Within peds, % of soil volume
Very few (vf)	< 5	—
Few (f)	5 - 25	< 2
Common (c)	25 - 50	2 - 20
Many (m)	50 - 90	> 20
Very many (vm)	>90	

$ Soil micromorphology can contribute a rich source of archaeological data that takes into account the effects of human activity on the cultural environment and the natural world.

$Ref.: The Use of Soil Micromorphology at Sylvester Manor - By Eric Proebsting

Soil Micromorphology has also been applied successfully to locate sites on the transition to agriculture by prehistoric humans

#Reference: Discussion of the Influence of Prehistoric Humans on soils in the British Isles - Virgil Yendell

Within peds (Code consists of upper case letter + lower case letter)

Carbonate concentrations (Ca) — Whitish concentrations that are identified by adding a few drops of HCl to the surface and watching for a fizzing reaction, as explained in the Reaction section.

Clay bridges (Cb) — Clay particles that form bridges between sand grains in coarse-textured soils, usually Bt horizons. The clay grains are oriented like a pack of cards (as seen in **micromorphology** studies). Clay bridges, usually reddish brown color, provide evidence for clay illuviation processes and thus argillic horizons. They usually occur in the matrix of weakly developed peds [Ma].

Iron concentrations (Fe) — Reddish or dark reddish brown zones not associated with ped surfaces or pores.

Manganese concretions (Mn) — Black specks or masses within peds. The presence of Mn can be identified by applying a few drops of 3% hydrogen peroxide to the feature. Mn catalyzes the conversion of H_2O_2 to H_2O and O_2. The production of oxygen gas is observed as release of small bubbles or fizzing.

Rhizosphere concentration (Rc) — A circular brownish or reddish zone around the outside of gray rhizosphere depletion.

Rhizosphere depletion — (Rd) A circular gray zone around a root channel or pore. Often there is rhizosphere concentration around the outside of this gray zone.

Surface concentration (Sc) — A planar brownish or reddish zone associated with a planar void; often there is a surface depletion between this concentration and a void.

Surface depletion (Sd) — A planar gray zone near the surface of ped; often found near the surface of a fragipan prism.

On ped surfaces (Code consists of two upper case letters)

Carbonate coats (CC) — White or light gray calcareous coatings on ped surfaces usually in upper C horizons. They usually are very effervescent because the secondary carbonate minerals are very fine and react quickly with acid.

Clay films (skins) (CF) — Thin layers of oriented, translocated clay that often appear to be waxy, with low luster. They seem to be painted on the ped and may have a color different from the matrix (interior) color. If there is sand in the matrix, the clay coating covers up the grains so they cannot be seen in the coating.

Iron coats (FE) — Reddish or brownish coatings on ped surfaces not associated with clay skins.

Manganese coats (MN) — Black coatings on ped surfaces that fizz with H_2O_2 application.

Organic matter coats (OM) — Dark coatings, that do not froth with H_2O_2 application, on ped surfaces, usually immediately below A horizons.

Silt coats (SI) — Coatings of silt grains on ped surfaces. They appear to be dusty and powdery, like sugar on a donut. Thin silt coats can be distinguished from clay films by moistening the sample. If the coating is silty, the color of the coating disappears and the underlying color comes through, like when you dunk the donut, but a clay skin keeps its color when moist. Silt coats often originate by removal of clay from a silty clay ped coating.

Slickensides (SS) — Outer surfaces of peds that have been altered when one surface slides across another surface, as shown by small ridges, valleys, grooves, striations, etc. In contrast to clay films, they are not coatings. If the ped contains sand, sand grains may show on a slickenside surface, and this surface is usually the same color as the ped interior.

* The distribution of soil pores within a faulted soil is different than the distribution of soil pores in the normal soil for the area.

A cutan "is a modification of the texture, structure, or fabric at natural surfaces in soil materials due to concentration of particular soil constituents or in situ modification of the plasma" (Brewer, 1960).

If the samples having the cutans which are composed dominantly of clay minerals, called argillans,

then these argillans are clay minerals which have been translocated to the Bt horizon of the pre-Holocene soil in an area.

Although the paleosoil was characterized by well developed argillans, only small remnants of argillans were found in the fault zone.

It must be assumed that highly oriented pedologic structures will get destroyed at the time of movement of the fault.

<u>* Reference:</u>

SOIL MICROMORPHOLOGY AND FAULTING by
Lowell A. Douglas, Rutgers University, Department of Soils and Crops
New Brunswick, New Jersey 08903
USGS CONTRACT NO. 14-08-0001-18320
Supported by the EARTHQUAKE HAZARDS REDUCTION PROGRAM

**Soil micromorphology is a technique well suited for analysing landscapes, supplemented by fundamental field descriptions and basic cartography of the geomorphologic units of the area. It can, for example, try to answer whether the pre-site soils were subjected to freshwater flooding and alluviation or not, as well as were they aggrading, disrupted by agriculture, and/ or affected by seasonal aridity or not?

Reference (above):
Identifying Human Behaviour by using Soil Micromorphology— a geoarchaeological approach
Sayantani Neogi

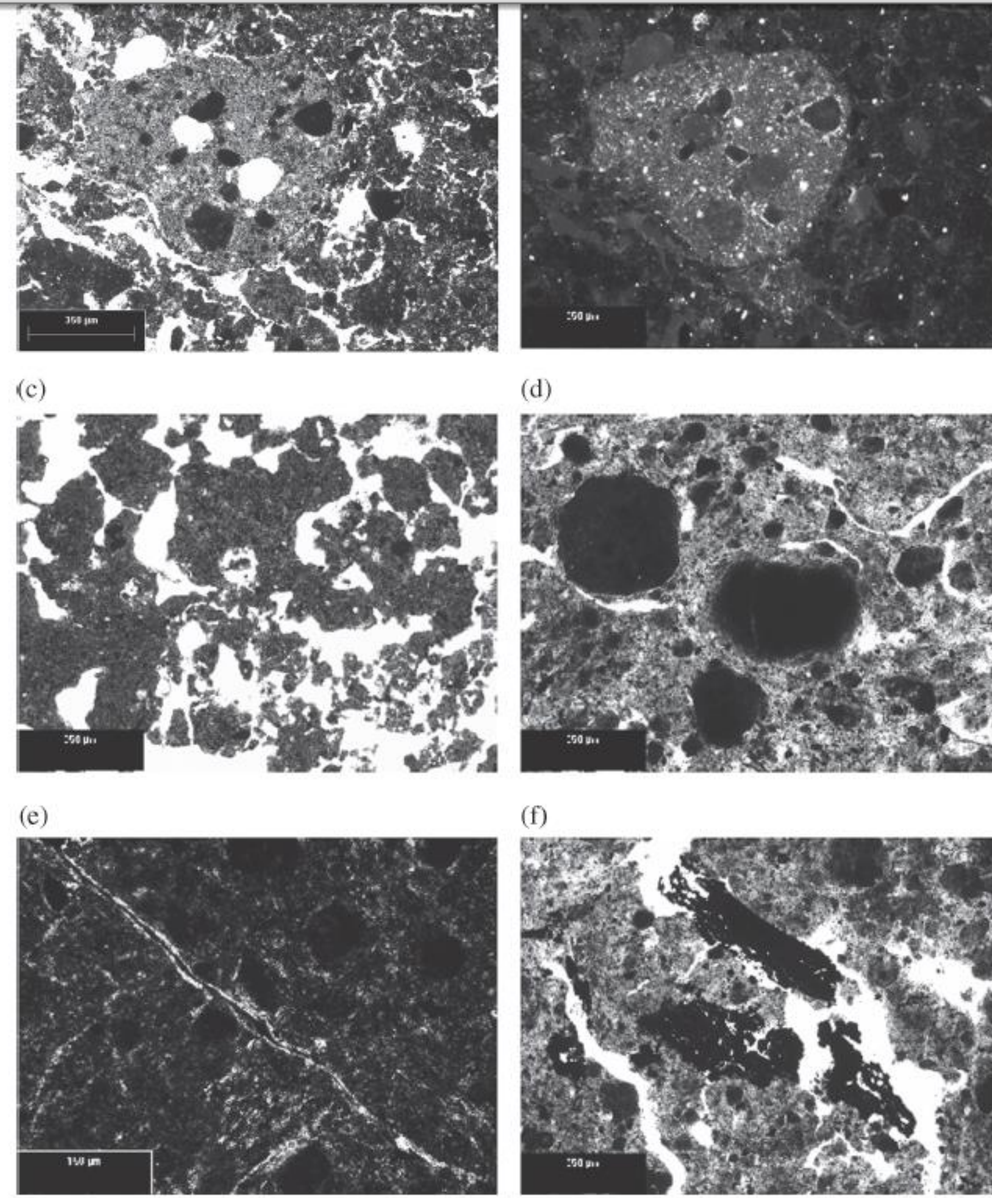


Fig. 2 Micromorphology of the upland soils from El Eden toposequence. PPL – plane polarized light, XPL – crossed polarizers. (**a**) Clay aggregate, Ah horizon of Rendzic Leptosol, PPL, (**b**) Same as (**a**), XPL, (**c**) Complex structure (subangular blocks and granules) and spongy fabric of Ah horizon of Leptic Phaeozem, PPL, (**d**) Compact material with fey fissures, frequent ferruginous nodules; Bg horizon of Gleyic Phaeozem, PPL, (**e**) Stress cutan, Bg horizon of Gleyic Phaeozem, XPL, (**f**) Charcoal fragments, Bg horizon of Gleyic Phaeozem, PPL

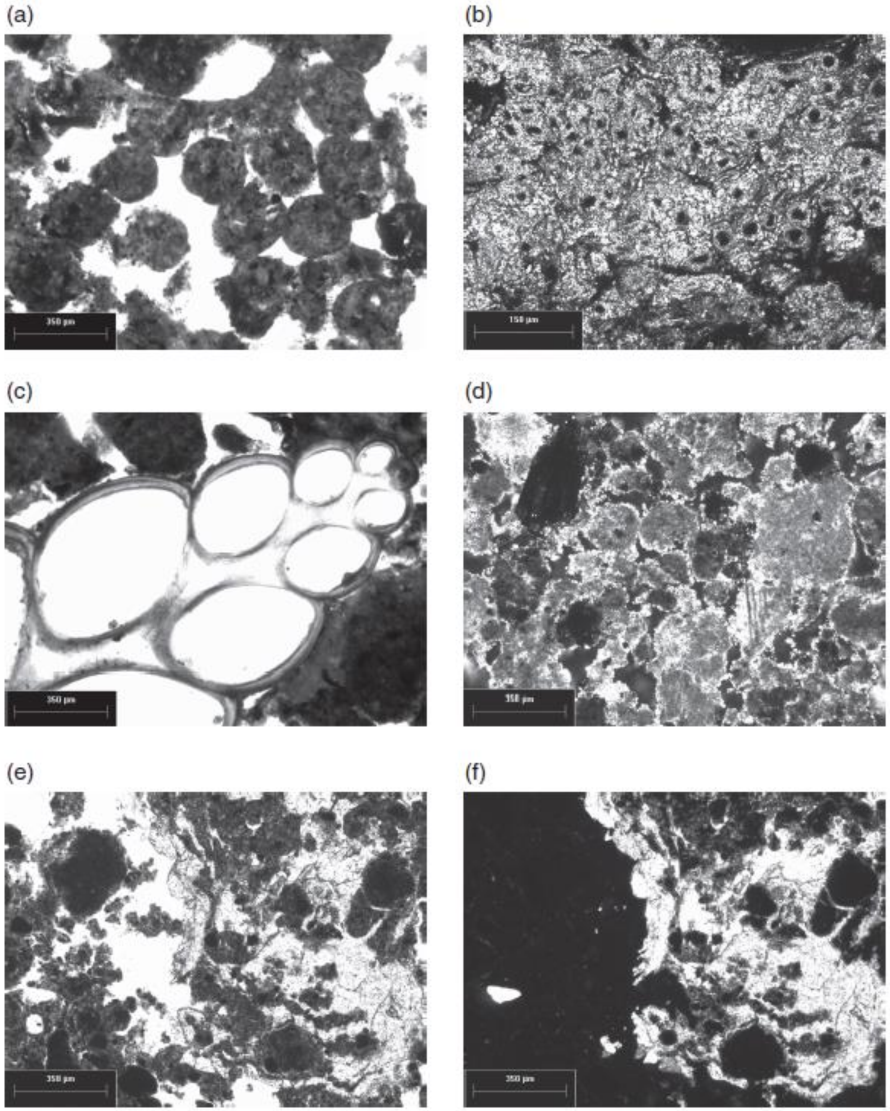


Fig. 3 Micromorphology of the wetland soils from El Eden toposequence. PPL – plane polarized light, XPL – crossed polarizers. (**a**) Micritic ooids, Bk horizon, Leptic Calcisol, PPL, (**b**) Channeled micritic aggregate, Bk horizon, Leptic Calcisol, XPL, (**c**) Mollusk shell, Bk horizon, Leptic Calcisol, PPL, (**d**) Granular structure, micritic groundmass with high birefringence in Bk horizon of upper Calcisol member of polygenetic profile, XPL, (**e**) Microarea cemented by coarse crystalline calcite (*center to right part*), Ah horizon of the lower Cambisol member of polygenetic profile, PPL, (**f**) Same as (**e**), XPL, note high birefrigence of calcitic cement

Reference:

Micromorphology of a Soil Catena in Yucatán: Pedogenesis and Geomorphological Processes in a Tropical Karst Landscape

By

Sergey Sedov, Elizabeth Solleiro-Rebolledo, Scott L. Fedick, Teresa Pi-Puig, Ernestina Vallejo-Gómez, and María de Lourdes Flores-Delgadillo

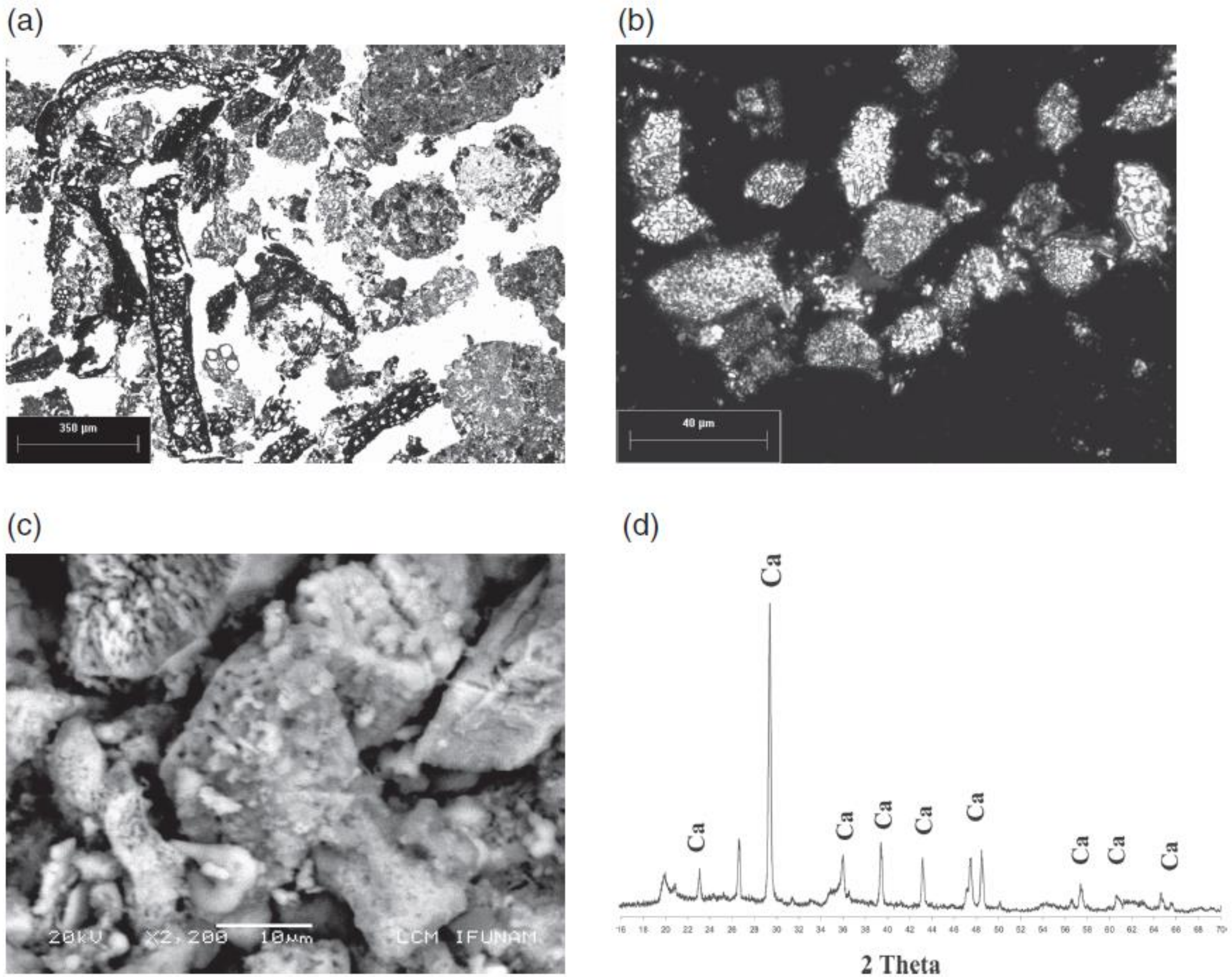
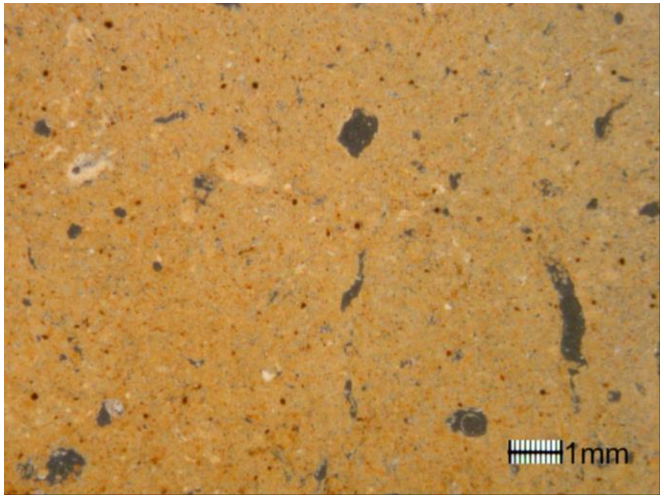


Fig. 4 Micromorphology and mineralogy of Rendzina, affected by forest fire. (**a**) Micromorphology of A horizon: clay and humus-clay aggregates (*right*), charcoal particles (*left*), PPL, (**b**) Neoformed carbonate grains in A horizon of irregular and rhombohedral shape. Note irregular extinction pattern, XPL, (**c**) Scanning electron microscopy of neoformed carbonates: note aggregative morphology of the rhombohedral grain, (**d**) Powder X-ray diffraction pattern of the soil material, enriched with neoformed grains; Maxima corresponding to calcite are marked with Ca

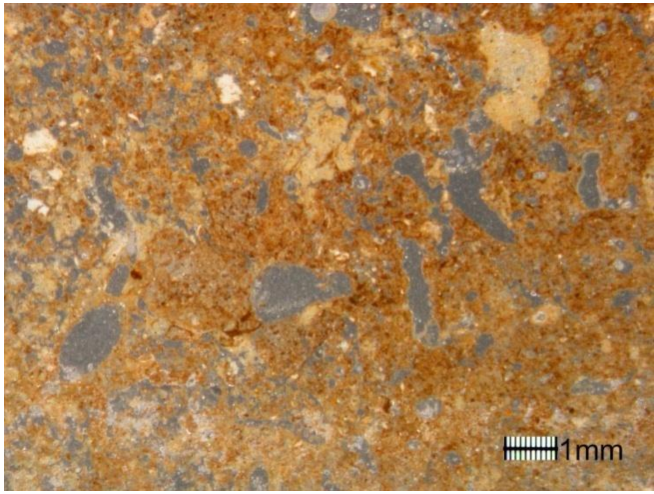


a)

REFERENCE:

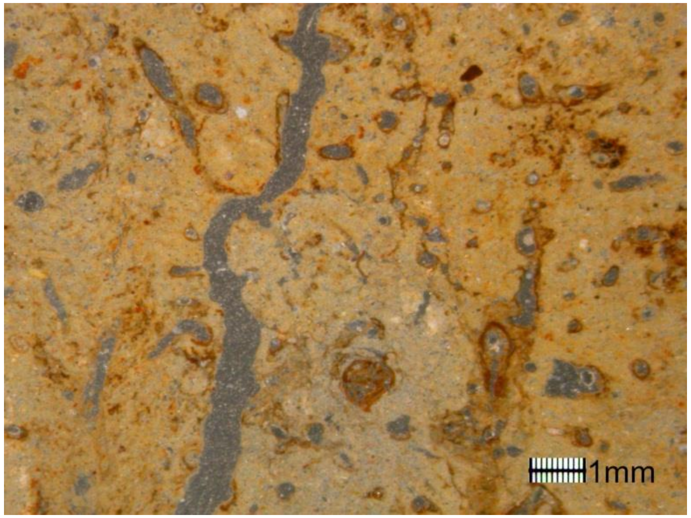
MICROMORPHOLOGICAL STUDY OF SOIL POROUS SYSTEM AFFECTED BY ORGANISMS AND ITS IMPACT ON SOIL HYDRAULIC PROPERTIES

Radka Kodesova[1], Vit Kodes[2], Anna Zigova[1] Czech Republic

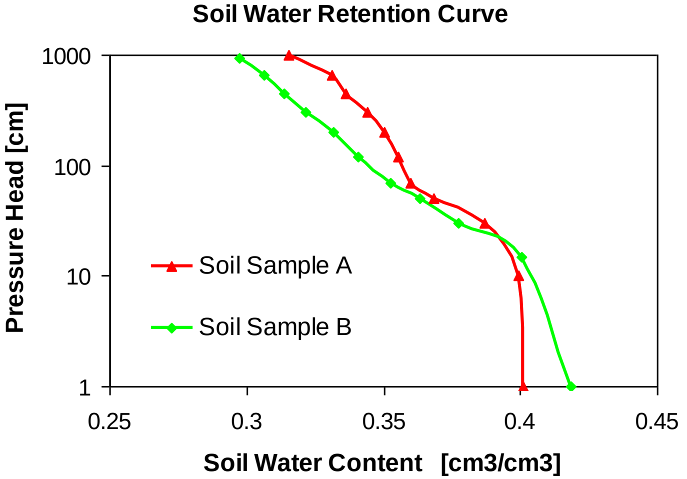


b)

Fig. 1. Micromorphological images of the soil sample characterizing the horizon at depths of 45–125 cm (a) and the image of krotovina soil structure at the depth of 100–110 cm (b)



a)



b)

Fig. 2. Micromorphological image of the soil sample characterizing the horizon at depths of 75–102 cm (a) and corresponding soil water retention curves (b).

RADIOMETRIC AGE DETERMINATION OF SOIL

SOIL AGE

- The age of most persons are measured in years since birth. For people and soils, there are also ways to judge age in terms of "maturity". The age of a soil is determined by the amount of weathering that has occurred; that is, to what extent the parent material has been converted to distinct horizons or soil layers. Soil age is based on three general criteria:
- • The more horizons that are present, the older the soil.
  • The thicker the horizons, the older the soil.
  • The more difference there is between adjacent horizons, the older the soil.

Soil Age determination

Radiometric dating (often called **radioactive dating**) is a technique used to date materials such as rocks, usually based on a comparison between the observed abundance of a naturally occurring radioactive isotope and its decay products, using known decay rates.

Radiometric dating methods are used in geochronology to establish the geological time scale.
Among the best-known techniques are radiocarbon dating, potassium-argon dating and uranium-lead dating.

Soil Age determination. …

- Radiocarbon dating is considered to be the most reliable.
- The two main regularities observed are:
  - (1) the upper horizons of a majority of soils are younger than the lower ones (exclusive of the humus-illuvial podzols);

    (2) forest ("podzolic") soils are younger than steppe ("chernozem") soils. At the same time, the first regularity is absent in arable soils, where a sharp increase of soil age is observed at the lower boundary of plowing. Recent data on tropical black clays reveal a great age of humus throughout their profiles due apparently to peculiarities of the clay.

Soil Age determination. …

- Every rock and mineral exists in the world as a mixture of elements, and every element exists as a population of atoms. One element's population of atoms will not all have the same number of neutrons, and so two or more kinds of the same element will have different atomic masses or atomic numbers. These different kinds of the same chemical element are called nuclides of that element. A nuclide of a radioactive element is known as a radionuclide.
- The nucleus of every radioactive element spontaneously disintegrates over time. This process results in **radiation**, and is called **radioactive decay**.

Soil Age determination. ...

- Losing high-energy particles from their nuclei turns the atoms of a radioactive nuclide into the daughter product of that nuclide.
- A daughter product is either a different element altogether, or is a different nuclide of the same parent element.
- A daughter product may or may not be radioactive. If it is, it also decays to form its own daughter product. The last radioactive element in a series of these transformations will decay into a stable element, such as lead.

Soil Age determination. …

- While there is no way to discern whether an individual atom will decay today or two billion years from today, the **behavior** of large numbers of the same kind of atom is so predictable that certain nuclides of elements are called radioactive clocks.
- Ages may be determined on the same sample by using different radioactive clocks.
- When the age of a rock is measured in two different ways, and the results are the same, the results are said to be concordant.