Soil Basics

Parent Material
Horizons
Soil Texture
Soil Structure
Organic Matter

2011- King's Dealer University Training

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July 21, 2011

What is Soil? Two Concepts First Concept

- 1st – Pedology- Considers soil as a natural entity: a biochemically weathered and synthesized product of nature.

Soils are the product of the general forces of:

- Weathering
- Vegetation
- Climate
- And TIME

working on the particular parent material and Topography of the region

What is Soil? Two Concepts Second Concept

- 2nd - Edaphology conceives the soil as a natural habitat for plants and justifies soil studies primarily on that basis
- A farmers perspective – A habitat to grow plants, agronomic considerations.

SOIL?

Where does Our understanding of soil come from?

- 1st. Source - Much practical knowledge has been gained by farmers through trial & error and passed down over the centuries.

- 2nd. Source Information available after the advent of Modern Soil Science.

Soils & History - What have we learned?

- Through trial & error man learned to distinguish differences in soil.
- Also, he learned the value of treating soils with plant & animal wastes.
- More than 42 centuries ago the Chinese used a schematic soil map as a basis for taxation.
- Many biblical references are to the “dung-hill” and to the beneficial practice of “dunging” around plants.

- Isaiah 28:23-26

23 Listen and hear my voice; pay attention and hear what I say.
24 When a farmer plows for planting, does he plow continually?
Does he keep on breaking up and working the soil?
25 When he has leveled the surface,
does he not sow caraway and scatter cumin?
Does he not plant wheat in its place,
barley in its plot,
and spelt in its field?
26 His God instructs him
and teaches him the right way.

Man adapts his plans to the soil and to the kind of grain; he avails himself of the best methods of preparing the ground, sowing the seed, collecting the harvest, and of separating the grain from the chaff.

Parent Material

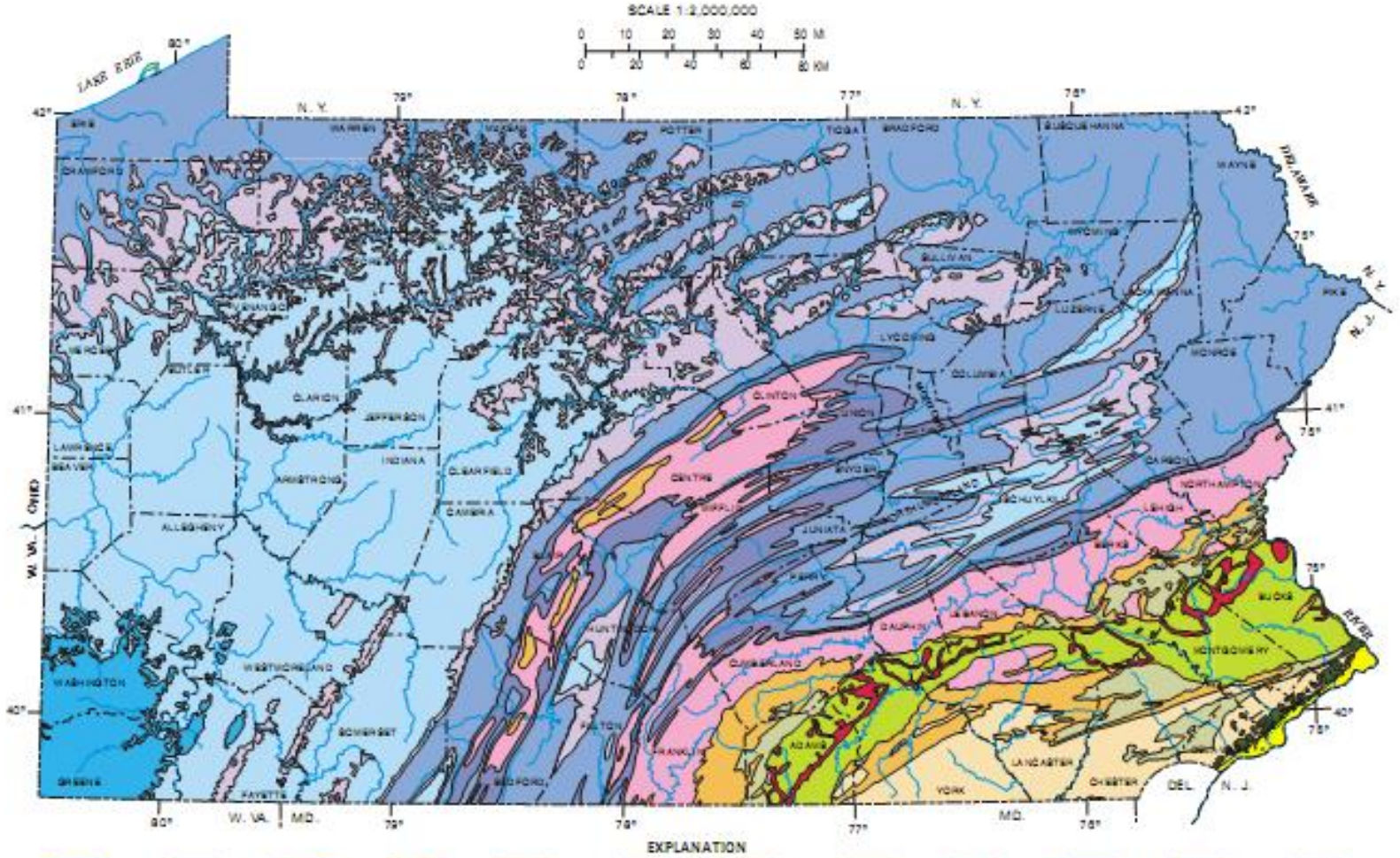
- This is the type of material or (Parent -Bedrock) from which the soil was formed. Many different types of bedrock underlie Pennsylvania.
- Types of Rocks (sedimentary, igneous, and metamorphic)
  - In PA Sedimentary Rocks are most common.

- Sedimentary Rocks
  - (Clastic Sedimentary - named for grain size) deposition of individual grains that have eroded from older rocks and have been transported by water or wind: {Conglomerate, Sandstone, Siltstone, Claystone & Shale}
  - (Non Clastic Sedimentary,-named for Chemical composition) formed by the precipitation of dissolved minerals from water or organic deposition. {Limestone & Dolomite}

- Igneous Rocks
  - Formed from the cooling of molten material. Above ground lava, Below ground - Magma (Classified by grain size and minerals) Most Igneous rock in PA has undergone Metamorphism and is classified as dark or light, the color being a reflection of the minerals in the rock.

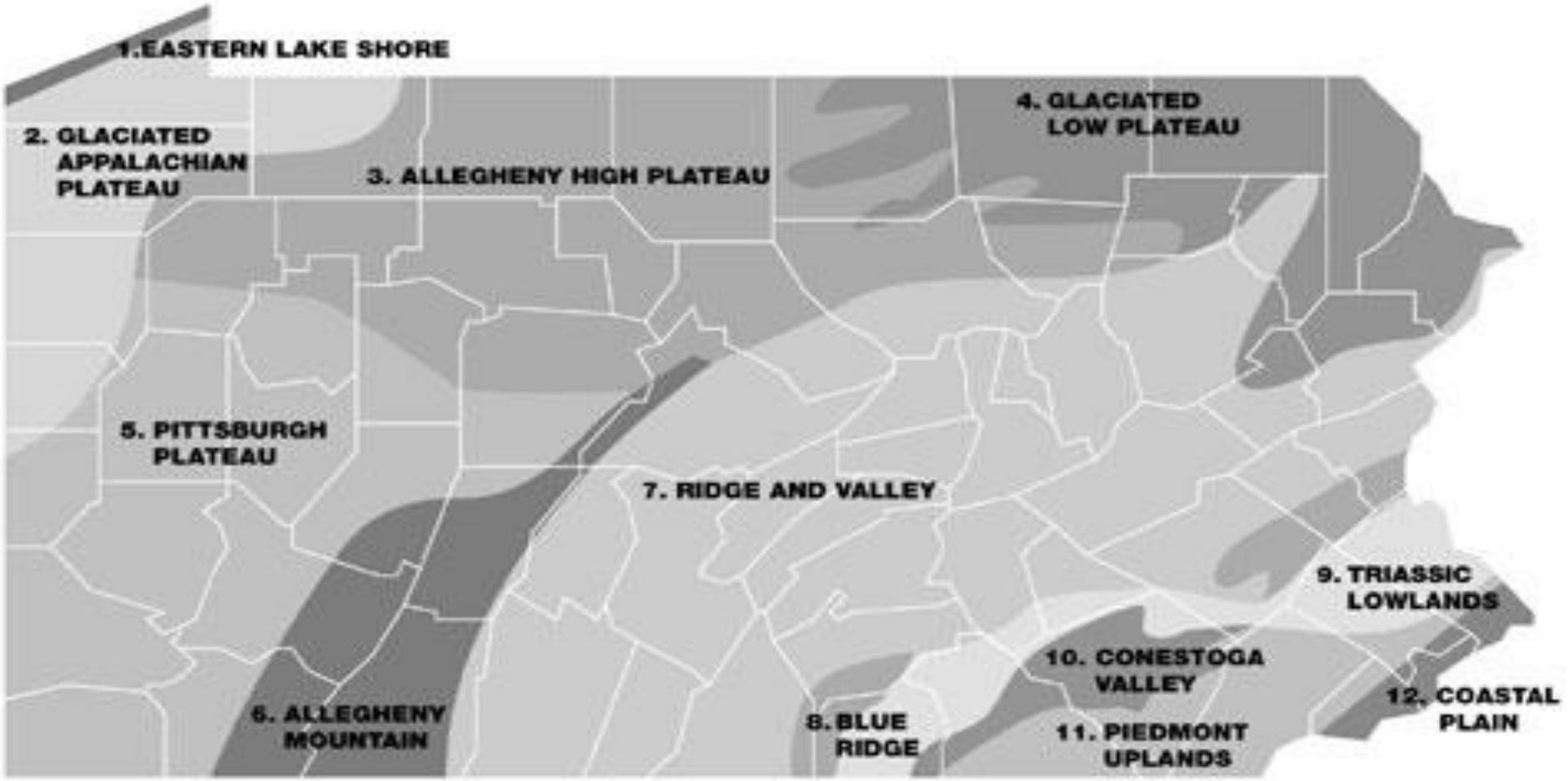
- Metamorphic Rocks
  - Formed by altering igneous, sedimentary, or other metamorphic rocks by heat and/or pressure. The heat and pressure cause changes in the minerals present, as well as rearranging the minerals in the rocks. Metamorphic rock names are based on grain size, organization of minerals into layers (foliation), and composition. Pennsylvania has gneiss, schist, phyllite, slate, marble, and quartzite.

GEOLOGIC MAP OF PENNSYLVANIA



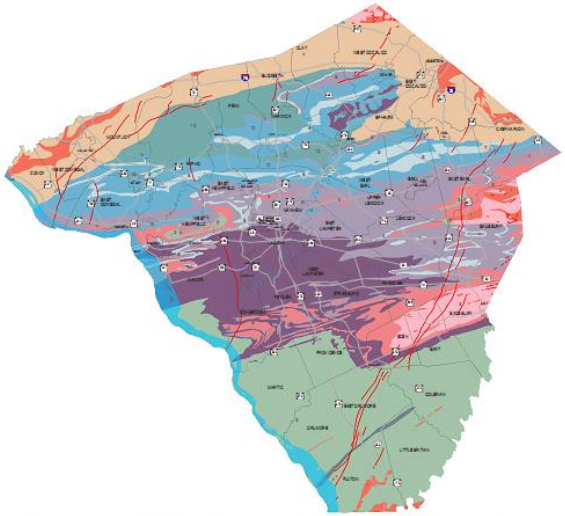
* Paleozoic rocks, which are present in small areas of southern Montgomery County, cannot be shown at the scale of this map.

Figure 1.1-1. Soil regions of Pennsylvania.



Soil Variability

- Soils may vary considerably from county to county throughout the state and throughout each county depending on the underlying “parent material” or bedrock from which they were formed.



DCNR

LANCASTER COUNTY

April 2008

N W E S

0 1 2 3 4 5 Mi

Stream or river
1, Dikes (if present)
Municipal boundary

web site: www.dcnr.state.pa.us/topogeo/groundwater/rocktypes.aspx

ROCK TYPES *See complete description. Not all rock types in the legend may be present on the map.

- 1, Dark crystalline rocks
- 2, Light crystalline rocks
- 3, Schist*
- 4, Marble
- 5, Quartzite
- 7, Red sedimentary rocks*
- 8, Limestone
- 9, Dolomite
- 10, Limestone and dolomite
- 11, Limestone or dolomite*
- 12, Slate
- 13, Shale and siltstone
- 14, Sandstone*

DCNR

BERKS COUNTY

April 2008

N W E S

0 1 2 3 4 5 Mi

Stream or river
1, Dikes (if present)
Municipal boundary

web site: www.dcnr.state.pa.us/topogeo/groundwater/rocktypes.aspx

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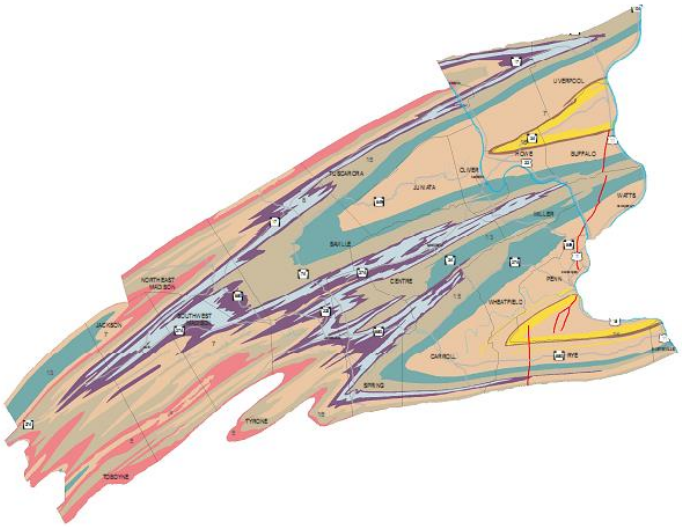
- 7, Red sedimentary rocks*
- 8, Limestone
- 9, Dolomite
- 10, Limestone and dolomite
- 11, Limestone or dolomite*
- 12, Slate
- 13, Shale and siltstone
- 14, Sandstone*
- 15, Shale or siltstone*
- 16, Sandstone, conglomerate
- 17, Sandstone, conglomerate*



DCNR

PERRY COUNTY

April 2008

N W E S

0 1 2 3 4 5 Mi

Stream or river
1, Dikes (if present)
Municipal boundary

web site: www.dcnr.state.pa.us/topogeo/groundwater/rocktypes.aspx

ROCK TYPES *See complete description. Not all rock types in the legend may be present on the map.

- 1, Dark crystalline rocks
- 5, Quartzite
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- 8, Limestone
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- 16, Sandstone, conglomerate
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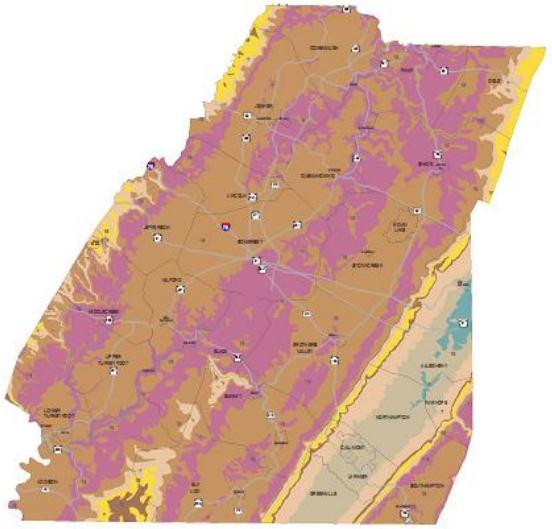


DCNR

SOMERSET COUNTY

April 2008

N W E S

0 1 2 3 4 5 Mi

Stream or river
1, Dikes (if present)
Municipal boundary

web site: www.dcnr.state.pa.us/topogeo/groundwater/rocktypes.aspx

ROCK TYPES *See complete description. Not all rock types in the legend may be present on the map.

- 5, Quartzite
- 7, Red sedimentary rocks*
- 8, Limestone
- 11, Limestone or dolomite*
- 13, Shale and siltstone
- 14, Sandstone*
- 15, Shale or siltstone*
- 16, Sandstone, conglomerate
- 18, Mixture of rock types 1*
- 19, Mixture of rock types 2*

Soil Horizon

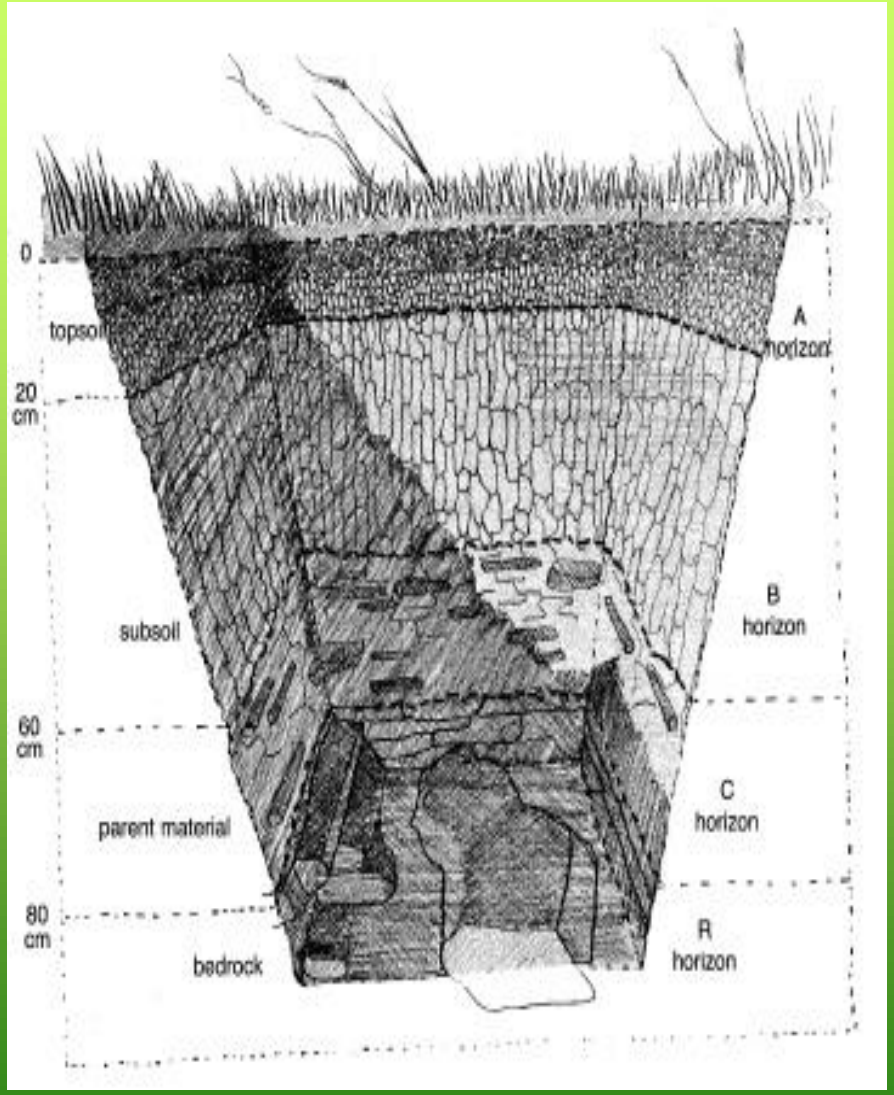
The topsoil, which has the most organic matter and is the root zone is called the A horizon.

The next layer, the subsoil or B horizon, contains higher concentrations of clay and is denser than the A horizon.

The C horizon is the parent material – the altered organic deposits or the weathered bedrock.

Bedrock is the last layer, the R Horizon.

The depth and thickness of the horizons vary with each soil.



Soil Horizons

- O1 – Organic, original forms recognized
- O2 – Organic, original forms not recognized
- A1 – Mineral, mixed with humus, dark colored
- A2 – Horizon of maximum eluviation of silicate clays, Fe, Al oxides.
- A3 – Transition to B, more like A than B
- B1 – Transition to A, more like B than A
- B2 – Maximum Illuviation of silicate clays , FE, Al oxides, some organic matter
- B3 - Transition to C, more like B than C
- C – Zone of least weathering, accumulation of calcium, Mg, carbonates, cementation
- Bedrock

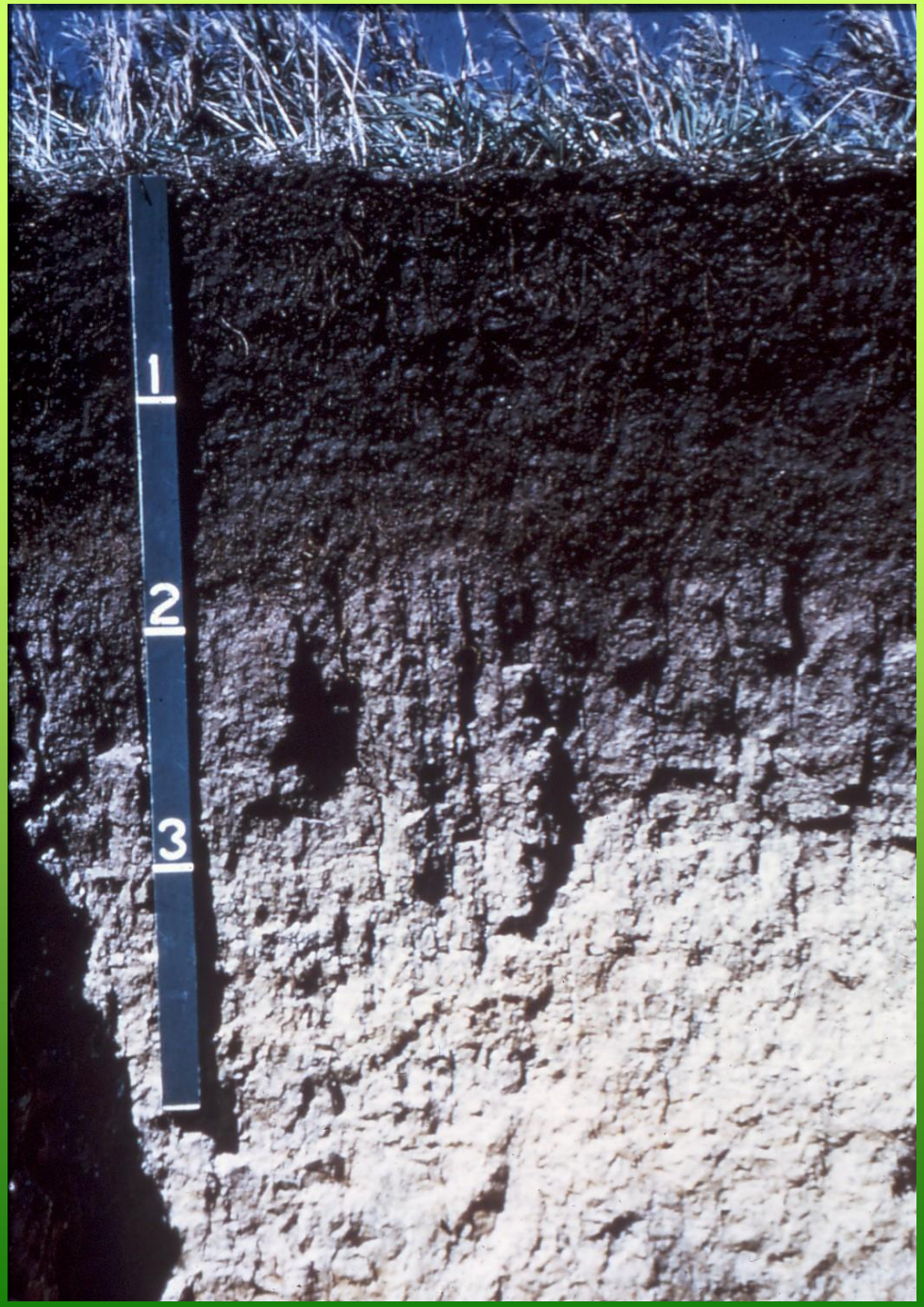
Soil Profiles

- Examples of different soil profiles and varying horizons, (following pictures)

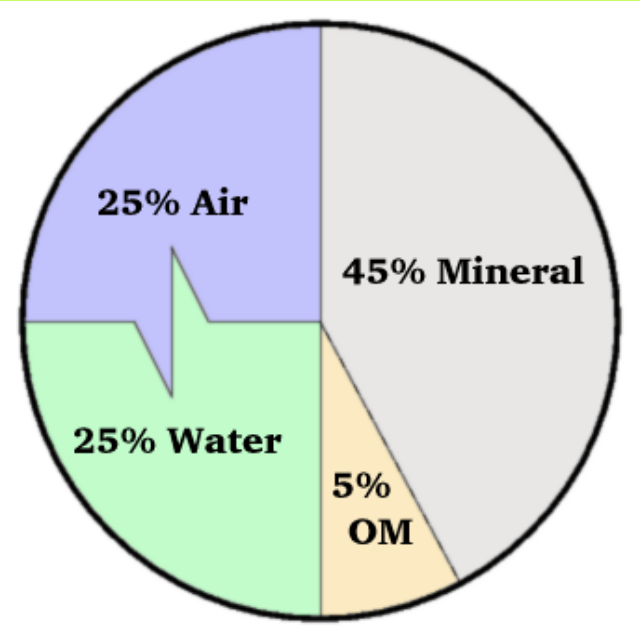
New Hampshire State Soil – Marlo Soil profile


1
2
3
4


2
3
4


1
2
3

Soil



Physically – a mineral soil is a porous mixture of

- Inorganic (mineral) particles
- Decaying organic material
- Air
- Water

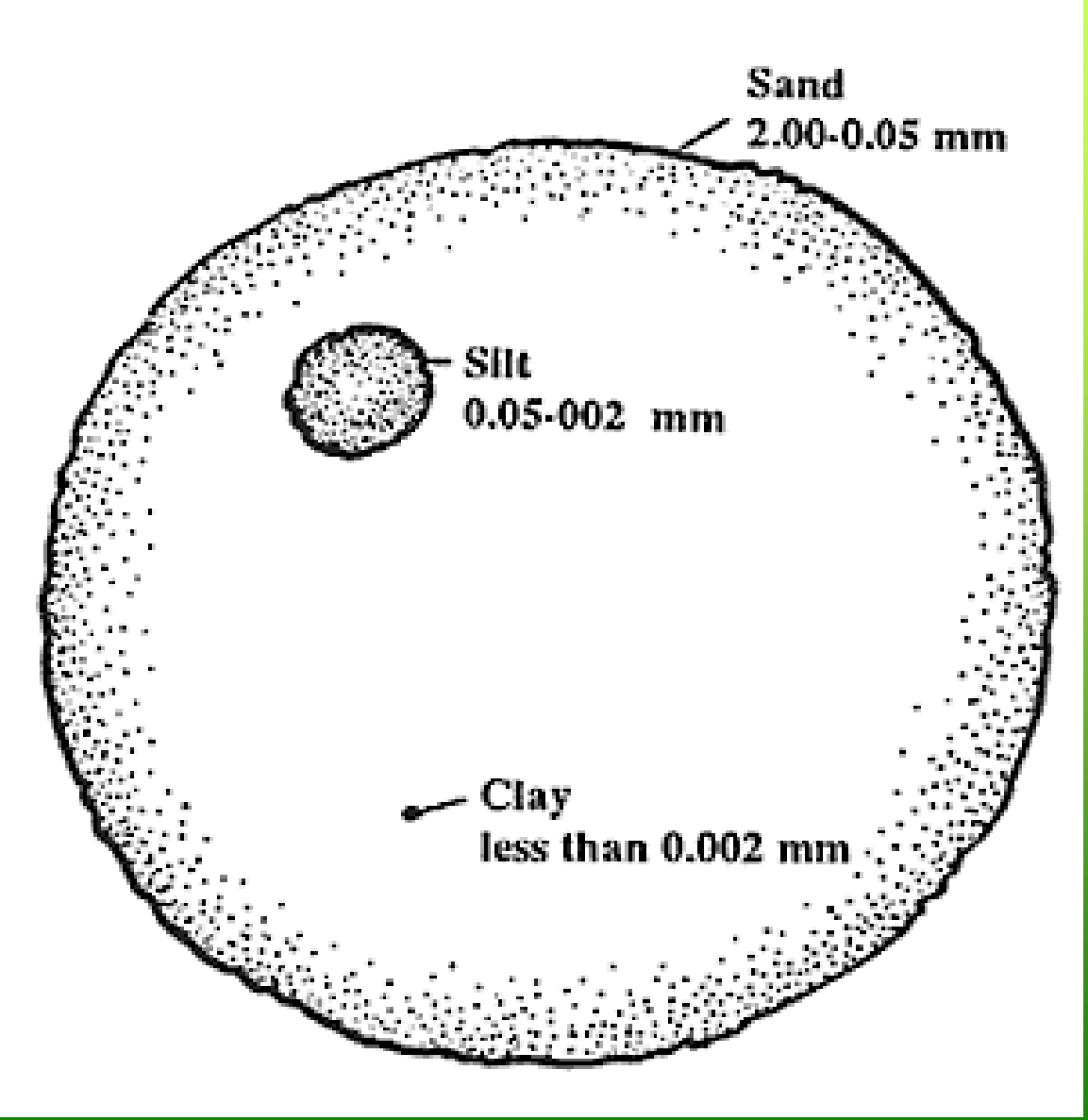
Soil particles

- The larger mineral fragments usually are embedded in and coated over with colloidal and other fine material.
- Colloid – Organic and inorganic matter with very small particle size and a correspondingly large surface area per unit of mass.

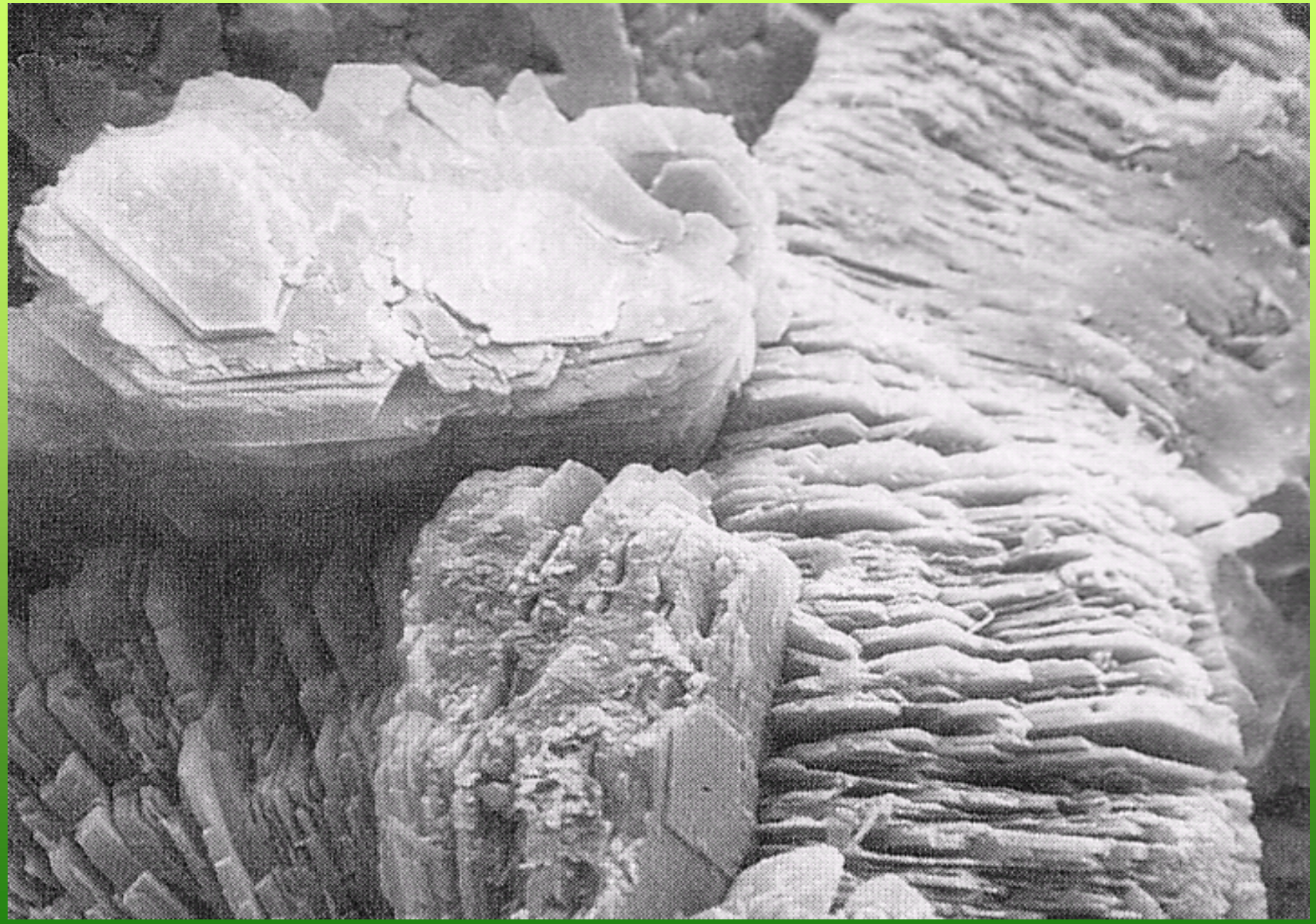
Soil Texture

- Texture is concerned with the size of the mineral particles.
- Specifically it refers to the relative proportion of particles of various sizes (Sand, silt & clay) in a given soil.
- The size of particles in mineral soil is not subject to ready change.
- So therefore a sandy soil remains sandy and a clay soil remains clay.
- Therefore Soil Texture is considered a basic property of soil.

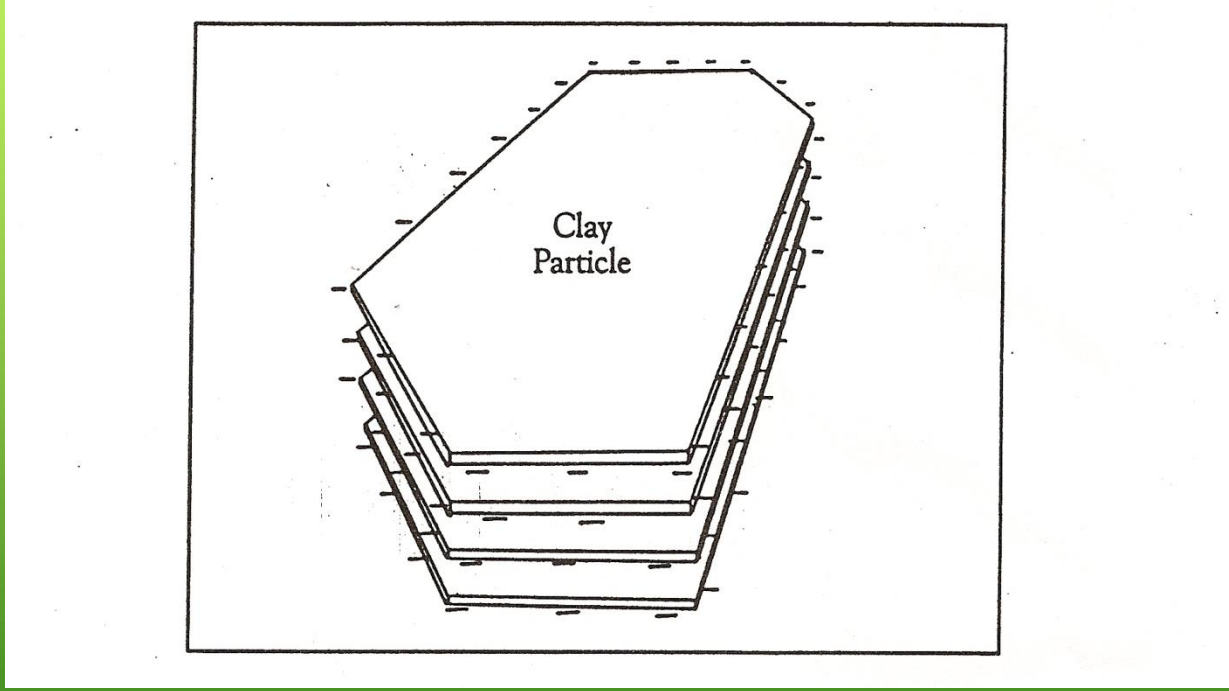
Soil Texture put in visual perspective



Clay Plate Structure



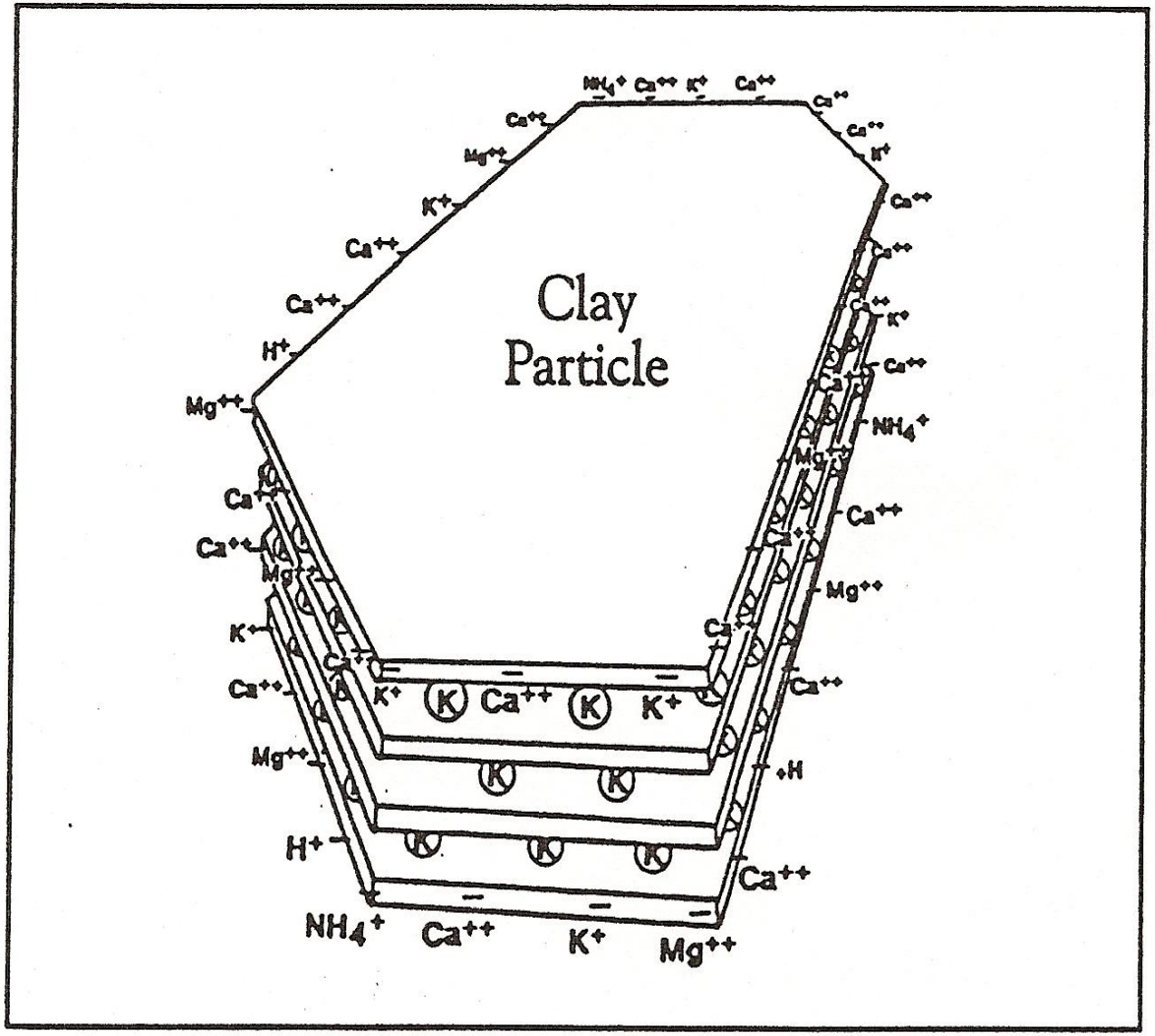
Clay Particles

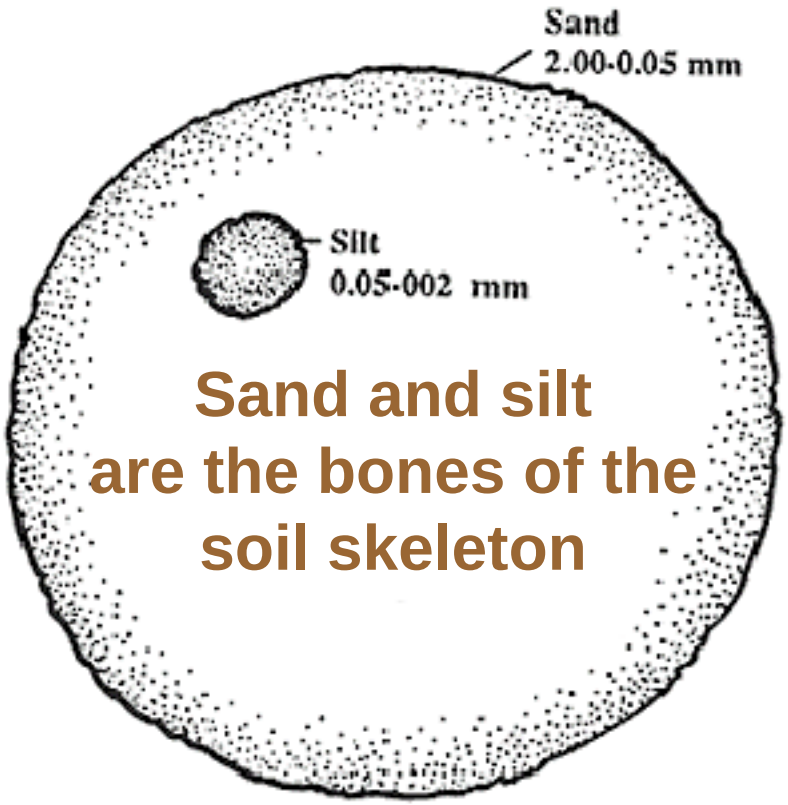


Ions (Cations & Anions)

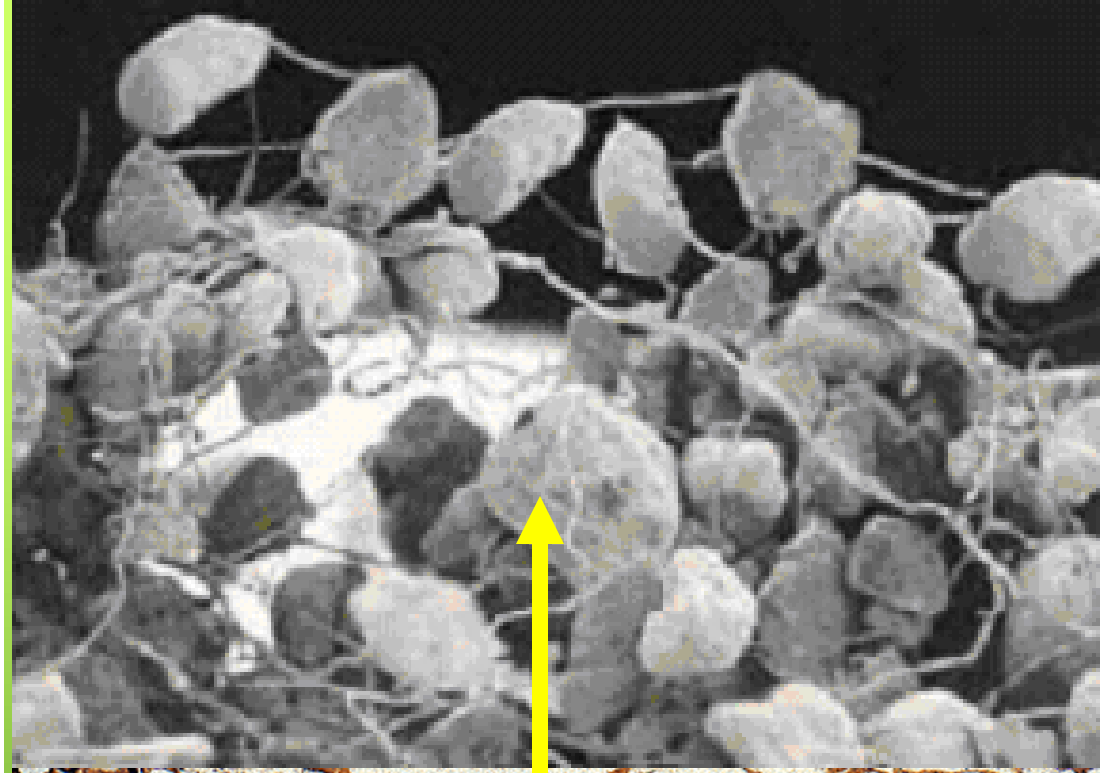
- An **ion** is an atom or molecule in which the total number of electrons is not equal to the total number of protons, giving it a net positive or negative electrical charge.
- An **anion** (-) is an ion with more electrons than protons, giving it a net **negative charge.**
- A **cation** (+) is an ion with fewer electrons than protons, giving it a **positive charge**.

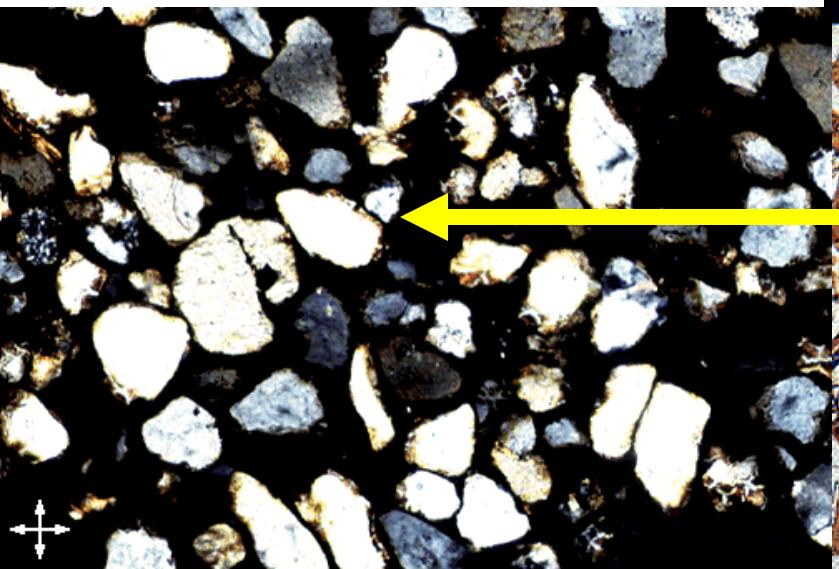
Clay Particles have a net negative surface charge and therefore attract cations. (Negative attracts positive)





Sand and silt are the bones of the soil skeleton

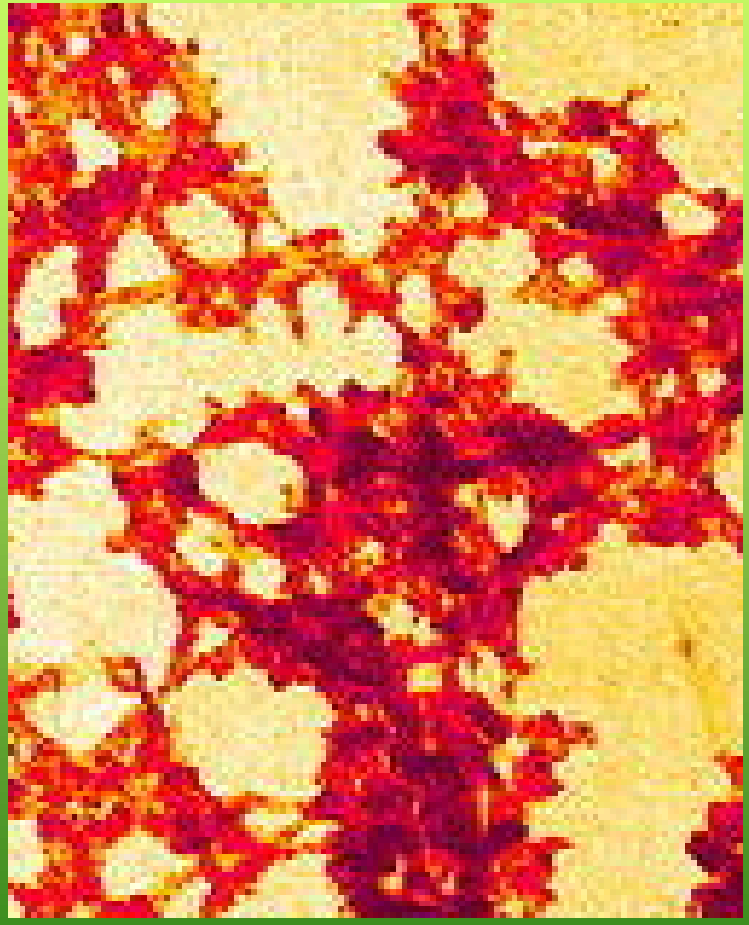




Soil skeletons

Clay and humus together make the clay-humus complex

clay minerals



humus

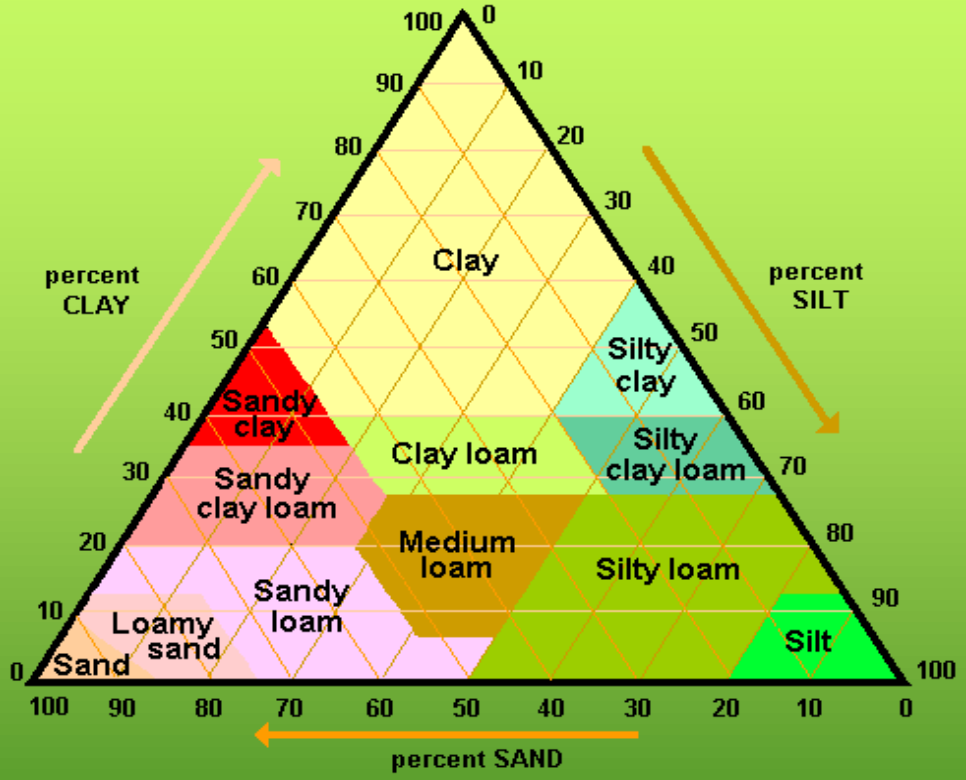
Why is the clay-humus complex important ?

- Adsorption of water films
- Adsorption of organic and inorganic chemicals
- Ion exchange
- Catalysis of chemical reactions
- Habitat for bacteria

20 years of similar tillage but different levels of organic inputs

Rodale Institute Farming Systems Trial

Mineral Portion of the soil
Soil Texture Triangle



- Use Clay line first then sand line to determine soil texture.
- Sand: 2mm - .05mm
- Silt: 05mm - .002mm
- Clay < .002mm

40% clay, 60% sand = Sandy Clay
10% clay, 30% sand = Silty loam (60% silt)
30% clay, 30% sand = Clay loam (40% silt)
45% clay, 10% sand = Silty clay (45% silt)
25% clay, 60% sand = Sandy clay loam (15% Silt)

Estimated Plant-Available Water in different soil texture types

Inches of soil per inch of water (Approximate)	Soil Texture
• 5 inches to hold 1 inch of water	• Loam, Silt loam, Silt, Silty clay loam, Clay loam
• 7 inches of soil to hold 1 inch of water	• Sandy loam, Sandy clay loam, Silty clay loam, Sandy Clay, Clay
• 10 inches of soil to hold 1 inch of water	• Loamy Sand, Course Sandy loam
• 20 inches of soil to hold 1 inch of water	• Sand, Loamy sand

Soil Structure

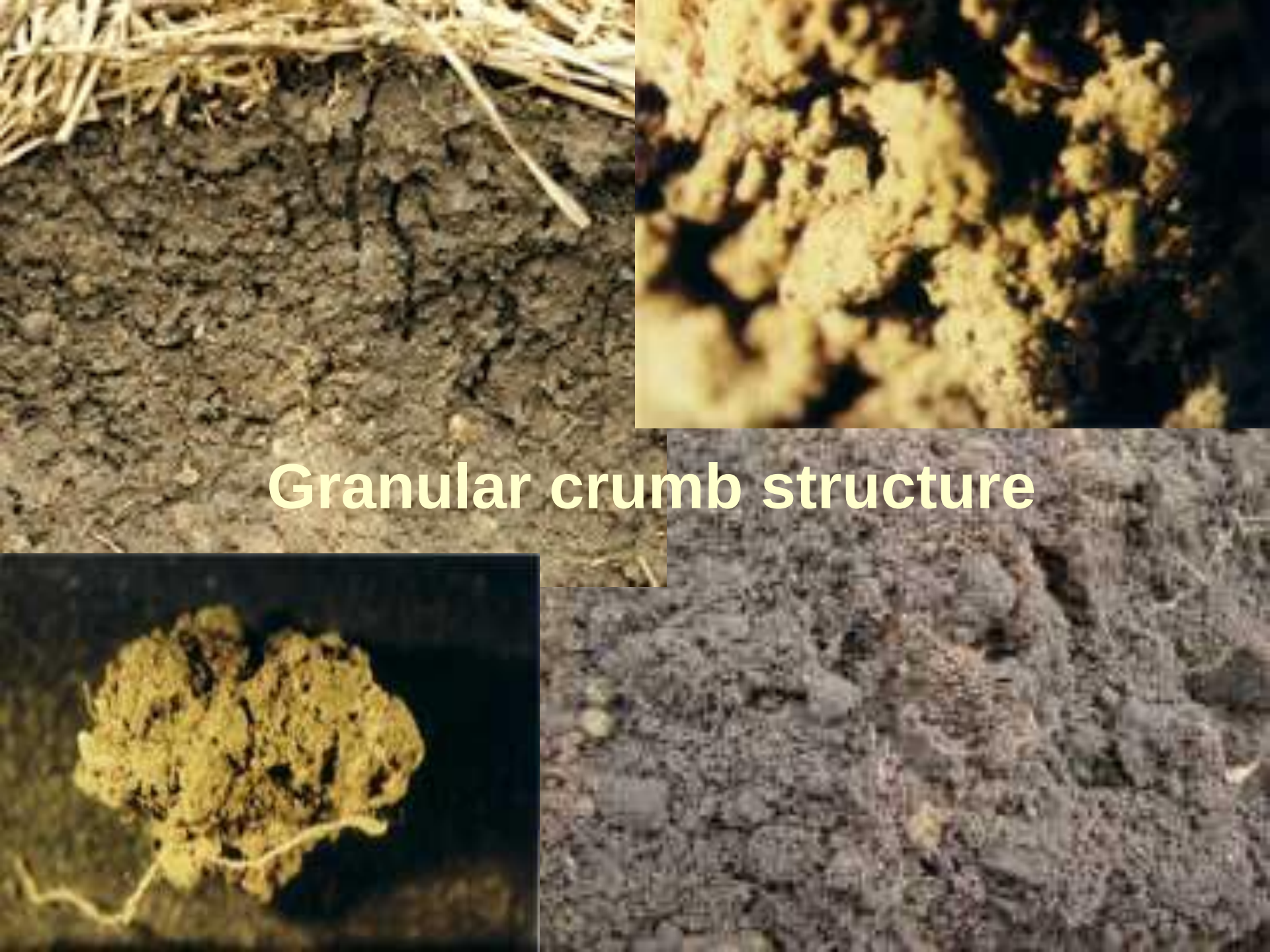
- The combination (arrangement) of primary soil particles into secondary particles, units or peds.

- Field term describing the over-all aggregation or arrangement of the soil separates.

Four primary types of soil Structure

- Platy – the aggregates are arranged into relatively thin horizontal plates.
- Prism like – columnar – vertically oriented aggregat6es or pillars which vary in length and diameter.
- Block like – original aggregates reduced to blocks, irregularly six faced bloc aggregates.
- Spheroidal – granular and crumb. All rounded aggregates.


Sub-Angular Blocky



Granular crumb structure


Disk pan
2 compacted layers
Plow pan

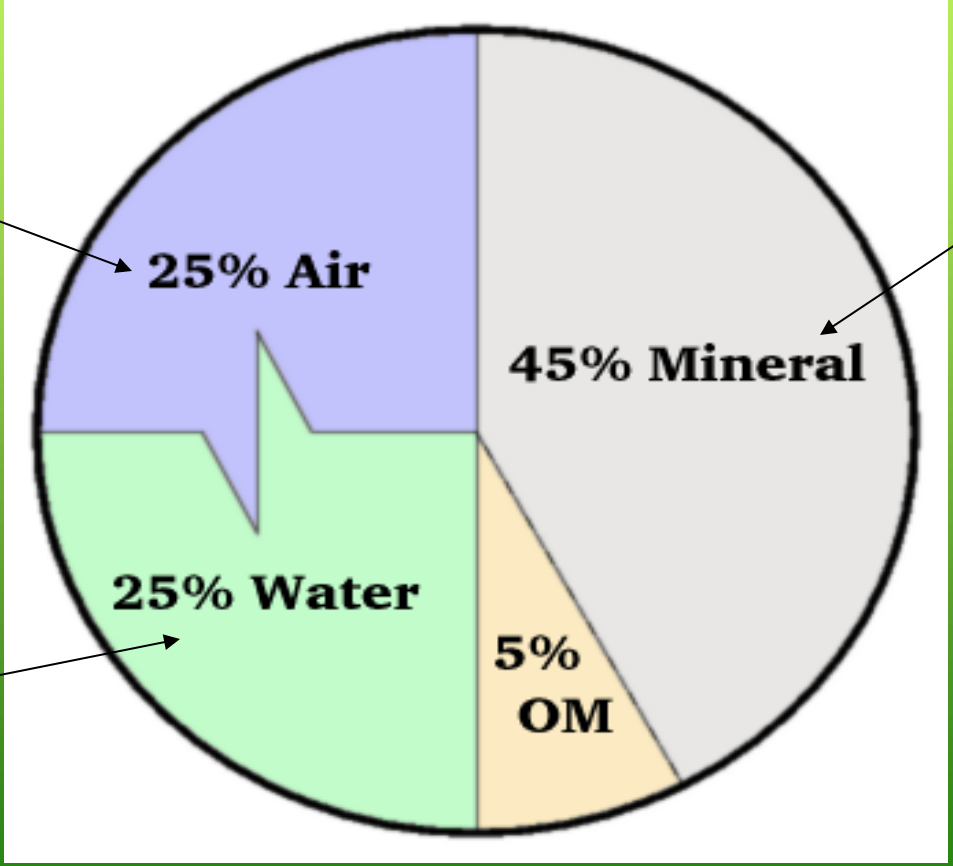
Organic Matter

- Soil organic matter – The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms and substances synthesized by the soil population.
- In a soil lab test % Organic matter is commonly determined as the amount of organic material contained is a soil sample that passed through a 2mm sieve.

Soils – 3 forms of matter

Gases

Liquids



Solids


Soil organic matter fuels
the soil food web

Soil Organic Matter

- Energy source for microorganisms
- Nutrient source for microorganisms and plants
- Improves soil structure and tilth
- Reduces soil erosion
- Increases water-holding capacity of soil
- Increases soil aeration
- Suppresses disease

Soil Organic Matter

- Growth-promoting substances
- Detoxifies
- Forms chelates for nutrient uptake
- Increases Cation Exchange Capacity (CEC)
- Buffers soil
- Dark color—warms up faster

What is humus ???

Humus is organic matter that has been transformed such that its original source is no longer apparent… The diverse products of "humification" have many common characteristics:

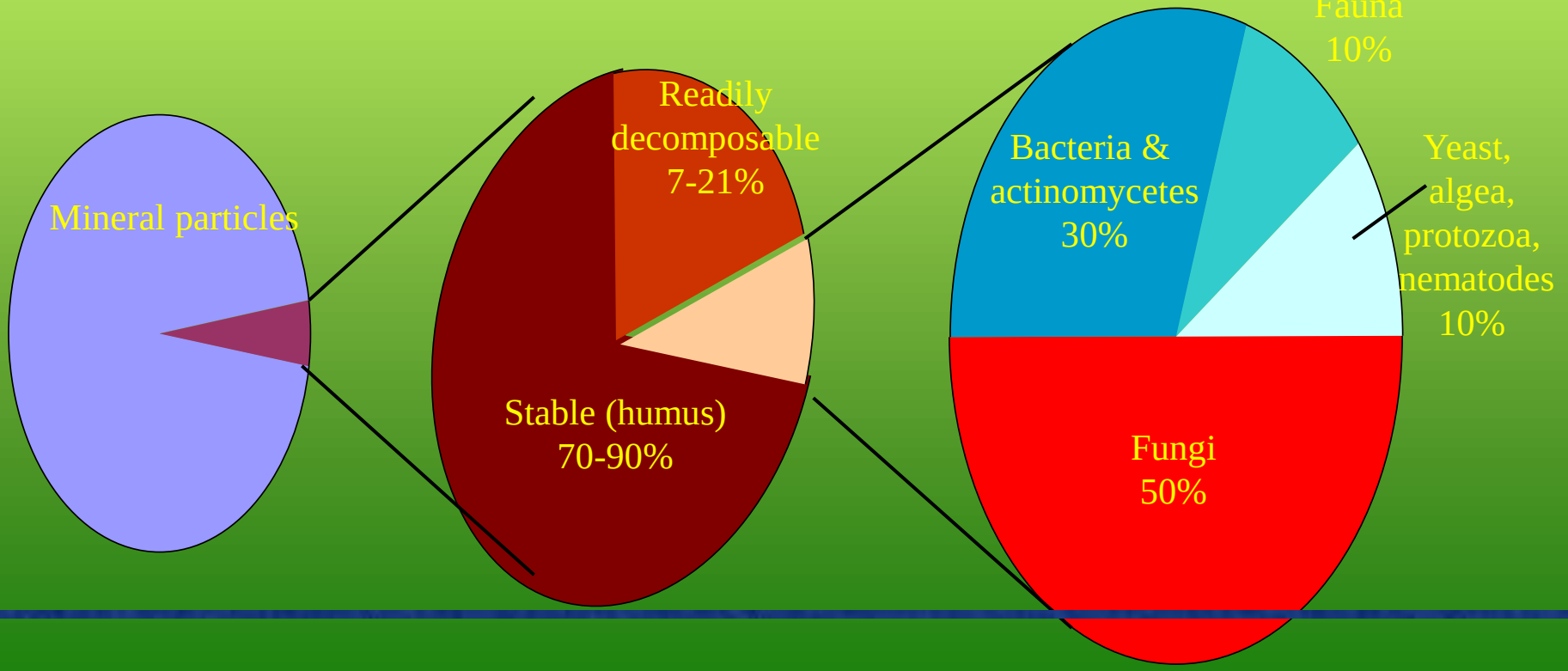
- **Extreme chemical complexity**
- **Resistance to further decomposition**
- **High specific surface and negative charge**
- **Dark color**

Soil Organic Matter
How much & what form?

Soil

Soil organic matter
1-6% of total soil mass

Soil microbial biomass
3-9% of total SOM mass



Soils perform vital functions

1. Sustaining plant & animal life below and above the surface
2. Regulating & partitioning water and solute flow.
3. Filtering, buffering, degrading, immobilizing and detoxifying.
4. Storing & cycling nutrients.

Where does soil fit into the big picture? Environmental factors influencing plant growth

1. Temperature, (**Soil Temperature**)
2. Moisture Supply (**Ability to percolate and hold moisture in the soil)**
3. Radiant Energy (Sunlight, quality, intensity & duration)
4. Composition of the atmosphere
5. Gas content of the **soil**
6. **Soil reaction** (Soil pH) Degree of acidity or alkalinity
7. Biotic factors (Plant variety type- genetics, **soil biology**)
8. **Supply of mineral nutrient elements**

Questions/Discussion?