SOIL

General Properties of Soil

- Where is the best place to build a farm structure?
- What type of crops will grow best in a particular area of the field?
- Will the area for crops and livestock production be flooded when it rained?
- How can the quality of water and area be improved?

Soil

- The soil is a natural medium for growth of plants which gives mechanical support as well as supplies water and essential plant nutrients needed by the plants.

Tomar, A. S. (2014). Soil Science : A Practical Perspective: with Glossary and Facts About the Soil. Biotech.

Soil

- Soil may also be defined as the collection of natural bodies occupying portions of the earth's surface that support plants and that have properties due to integrated effect of climate and living matter, acting upon parent material as conditioned by relief over periods of time.

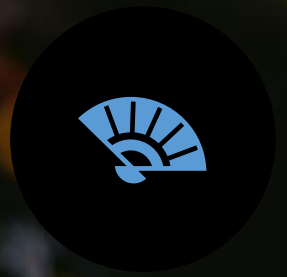
Tomar, A. S. (2014). Soil Science : A Practical Perspective: with Glossary and Facts About the Soil. Biotech.

PRINCIPAL COMPONENTS OF SOIL

MINERAL COMPONENTS
(SAND, SILT, OR CLAY)

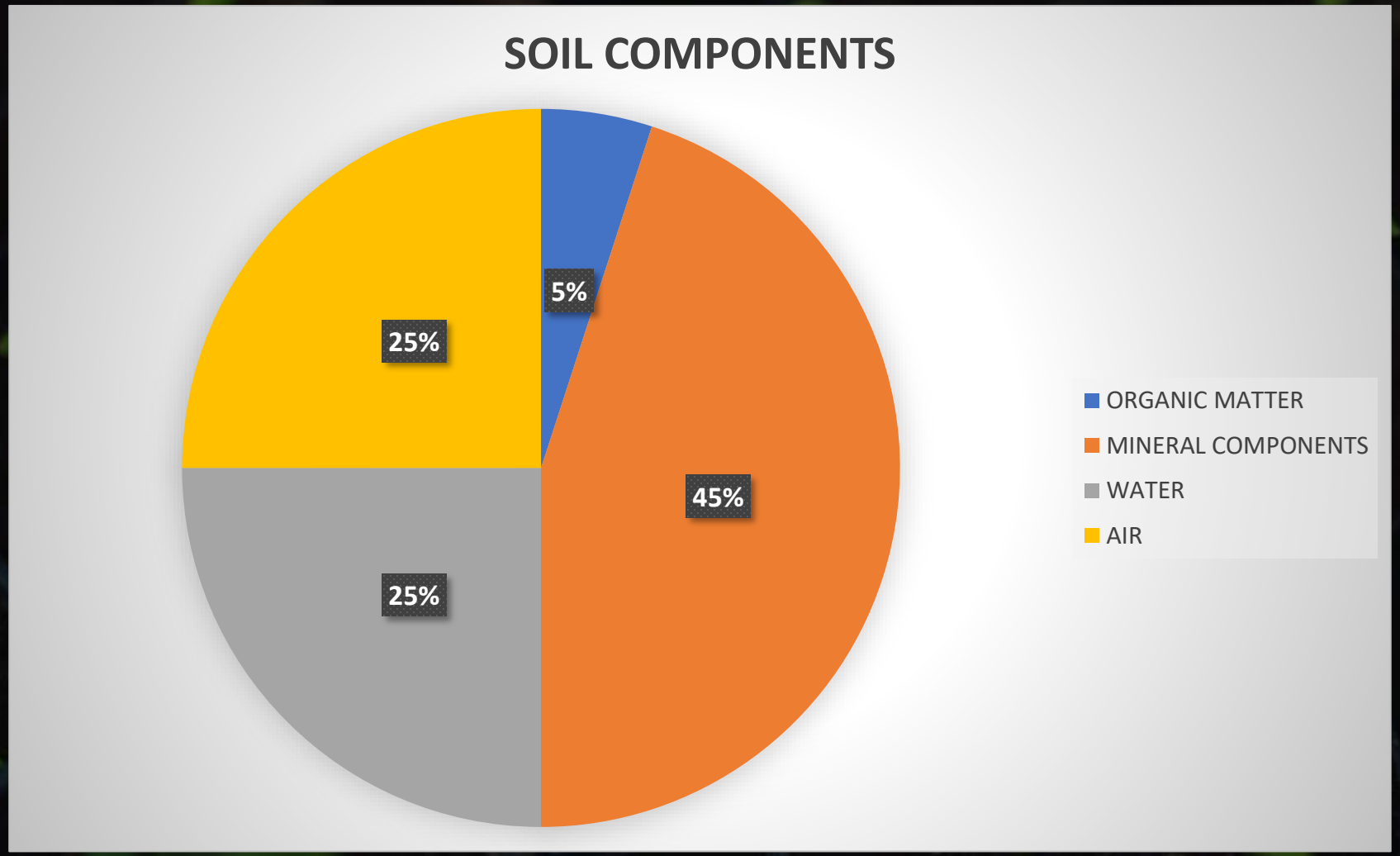
ORGANIC MATERIALS

WATER



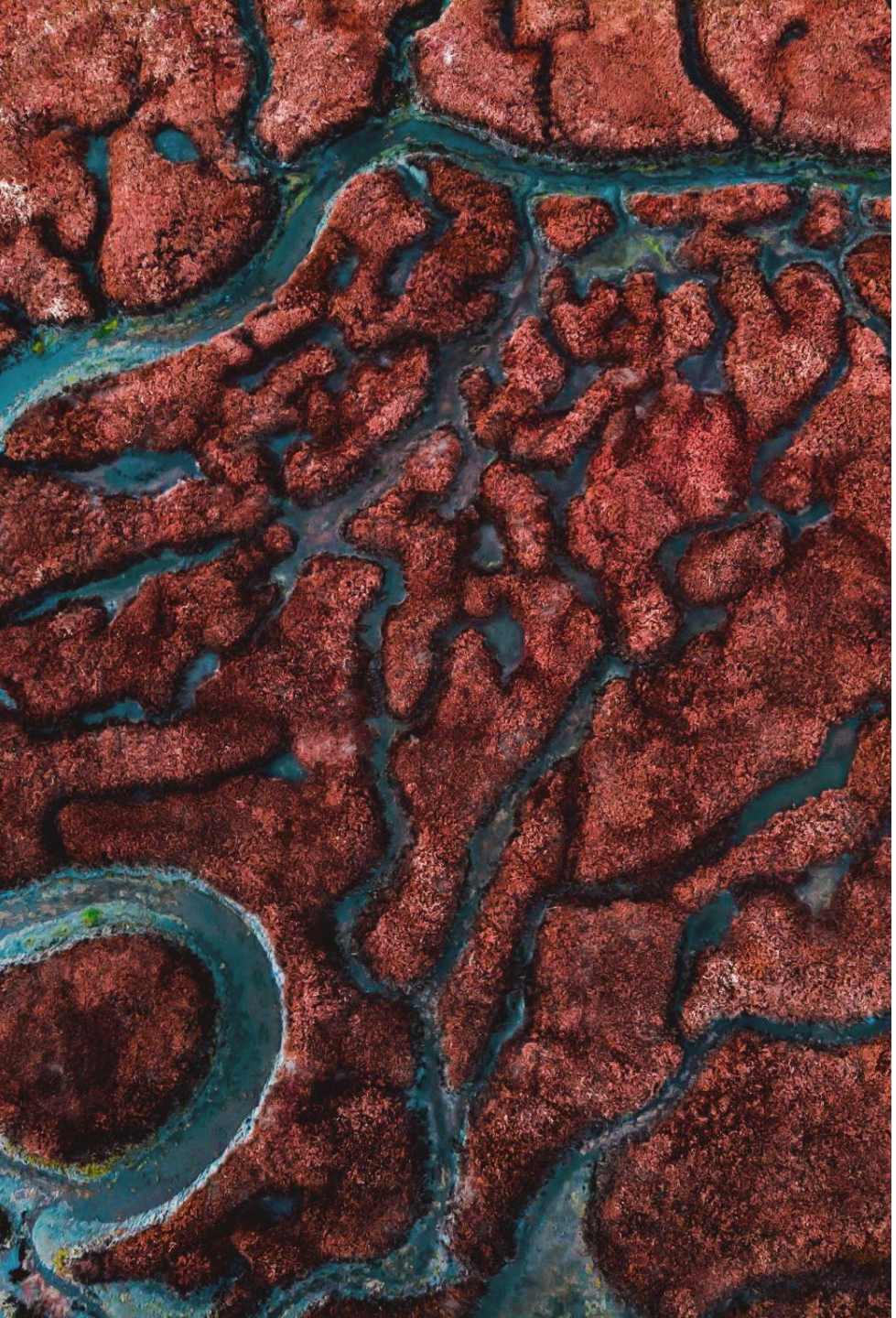
AIR

A GOOD SOIL CONSISTS OF:



SOIL FORMATION

The development of soils from original rock materials is a long-term process involving both physical and chemical weathering, along with biological activity.



Weathering

- Weathering is the breaking down of rocks, soils, and minerals as well as wood and artificial materials through contact with the Earth's atmosphere, water, and biological organisms.

- Mechanical Weathering
- Chemical Weathering

Mechanical weathering

also called physical weathering and disaggregation, causes rocks to crumble.

Water
Air
Temperature Changes
Change in pressure
Plants and animals

Chemical Weathering

- process changes the composition of rocks, often transforming them when water interacts with minerals to create various chemical reactions.
- Chemical weathering changes the molecular structure of rocks and soil.

  - carbonation
  - oxidation
  - hydration

FACTORS THAT FORM SOILS

CL - **Climate**

O - **Organisms**

R - **Relief/ Topography**

P - **Parent material**

T - **Time**

CLIMATE

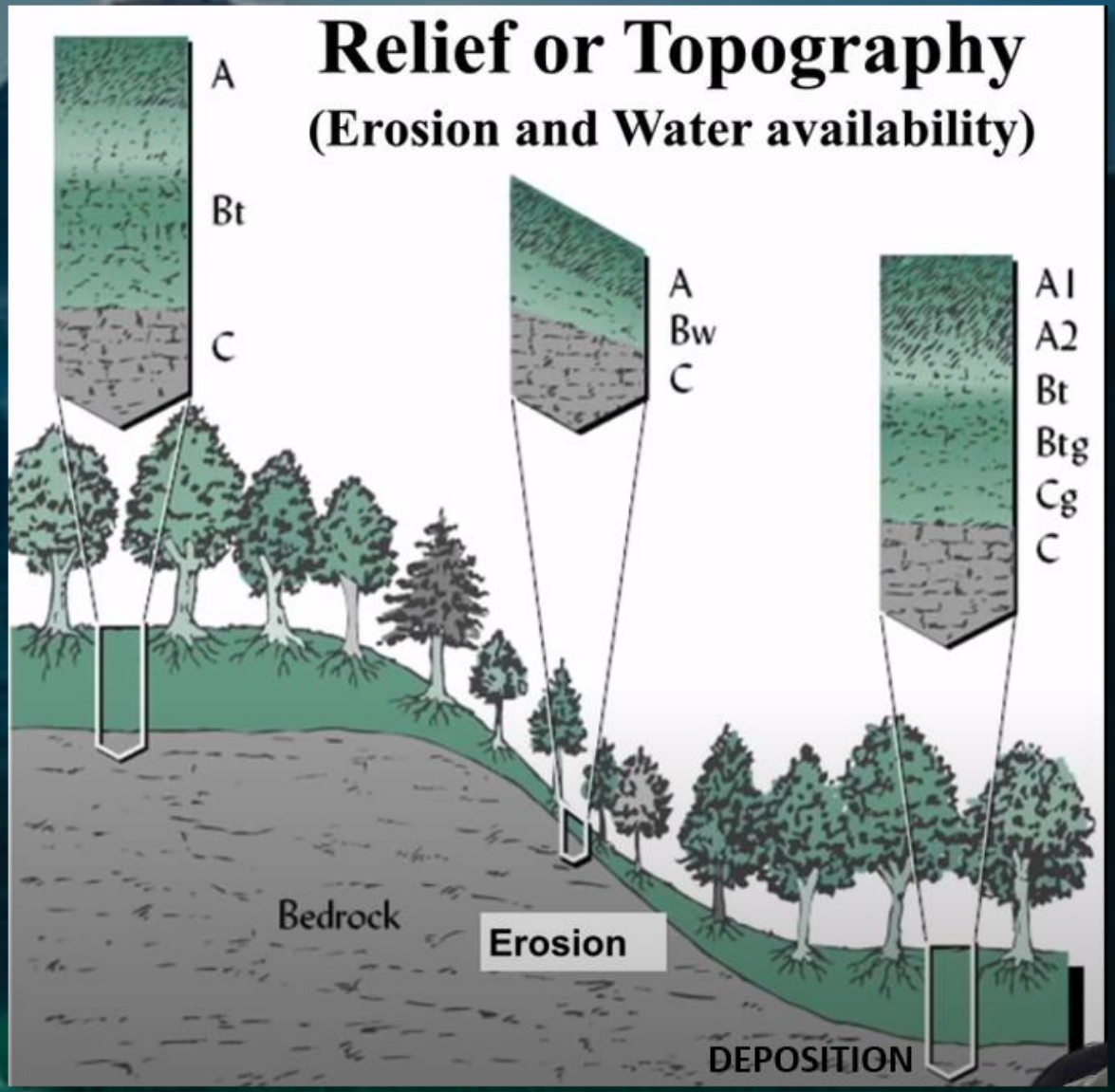
- temperature and moisture.

ORGANISMS

- microscopic and macroscopic plants and animals.

RELIEF or TOPOGRAPHY

shape and position of land surfaces.



SANDSTONE

GRANITE

BASALT

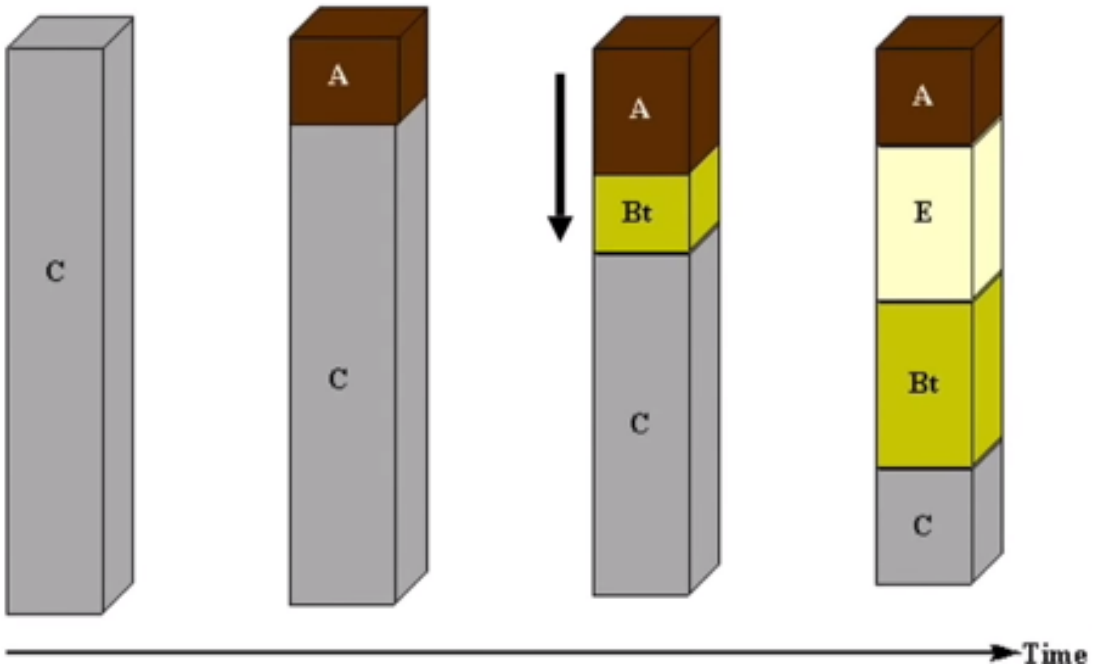
SHALE

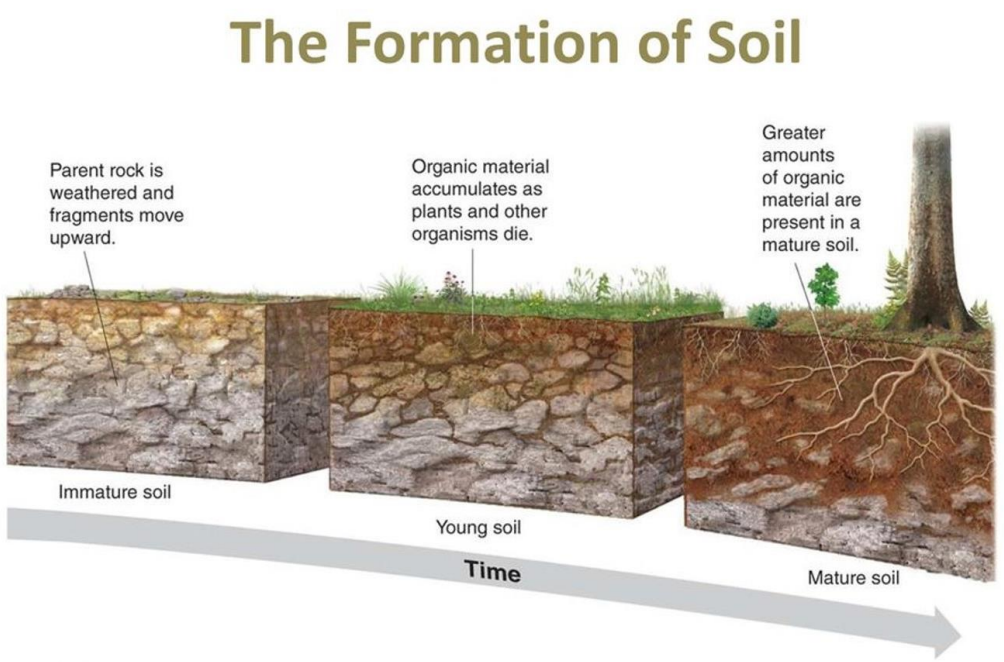
PARENT MATERIAL

- material from which soils are formed.

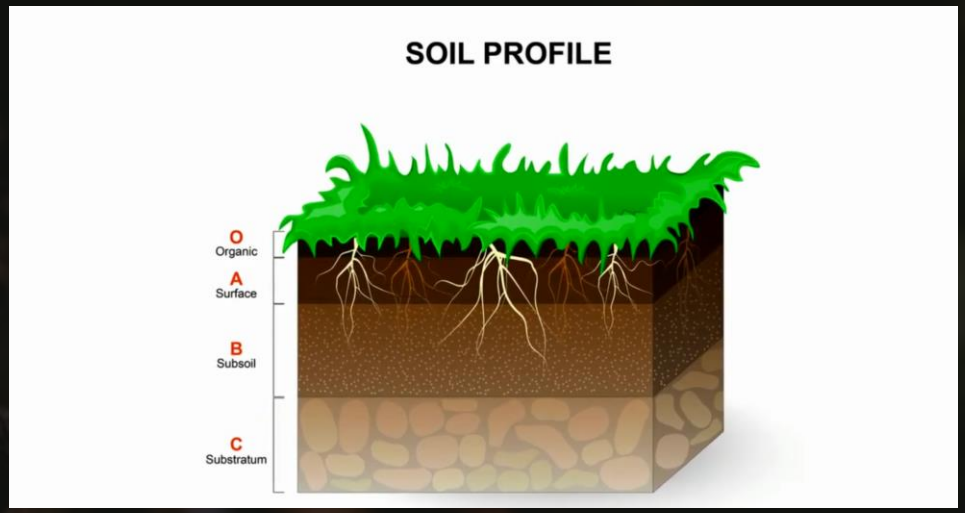
TIME

- period during which parent materials have been subjected to soil formation.





SOIL PROFILE

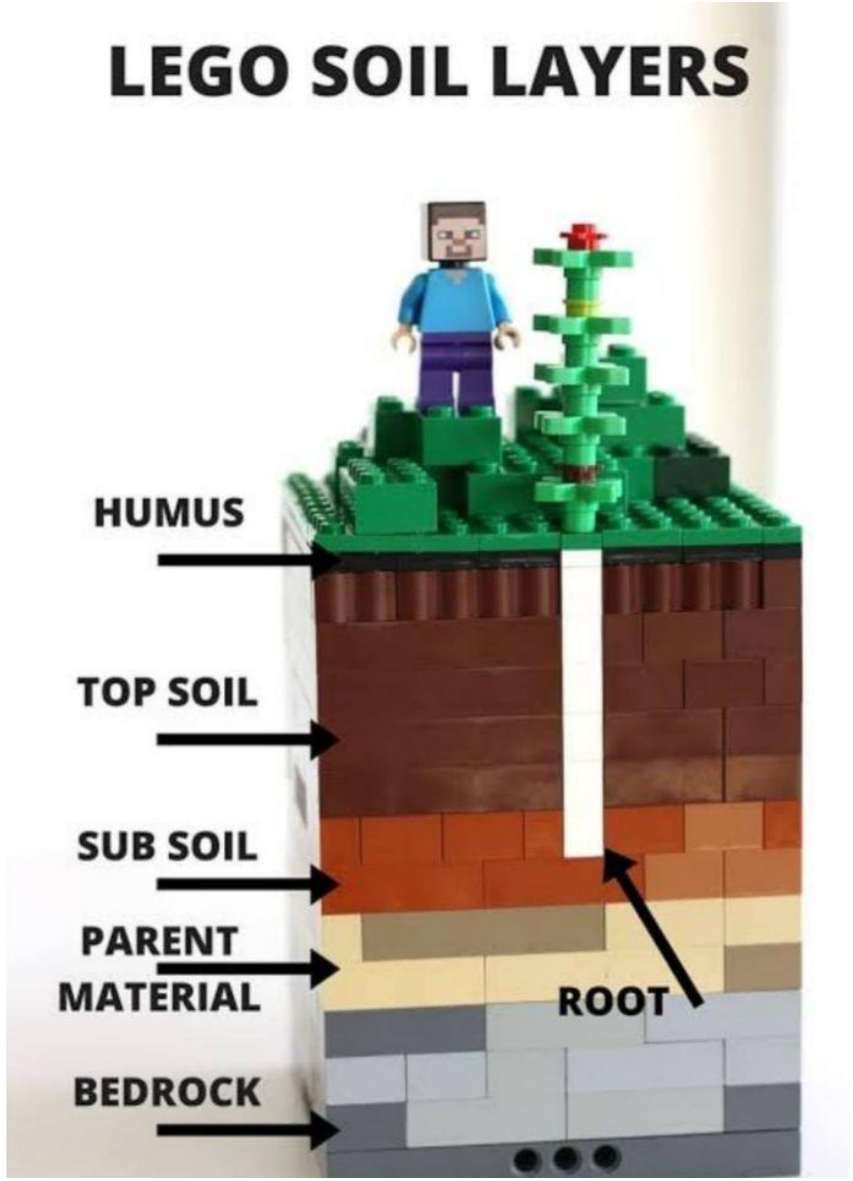


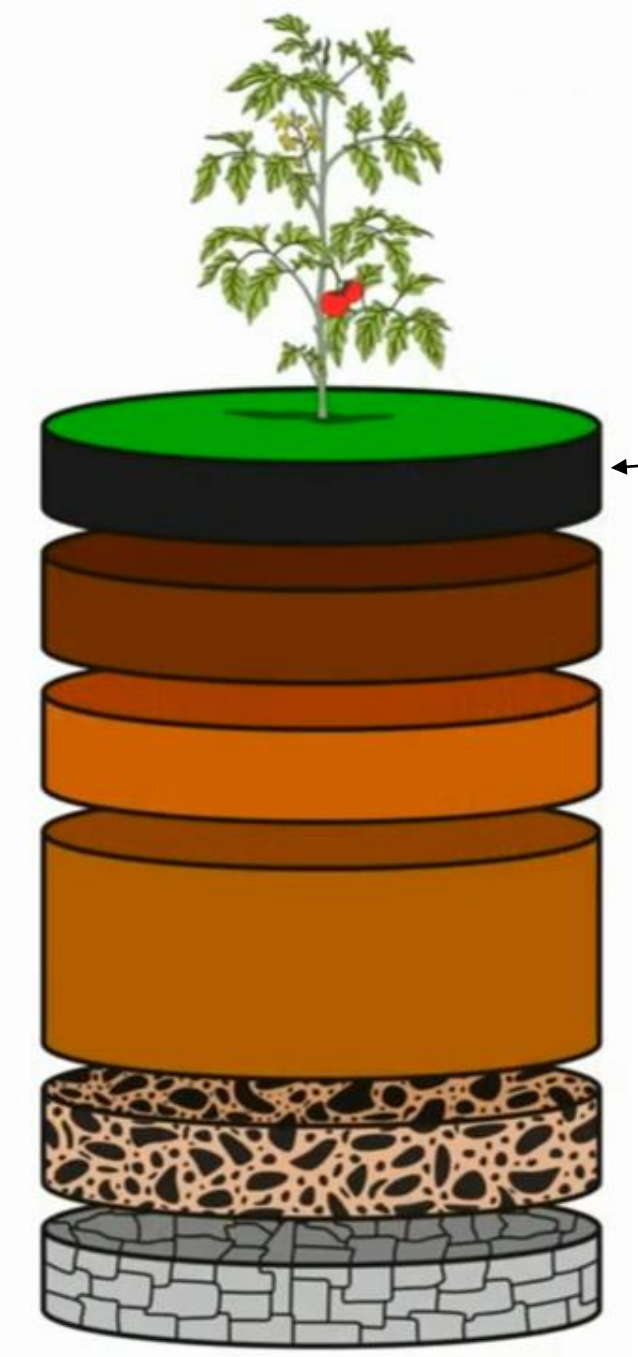
- A vertical section of the soil up to unweathered rock.
- The individual layers are referred to as “**horizons**”

Tomar, A. S. (2014). Soil Science : A Practical Perspective: with Glossary and Facts About the Soil. Biotech.

HORIZONATION

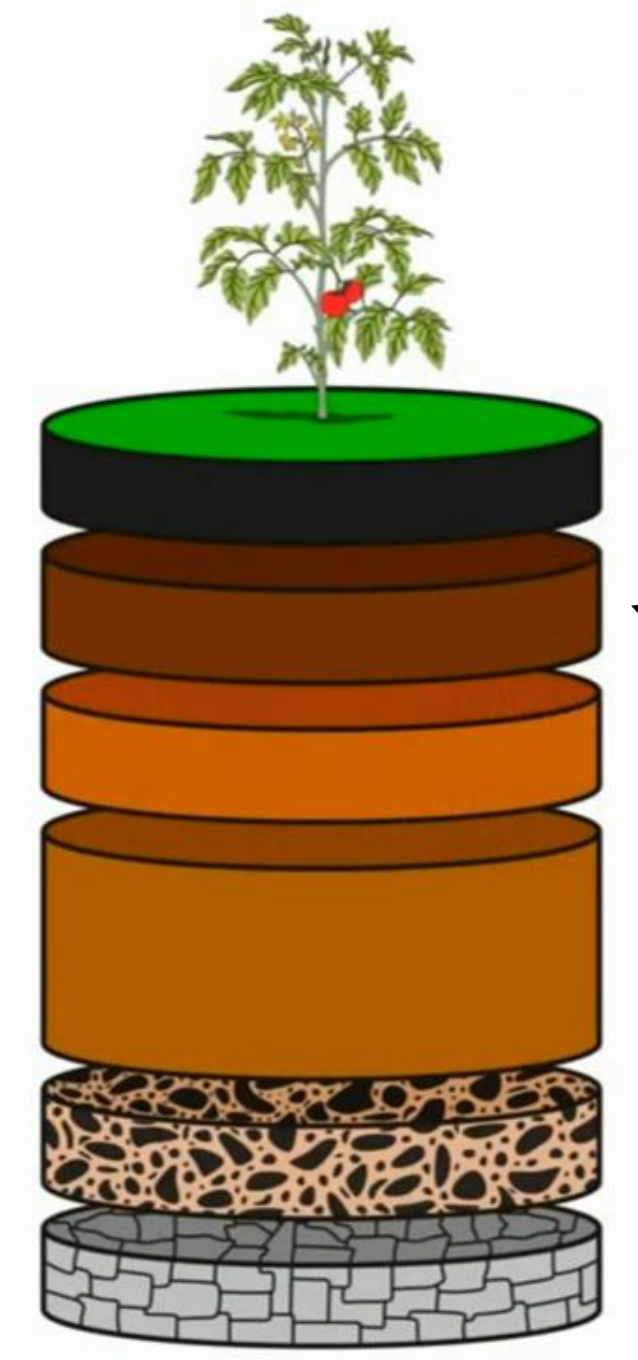
- The formation of soil horizons.
- results from differential gains, losses, transformations and translocations that occur over time within various types of a vertical section of the parent material.





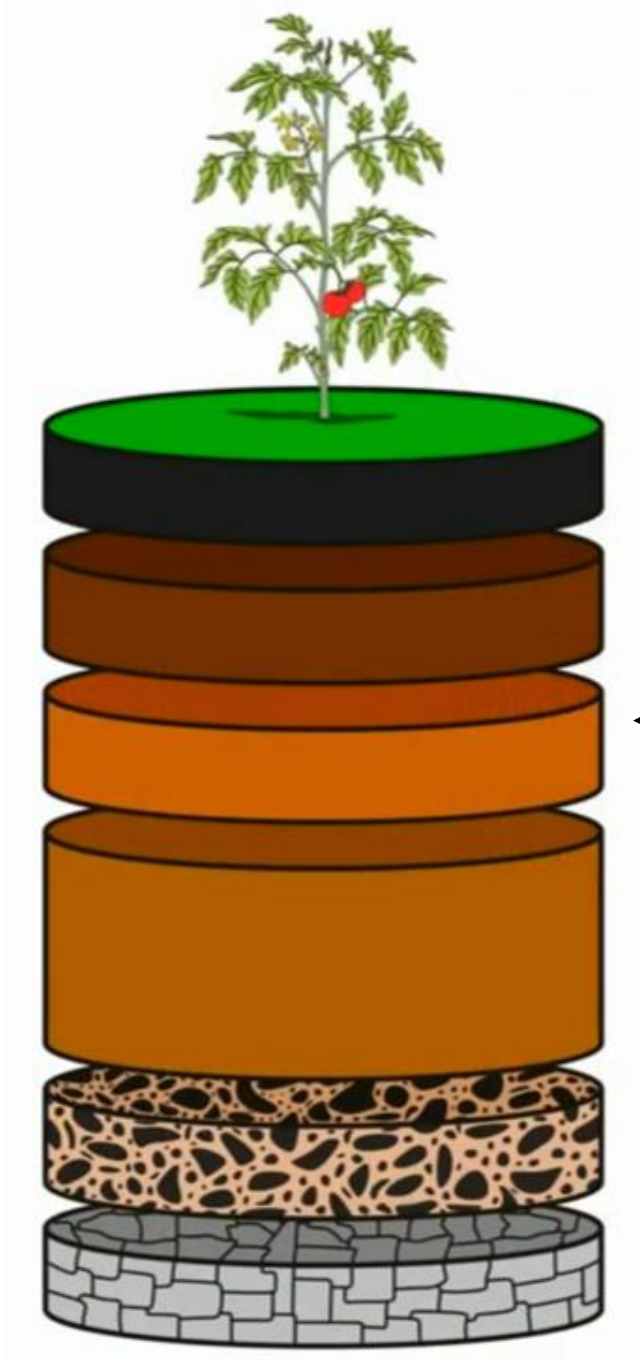
O-Horizon

- Litter layer of plant residues
- are dominated by organic material.
- the top layer of soil.
- Animals live on this layer.
- The color ranges from brown to black



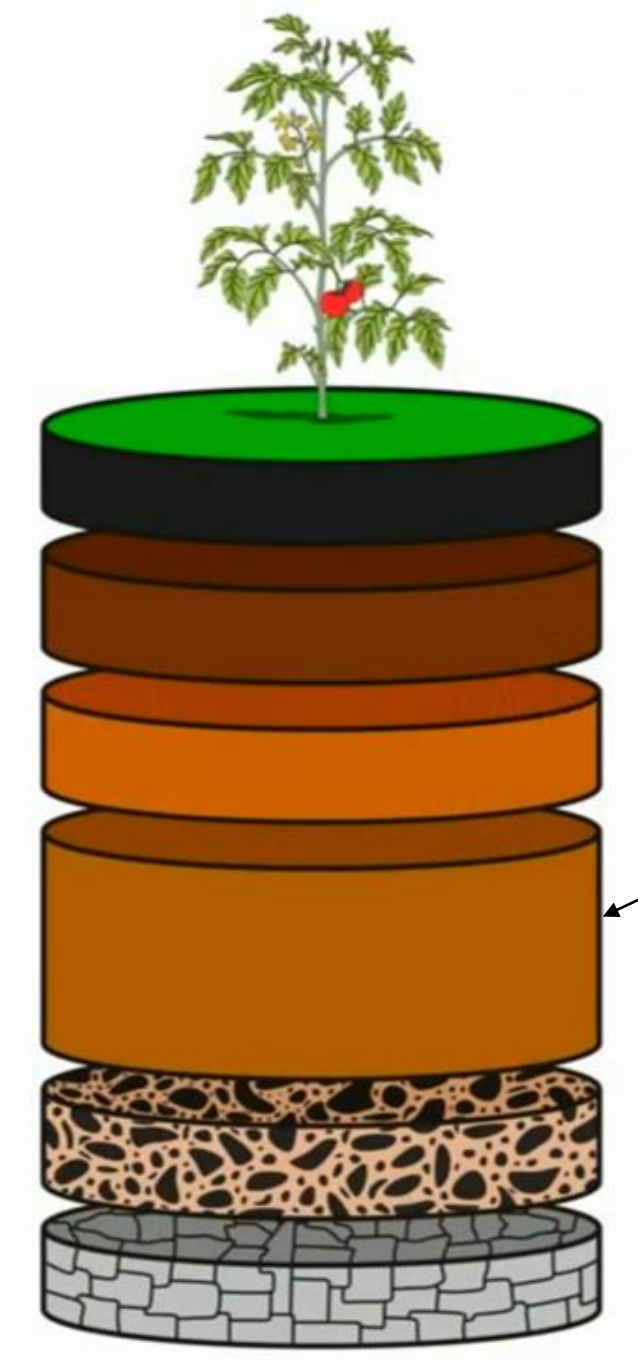
A-Horizon

- also called as the “topsoil”
- layer of mineral soil with most organic matter accumulation and soil life.
- The color ranges from brown to gray.
- A horizon forms the surface soil of the plough layer.



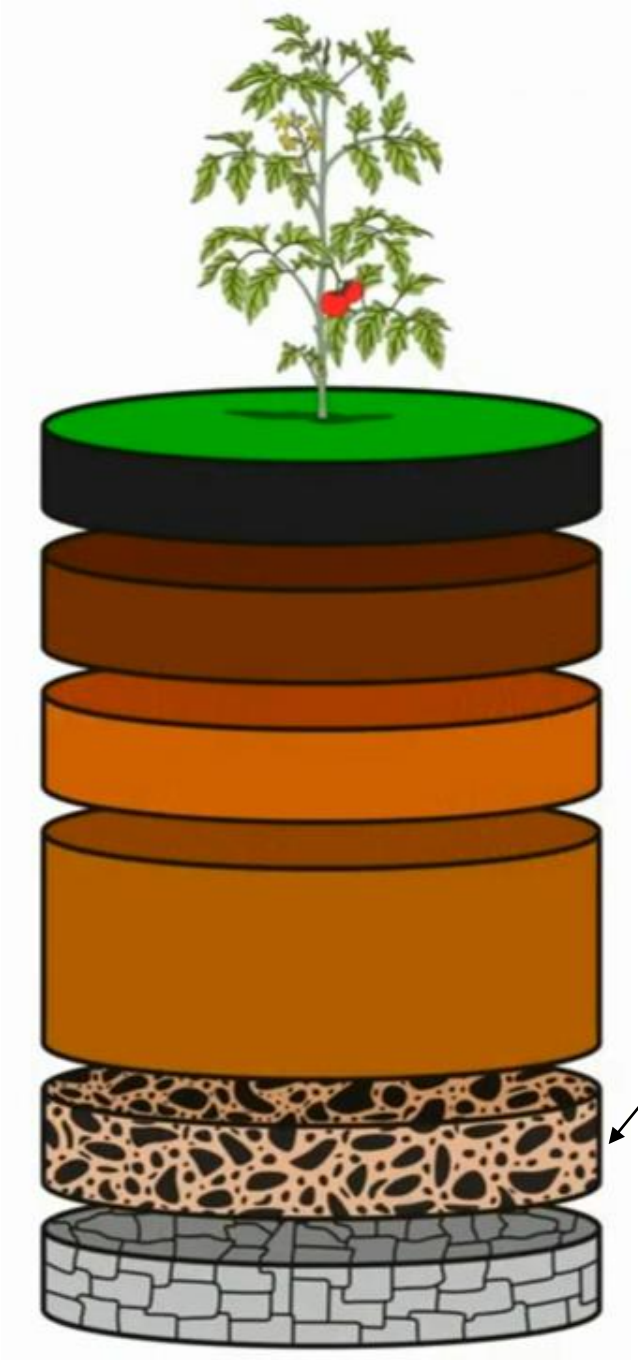
E-Horizon

- “eluviation layer”
- pale layer, mainly consisting of silicates.



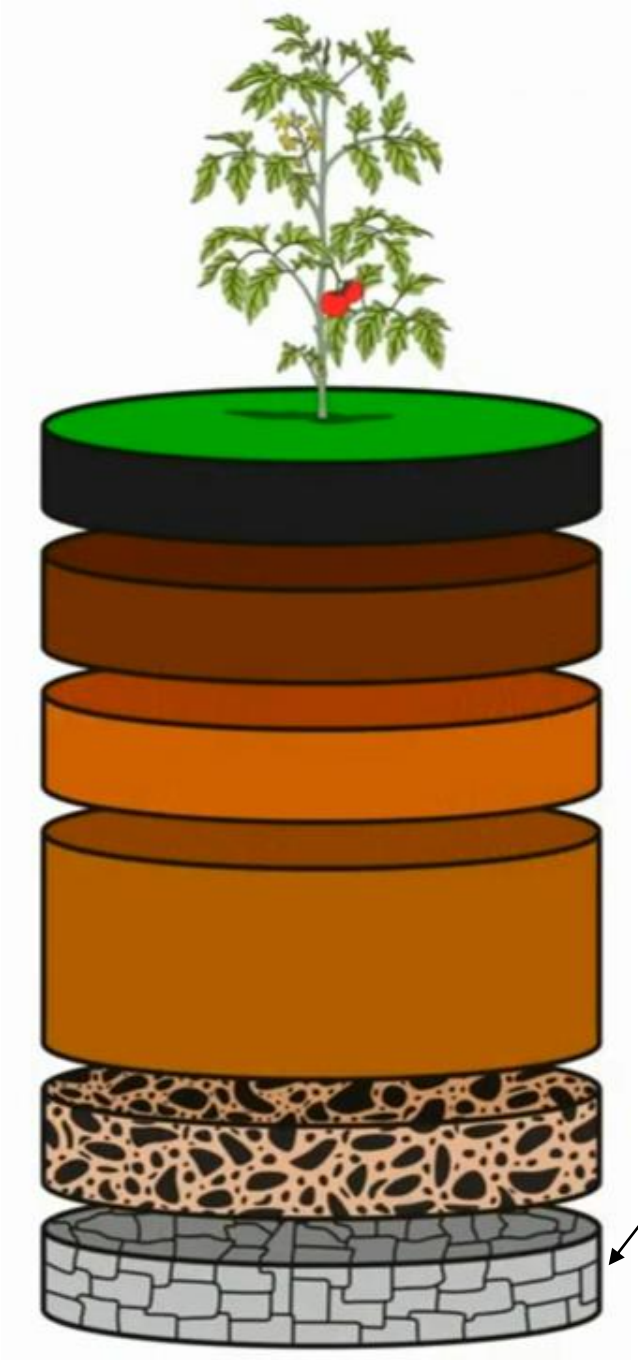
B-Horizon

- “subsoil”
- layer that accumulates iron, clay, aluminum and organic compounds, a process referred to as illuviation.
- Color ranges from reddish brown to tan



C-Horizon

- consists of weathered parent material in the upper part and unweathered rock below.



R-Horizon

- “bedrock”
- layer of partially weathered bedrock at the base of the soil profile.

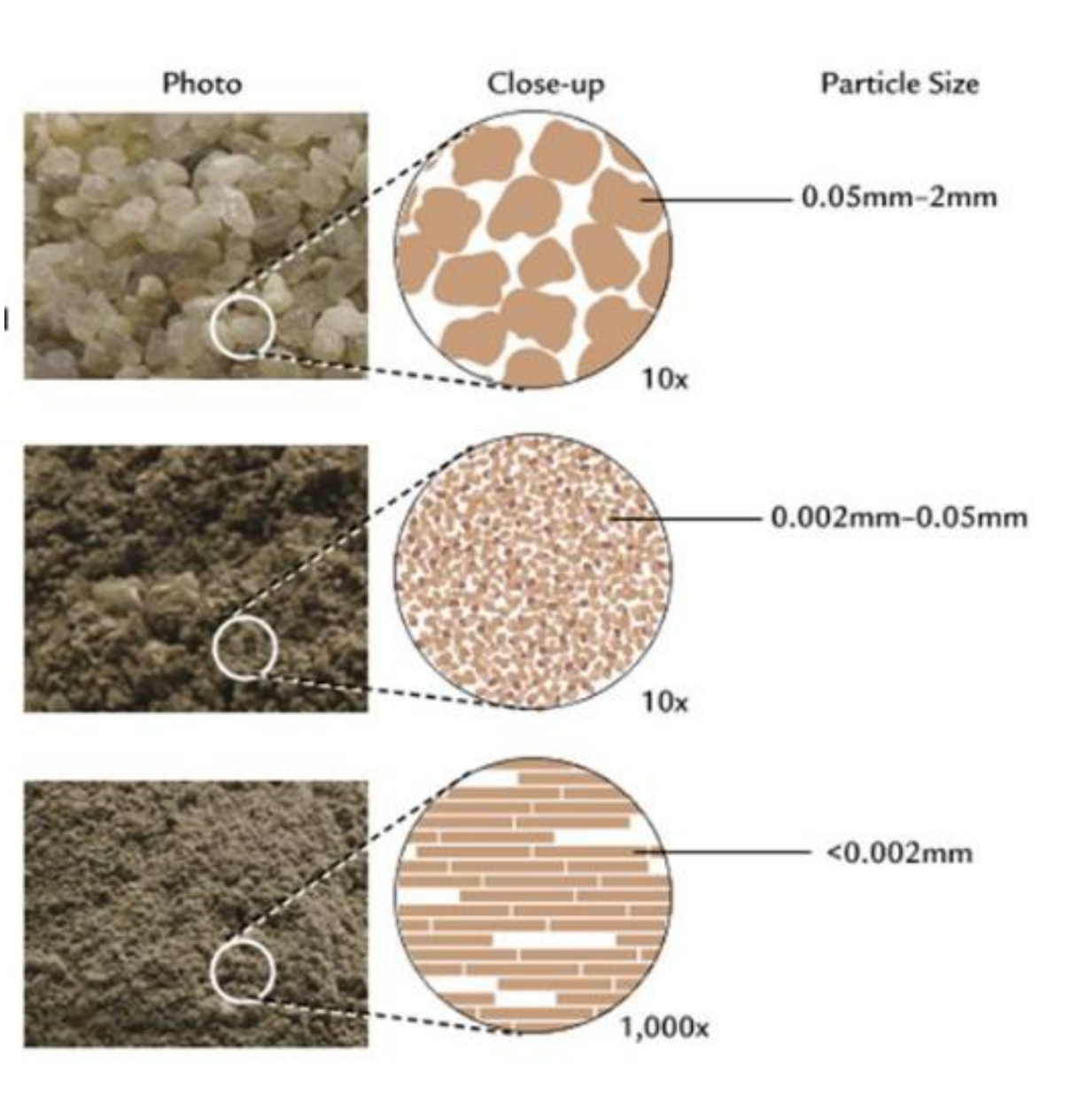
SOIL CHARACTERIZATIONS CARRIED OUT IN FIELD

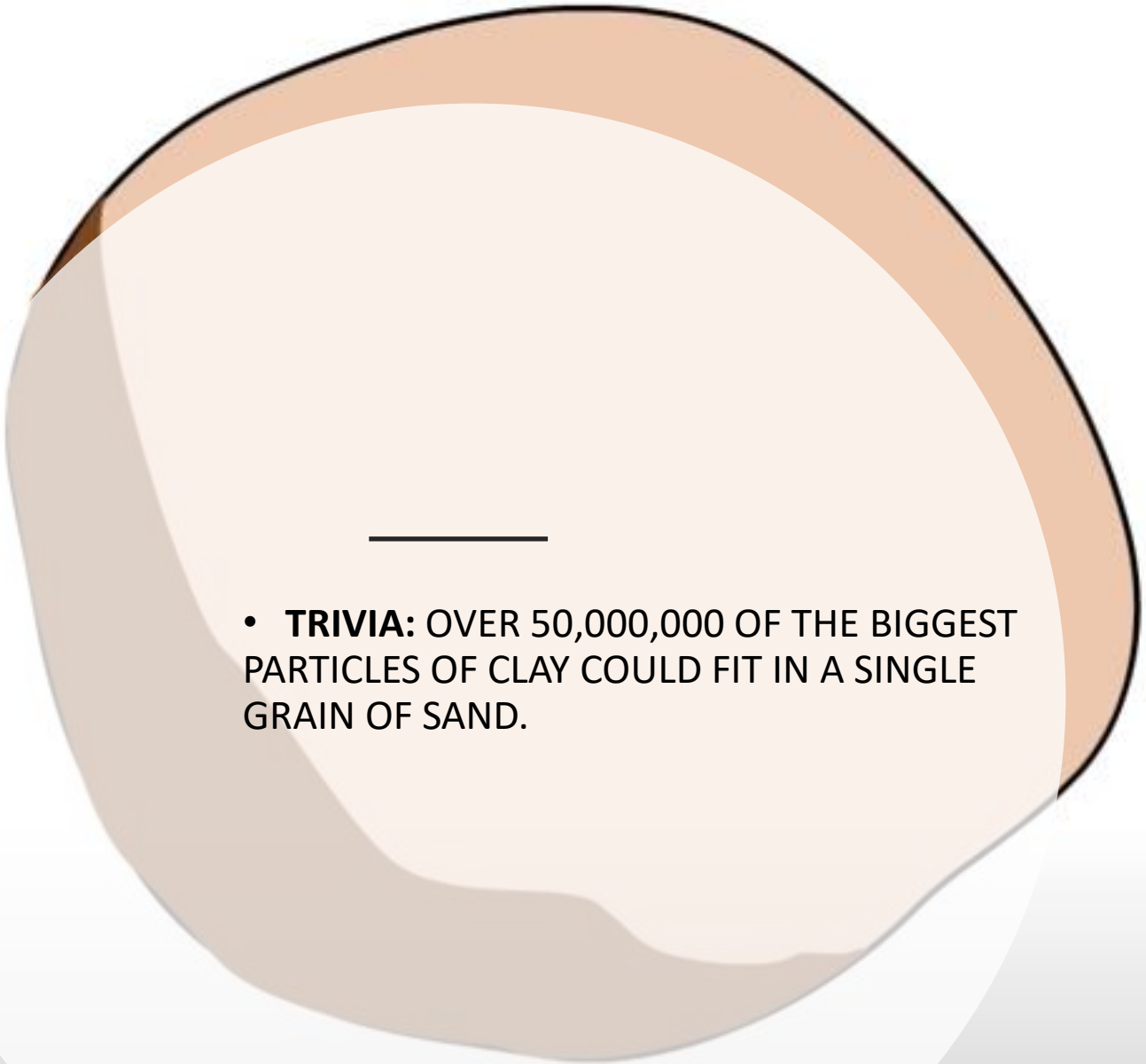
- **SOIL TEXTURE**
- **SOIL STRUCTURE**
- **SOIL COLOR**
- **SOIL CONSISTENCE**
- **BULK DENSITY**
- **SOIL WATER**
- **SOIL TEMPERATURE**
- **SOIL FERTILITY**

- refers to the proportion of the soil “separates” that make up the mineral component of soil.

SOIL TEXTURE

- describes how a soil feels and is determined by the amount of sand, silt and clay particles present in the soil sample.





SAND
2.00-0.05 MM

- **TRIVIA:** OVER 50,000,000 OF THE BIGGEST PARTICLES OF CLAY COULD FIT IN A SINGLE GRAIN OF SAND.

SILT
0.05-0.002 MM

CLAY
<0.002 MM

Sand and Silt

- Sand and silt are the “inactive” part of the soil matrix, because they do not contribute to a soil’s ability to retain soil water or nutrients.

SAND

- fairly coarse and loose, water can drain through it easily.
- While this is good for drainage, it is not good for growing plants

SILT

- can be thought of as fine sand
- and it will hold water better than sand.

Clay

- clay is the “active” portion of the soil matrix.
- very fine-grained soil
- particles are even smaller than silt
- clay does not drain well or provide space for plant roots to flourish

LOAM

- Considered as our fourth type of soil
- combination of sand, silt and clay
- holds moisture, but also allows for good drainage

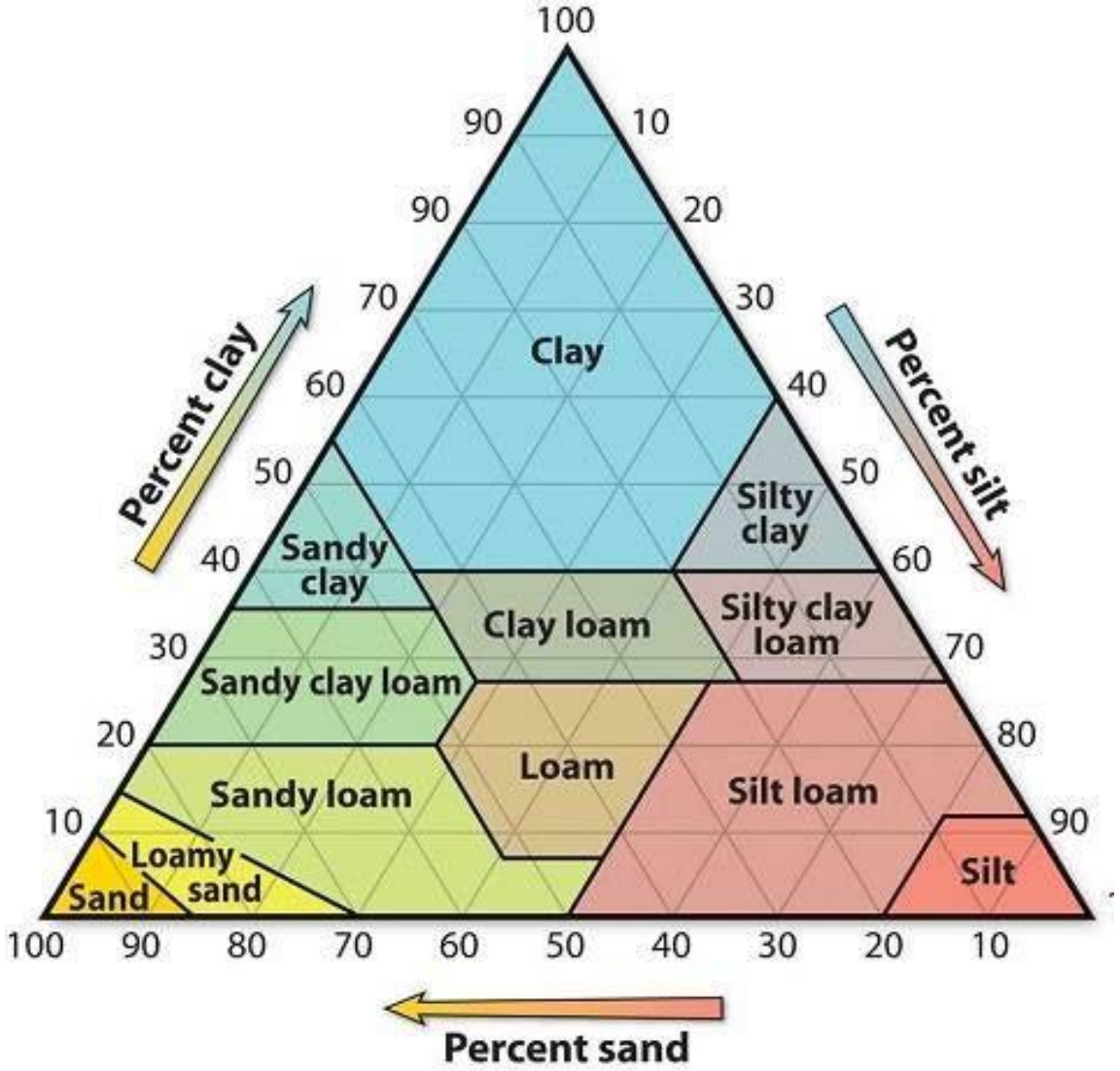
SOIL TEXTURE CLASSES

- For all mineral soils, the proportion of sand, silt, and clay always adds up to 100 percent. These percentages are grouped into soil texture **“classes”**, which have been organized into a **“textural triangle”**.

1. Clay	**7. Sand**
2. Sandy clay	**8. Loamy sand**
3. Silty clay	**9. Sandy loam**
4. Sandy clay loam	**10. Loam**
5. Clay loam	**11. Silt loam**
6. Silty clay loam	**12. Silt**

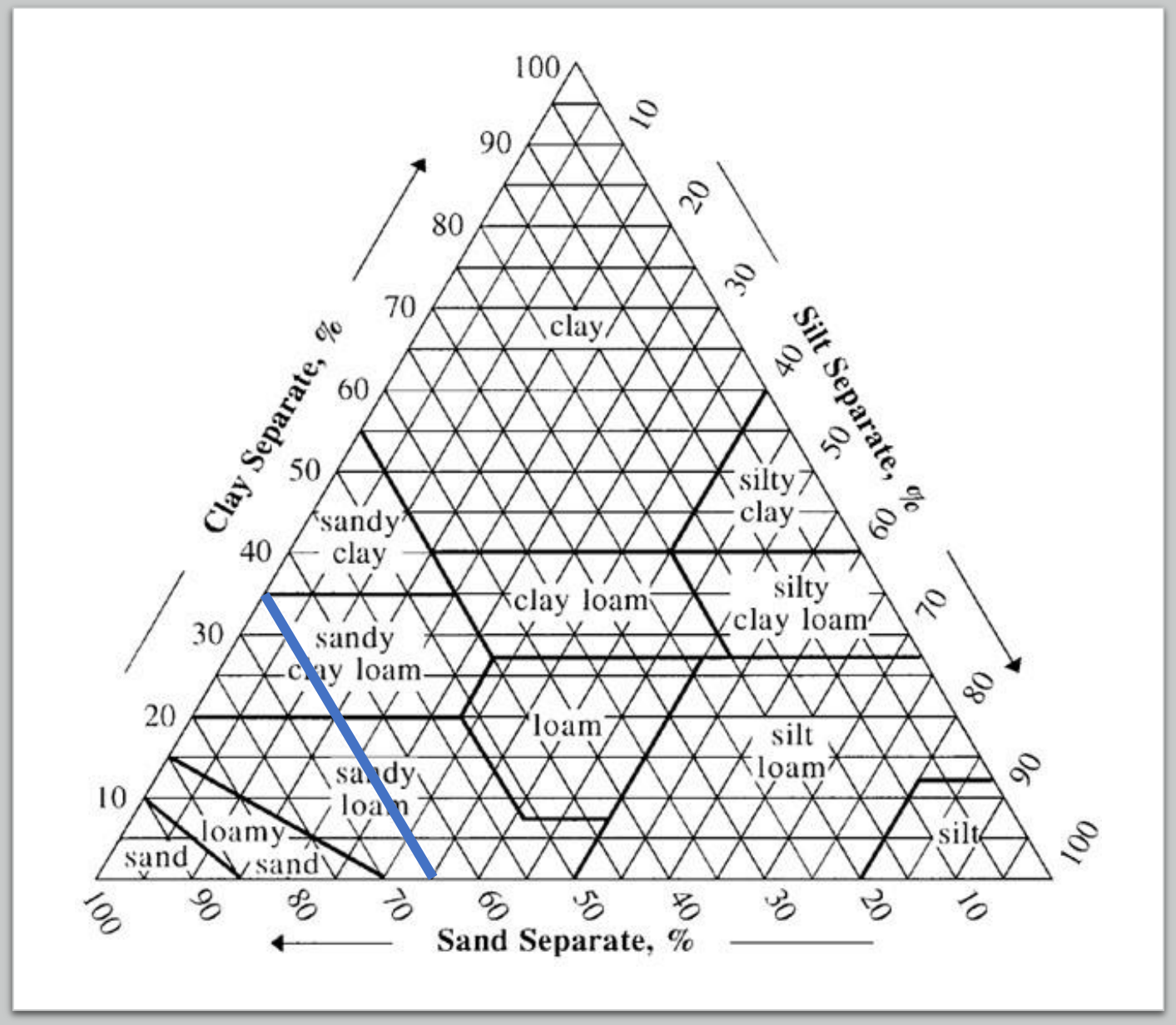
SOIL TEXTURE TRIANGLE

- The soil texture triangle is one of the tools that soil scientists use to visualize and understand the meaning of soil texture names.
- The textural triangle is a diagram which shows how each of these 12 textures is classified based on the percent of sand, silt, and clay in each.



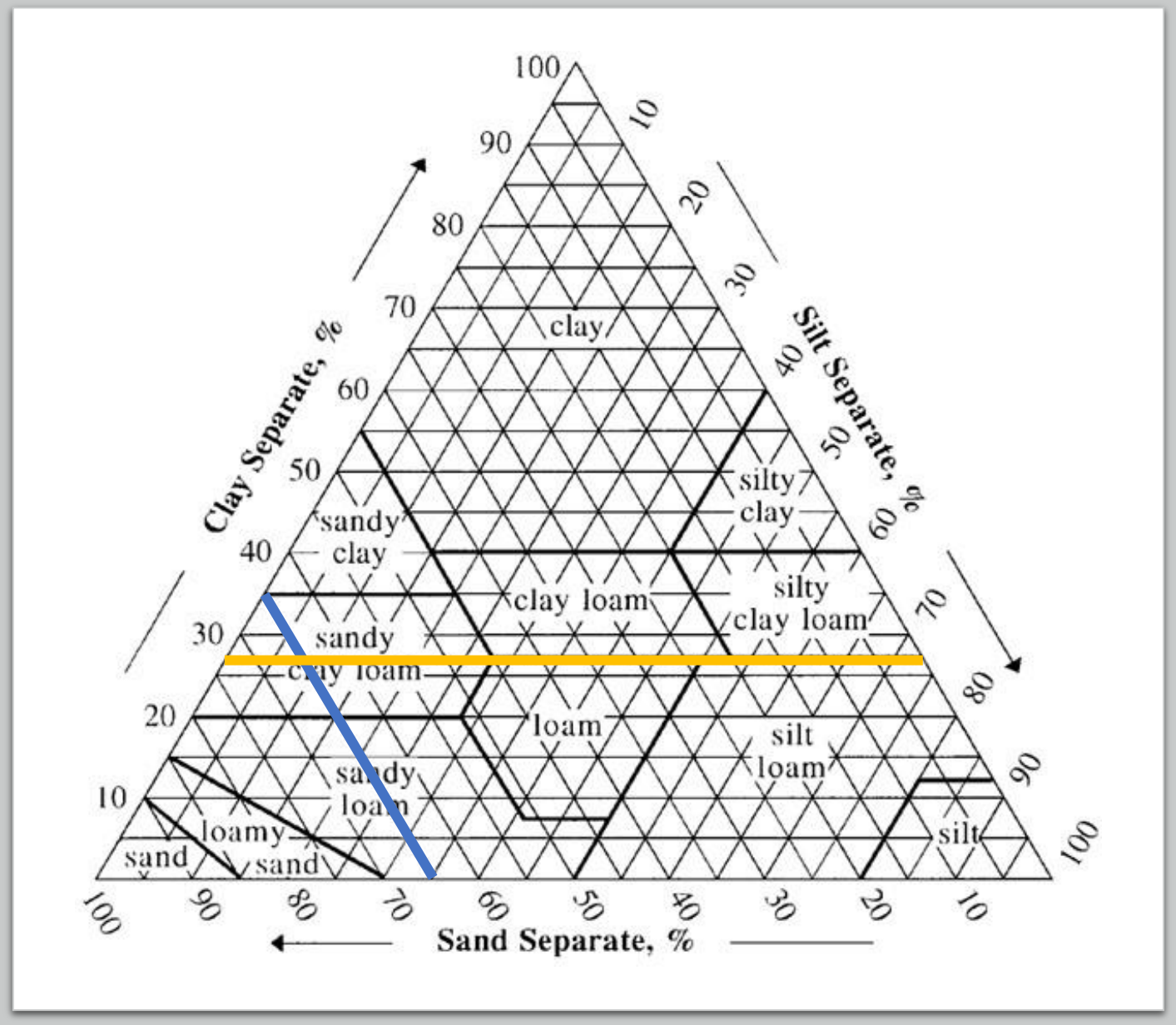
Steps in Using Textural Triangle

1. Determine the percent sand of your sample and find that number on the bottom of the triangle. Note that the numbers read from right to left, not left to right. For example, if your sample is 65% sand, then you need to pick a point to the LEFT of the 60 mark.



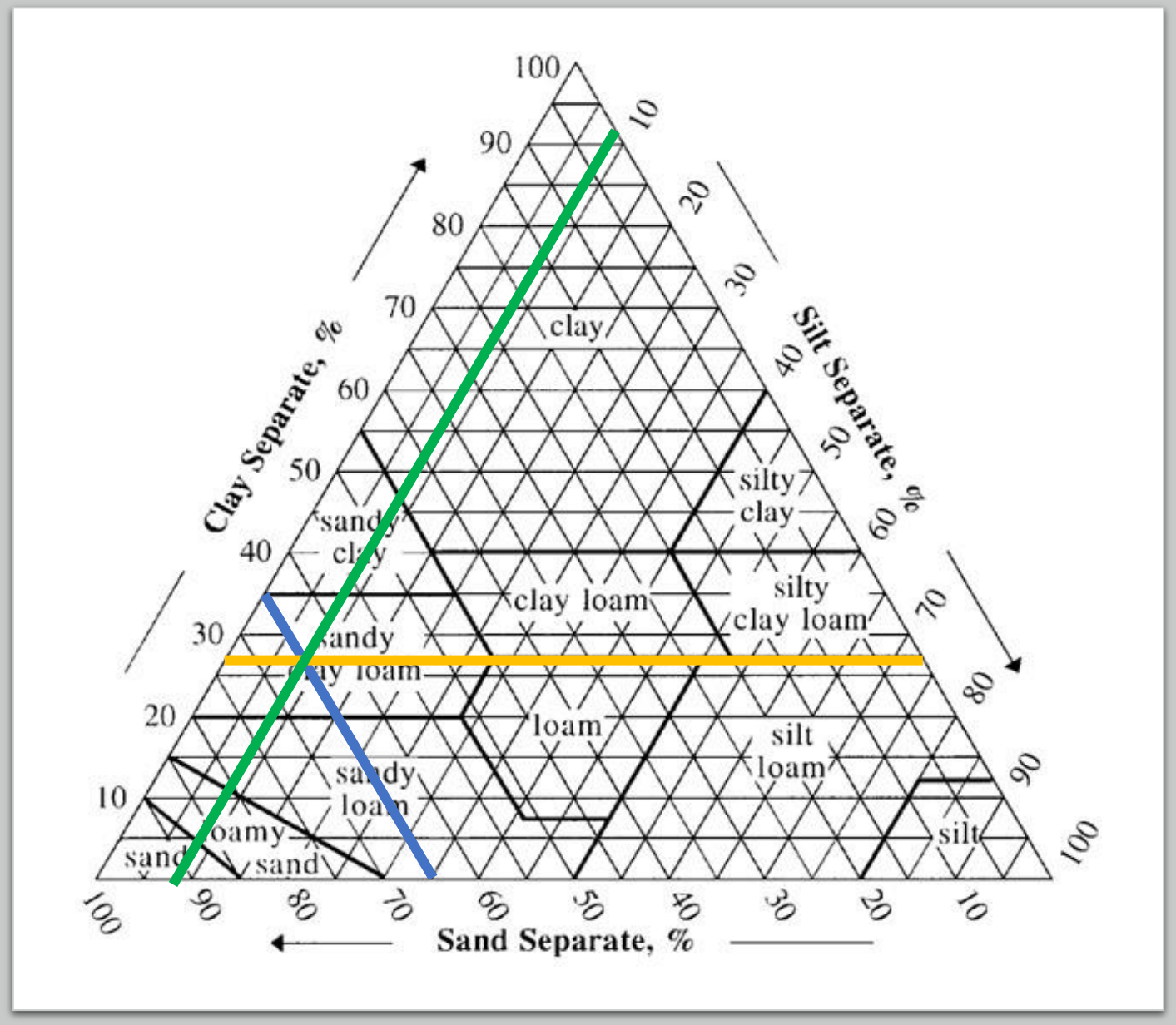
Steps in Using Textural Triangle

2. Draw another line to correspond to the percent clay. Let's say you had 27% clay.



Steps in Using Textural Triangle

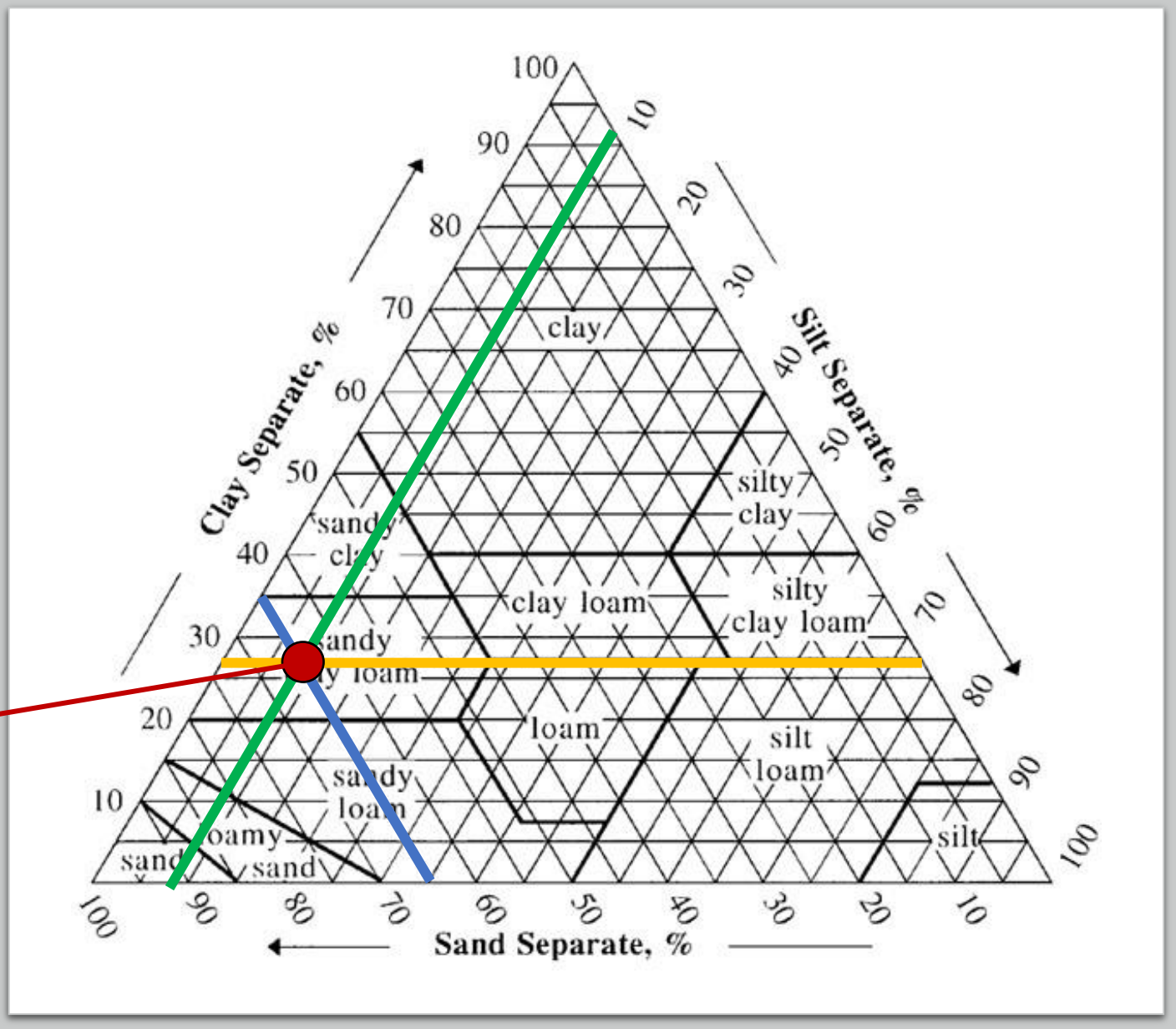
3. Where the lines intersect should also indicate percent silt. On the graph above, you can see that it is about 8% silt.



Steps in Using Textural Triangle

4. Wherever your lines intersect indicates the soil type you have. In this situation, with 65% sand, 27% clay, and 8% silt, it is sandy clay loam.

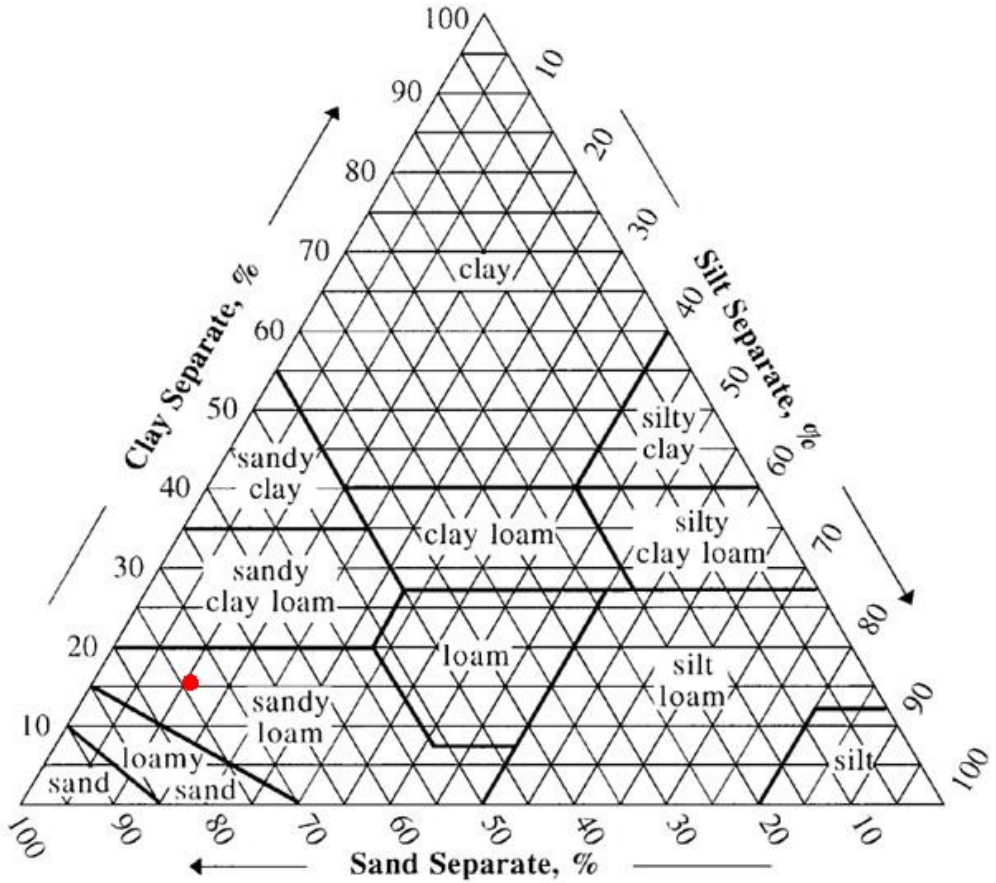
SANDY CLAY LOAM



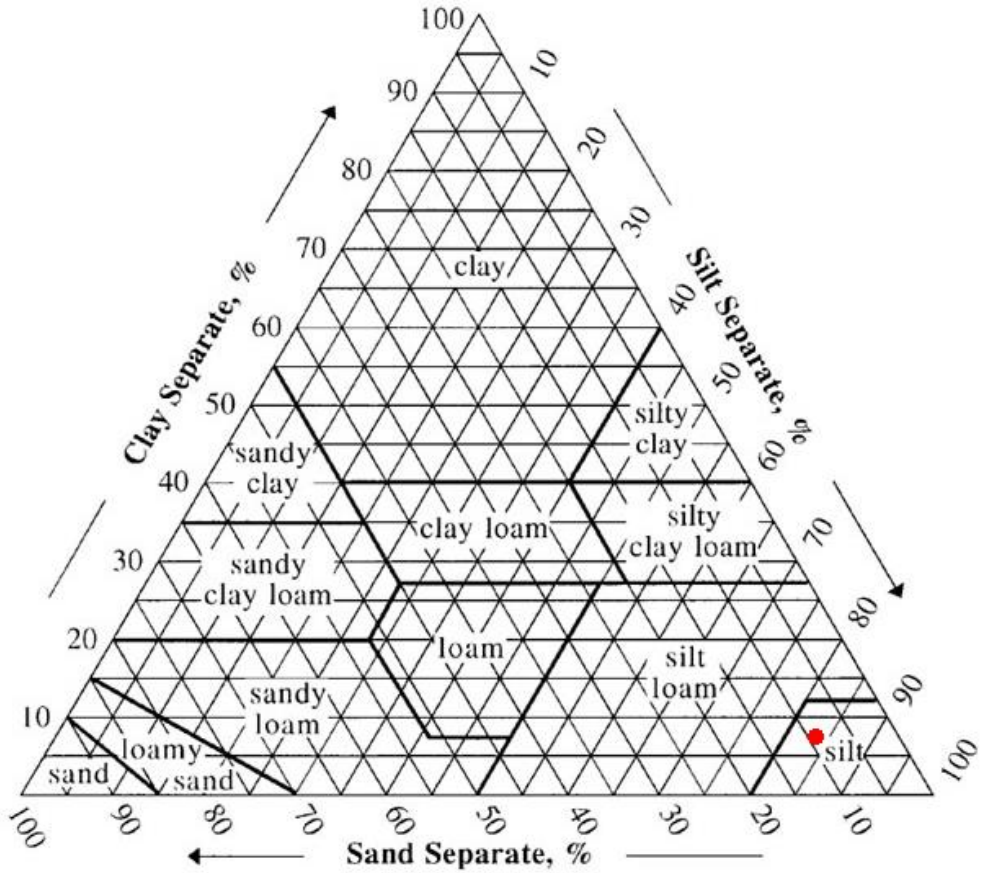
(Answers)

Activity No. 1

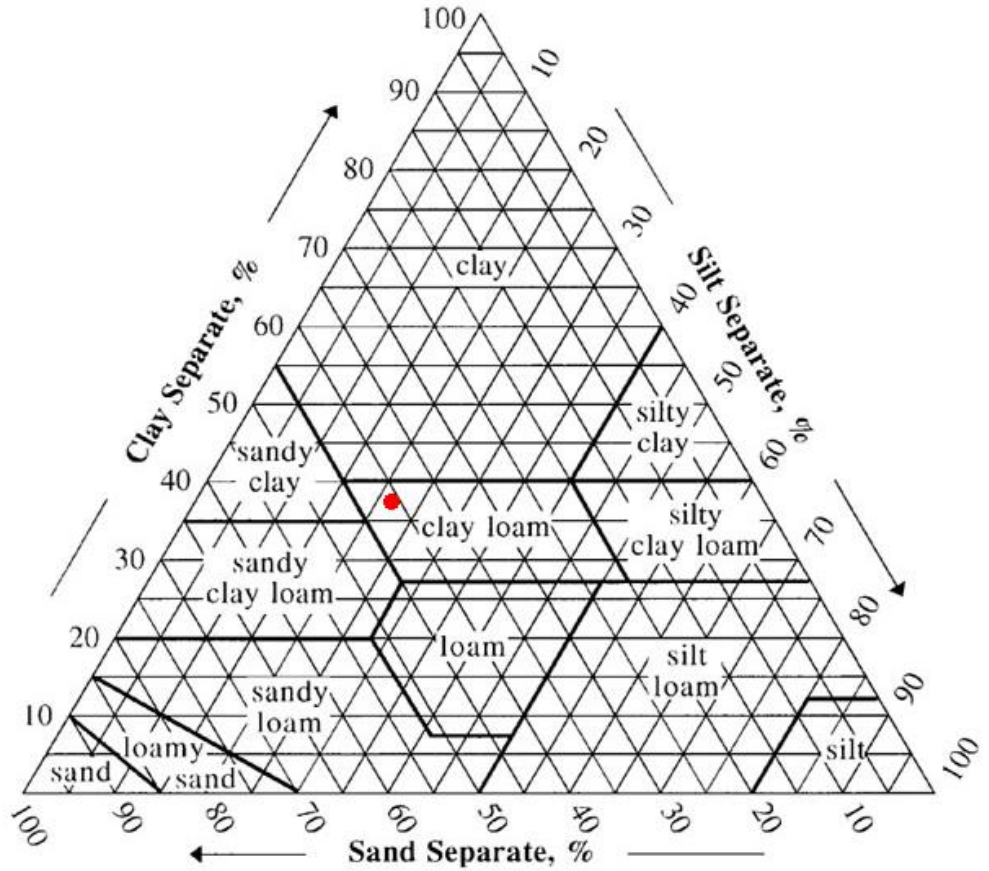
A – 75%, 10%, 15% Sandy Loam



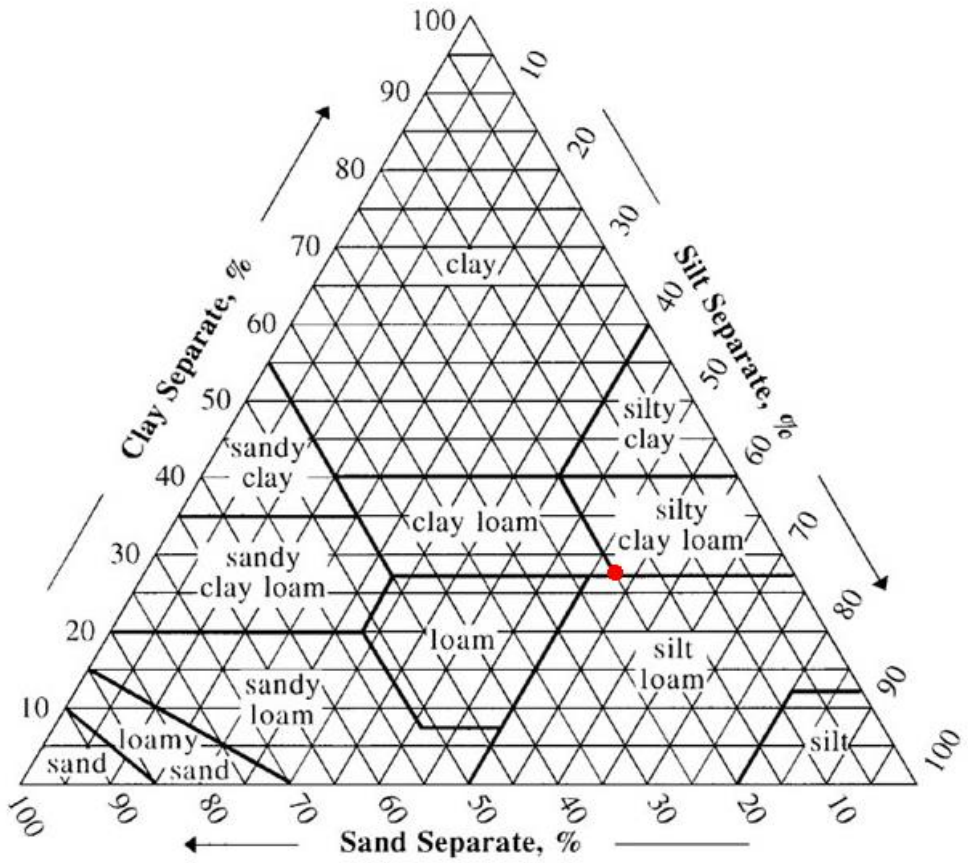
B – 10%, 83%, 7% Silt


Clay Separate, %
Silt Separate, %
Sand Separate, %
clay
silty clay
sandy clay
clay loam
silty clay loam
sandy clay loam
loam
silt loam
sandy loam
loamy sand
sand
silt

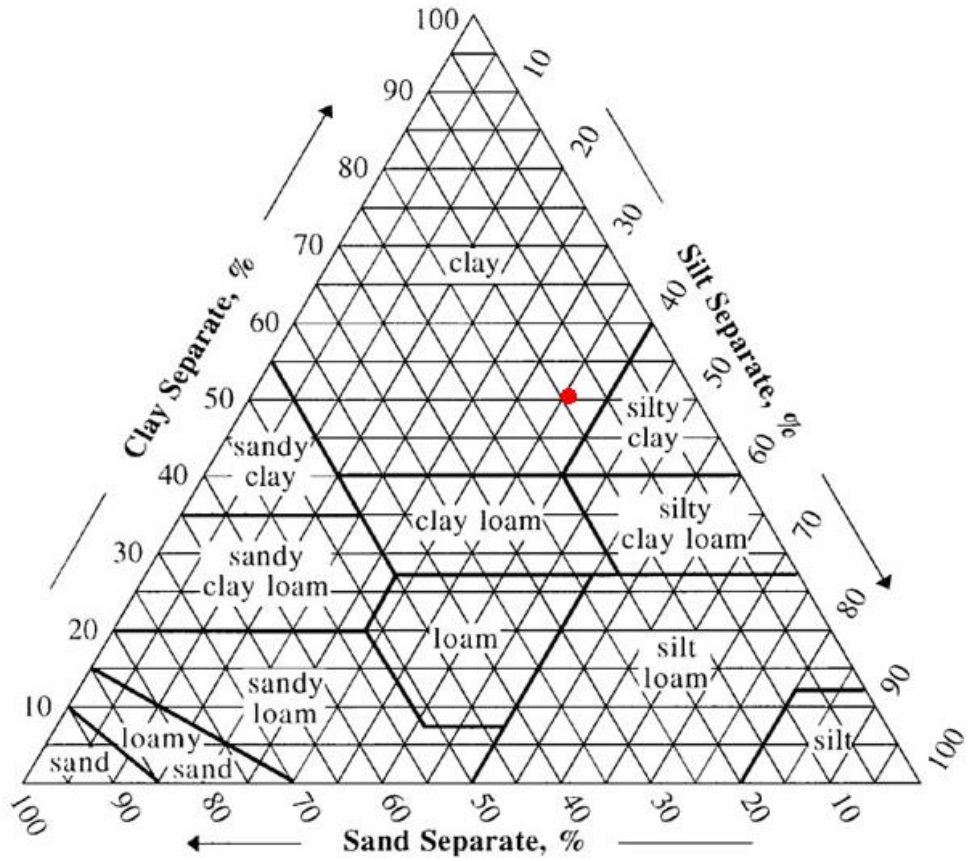
C – 42%, 21%, 37% Clay Loam



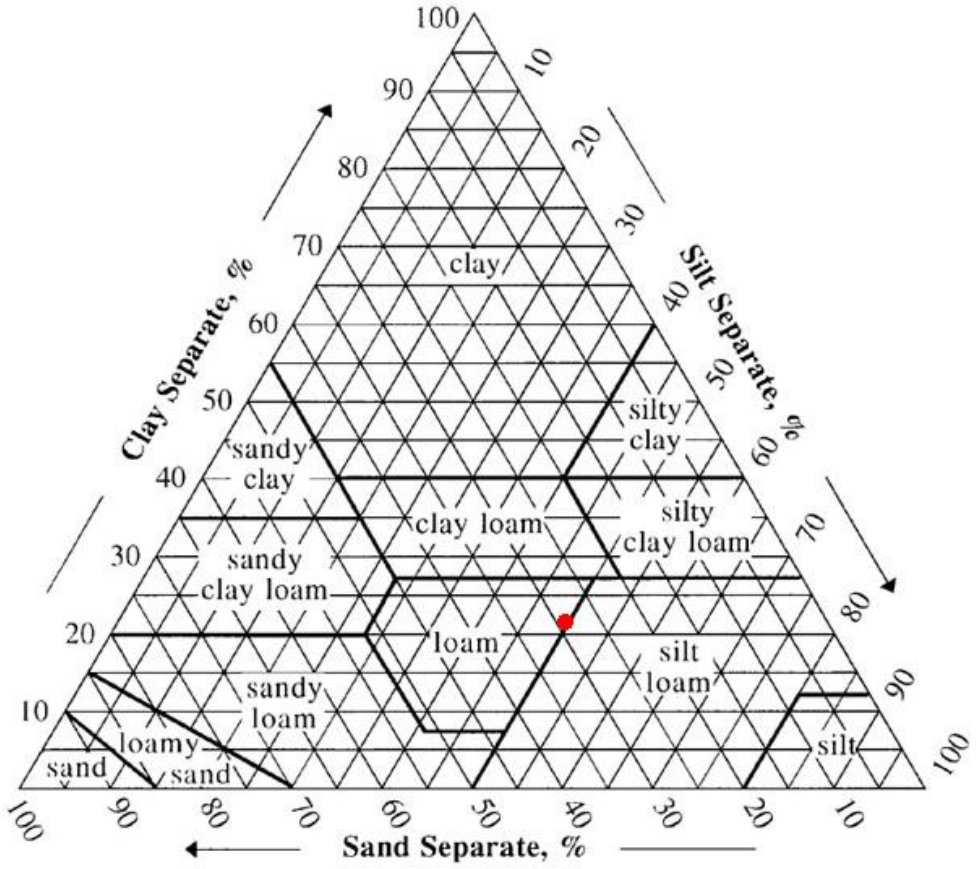
D – 21%, 52%, 27% Clay Loam



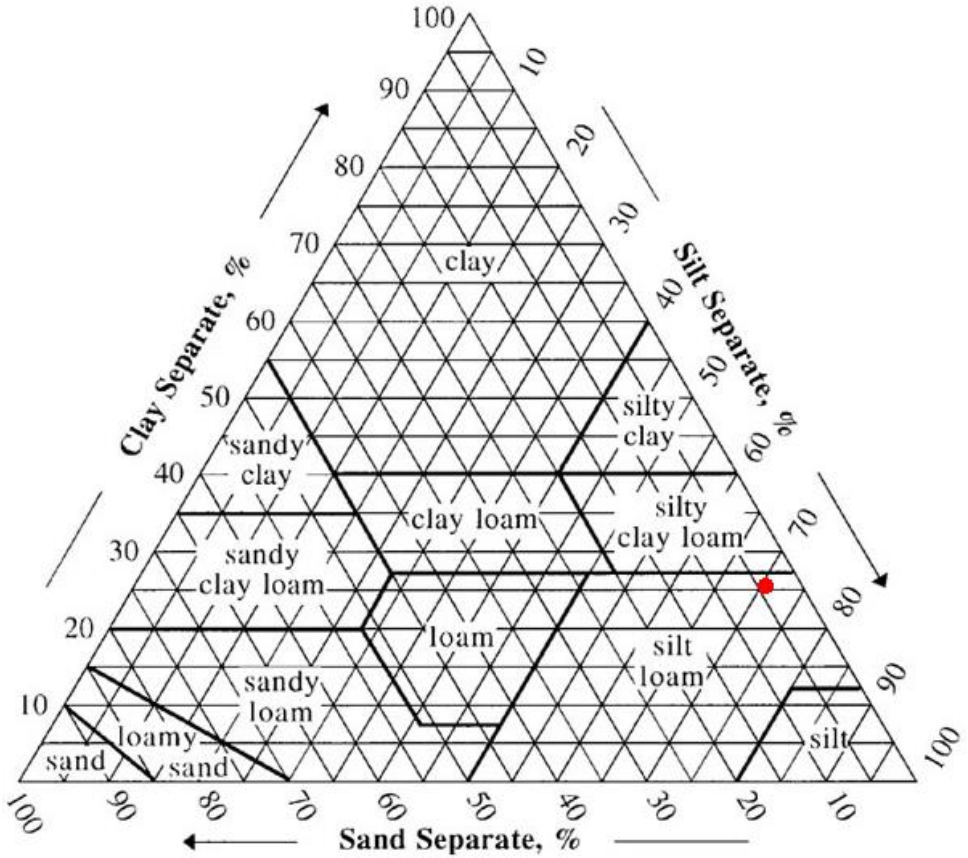
E – 15%, 35%, 50% Clay



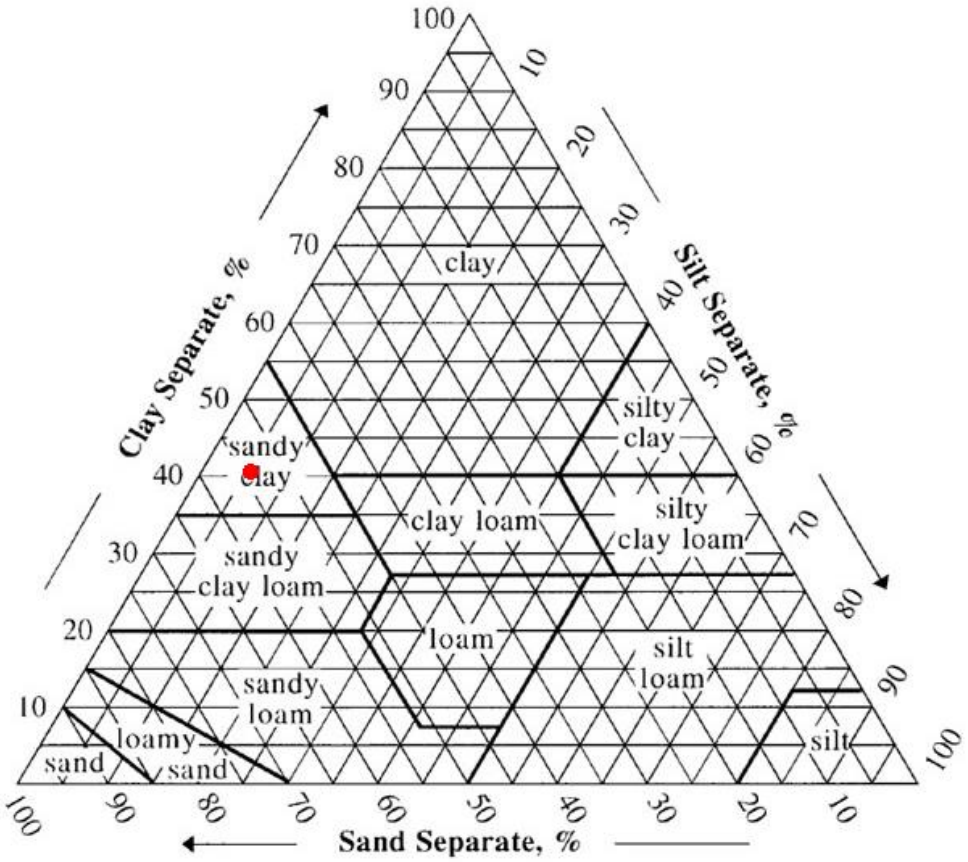
F – 30%, **49%,** 21% **Loam**



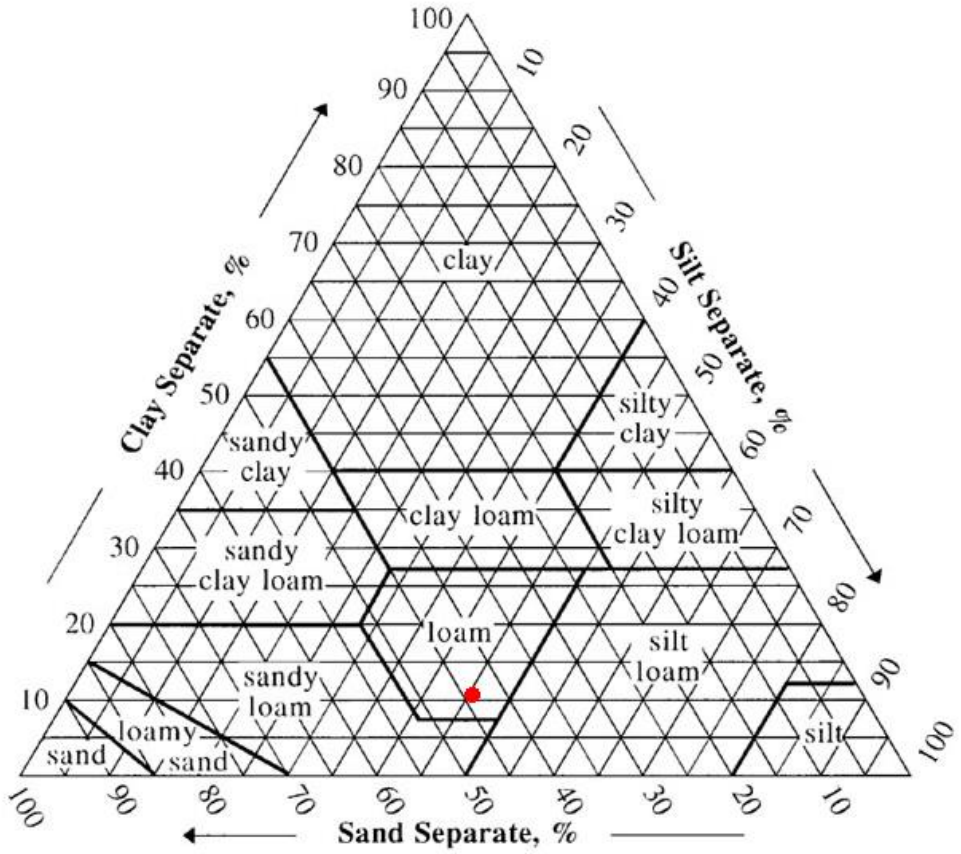
G – 5%, 70%, 25% Silt Loam



H – 55%, 5%, 40% Sandy Clay



I – **45%**, 45%, 10% **Loam**



SOIL STRUCTURE

SOIL STRUCTURE

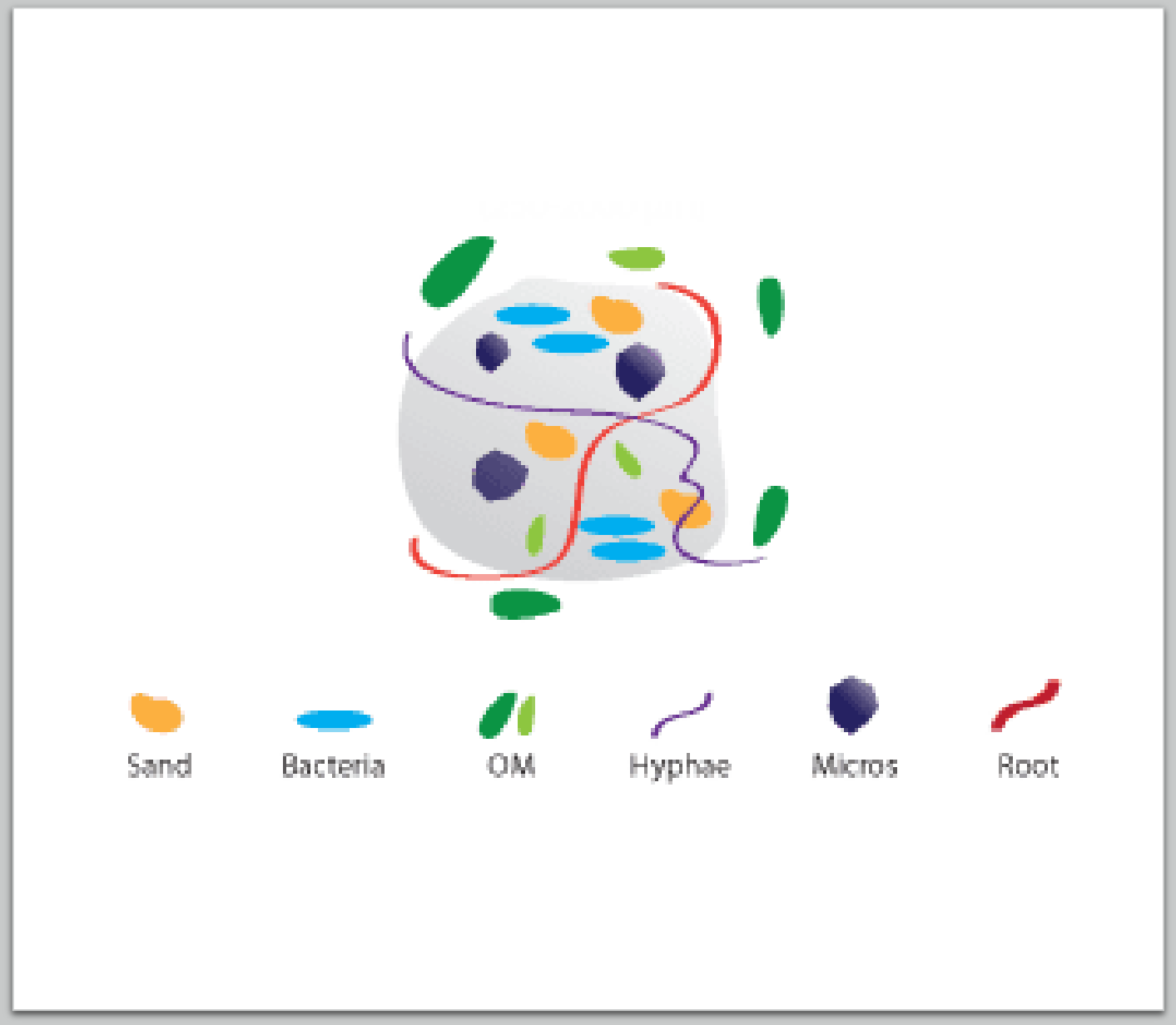
- Refers to the natural shape of aggregates of soil particles, called peds in soil.
- Provides information about the size and shape of pore spaces in soil through which water, heat, and air flow, and in which plant roots grow.

Aggregation

- – Arrangement of primary soil particles (sand, silt, clay) around soil organic matter and through particle associations. Aggregate stability is a good indicator of soil health.

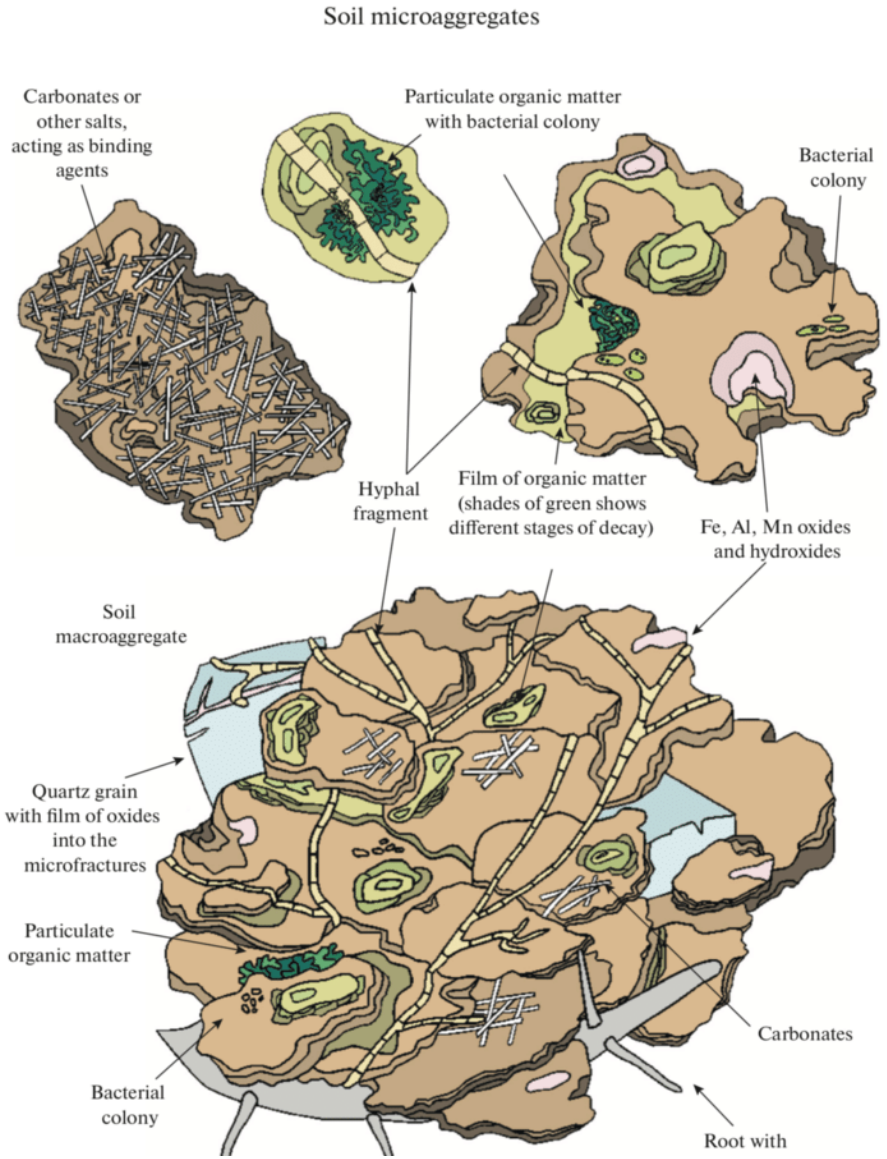
Aggregate Formation

- Soil organic matter holds aggregates together, making them stable and structural. At the same time, aggregates protect the organic matter from decomposition. Aggregates are broken down into microaggregates and macroaggregates; each class having specific benefits for soil health.



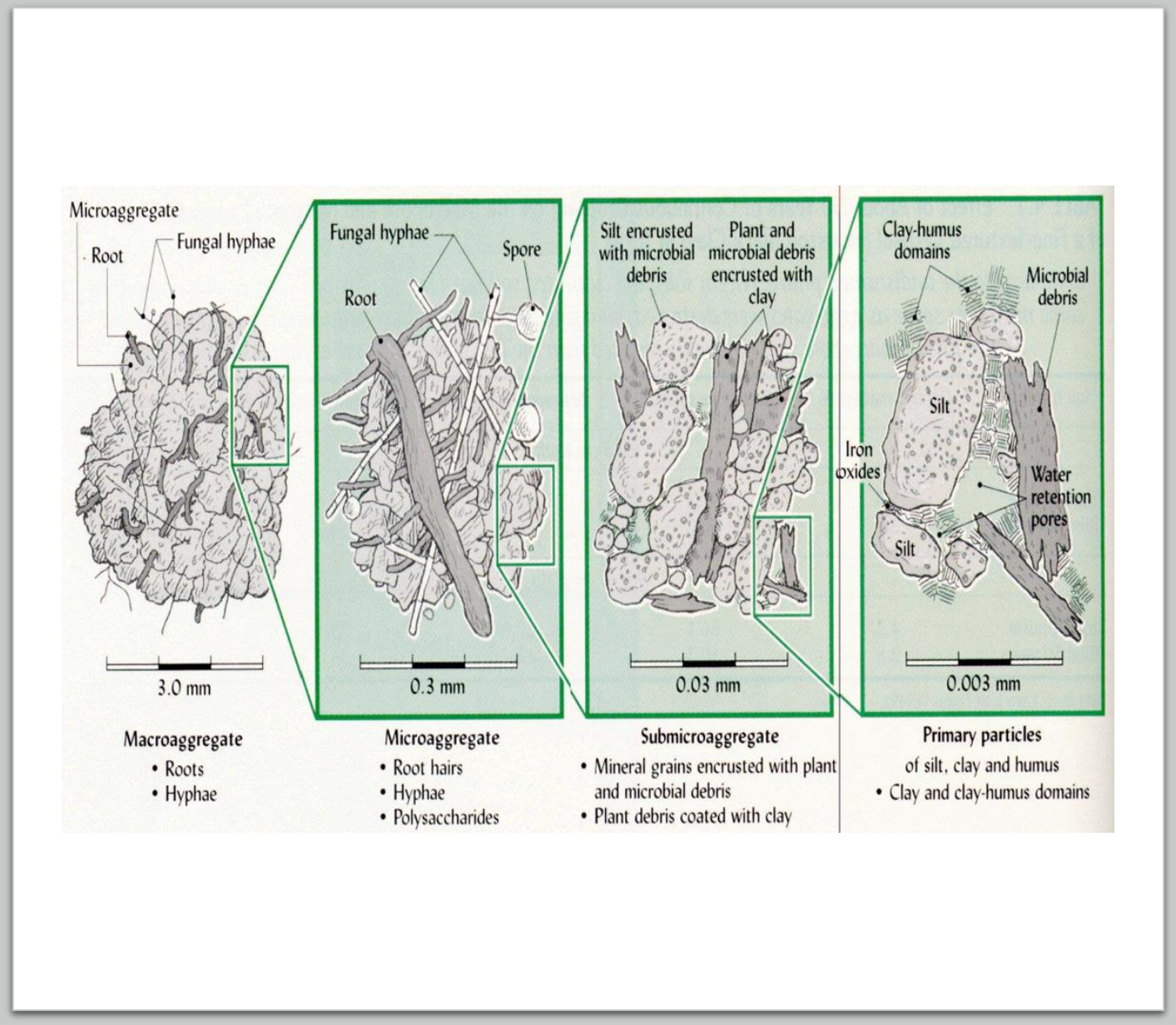
Microaggregates

- are silt and clay particles tightly bound by organic materials. This providers a long-term pool for organic matter.



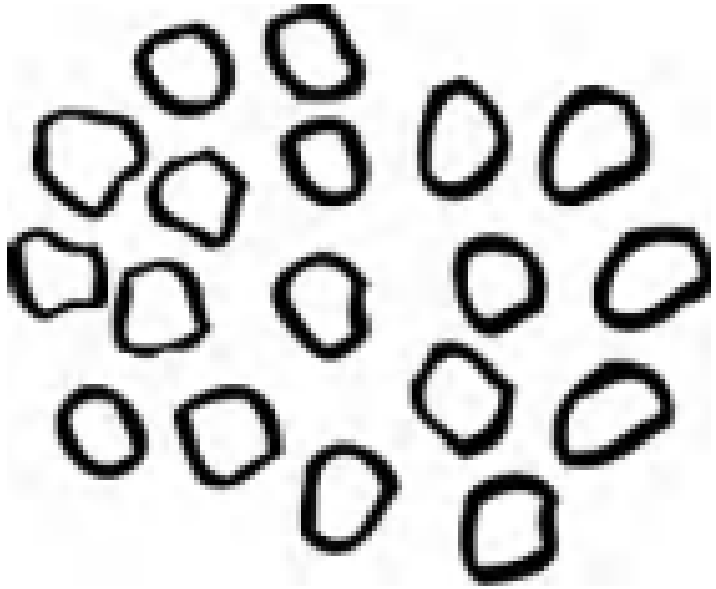
Macroaggregates

- are a collection of silt/clay particles, microaggregates, and organic matter. Plant roots, mycorrhizae and earthworms are major contributors to the formation of macroaggregates. These larger aggregates have a shorter breakdown time, providing an organic matter source for roots, bacteria, and fungi.



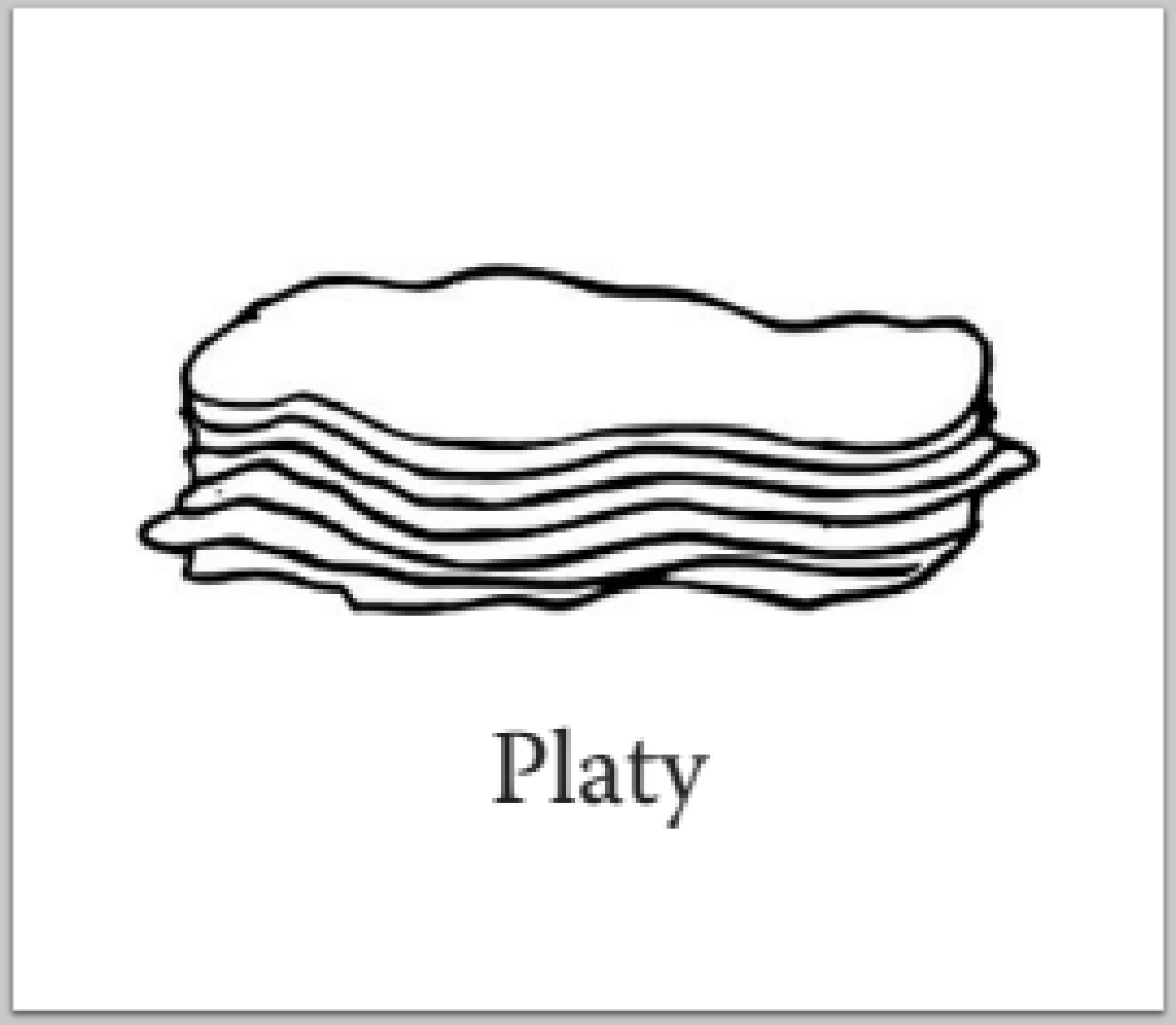
Granular
(Spheroidal or Crumb)

- roughly spherical, like grape nuts. Usually 1-10 mm in diameter. Most common in A horizon, where plant roots, microorganisms, and sticky products of organic matter decomposition bind soil grains into granular aggregates. The ideal structure for irrigation.



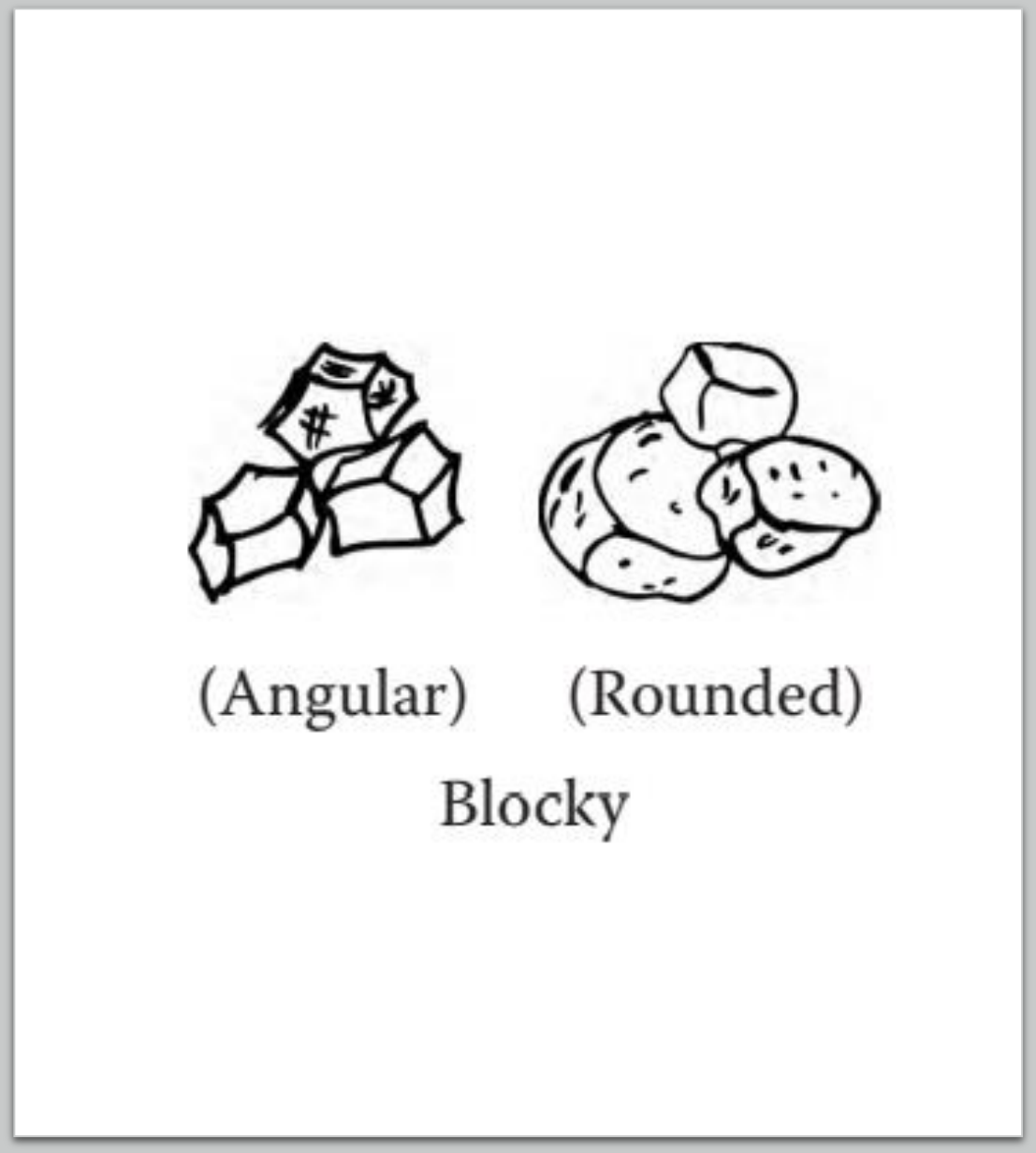
Platy

- flat peds that lie horizontally in the soil. Platy structure can be found in A, B and C horizons. It commonly occurs in an A horizon as the result of compaction. More conducive to puddling hence lesser absorption of water.



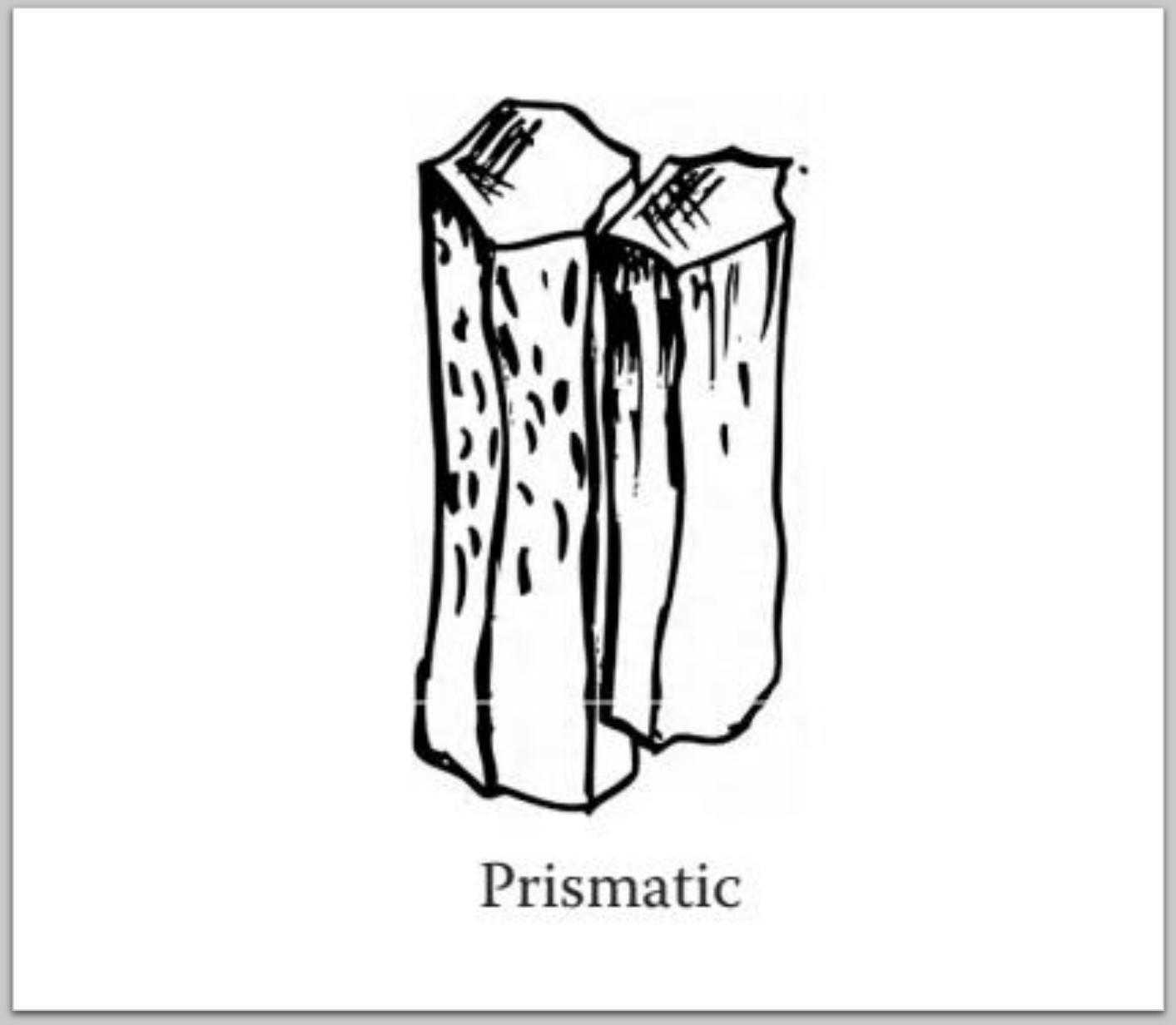
Blocky

- roughly cube-shaped, with more or less flat surfaces. If edges and corners remain sharp, we call it angular blocky. If they are rounded, we call it subangular blocky. Sizes commonly range from 5-50 mm across. Blocky structures are typical of B horizons, especially those with a high clay content. They form by repeated expansion and contraction of clay minerals. Pore spaces are easily clogs.



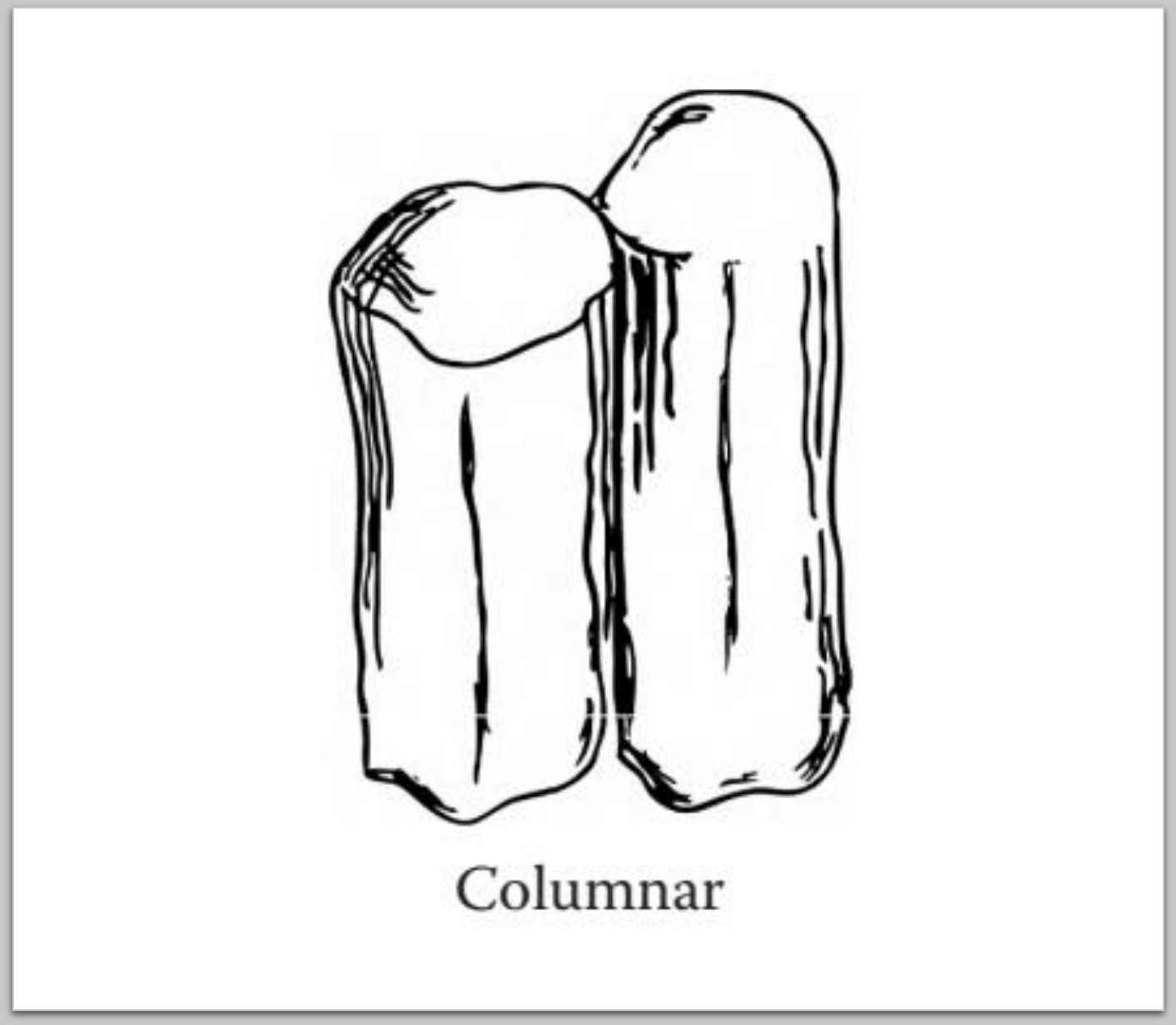
Prismatic

- larger, vertically elongated blocks, often with five sides. Sizes are commonly 10-100mm across. Prismatic structures commonly occur in fragipans. More conducive to vertical movement of water.



Columnar

- the units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns, in contrast to those of prisms, are very distinct and normally rounded. More conducive to vertical movement of water.

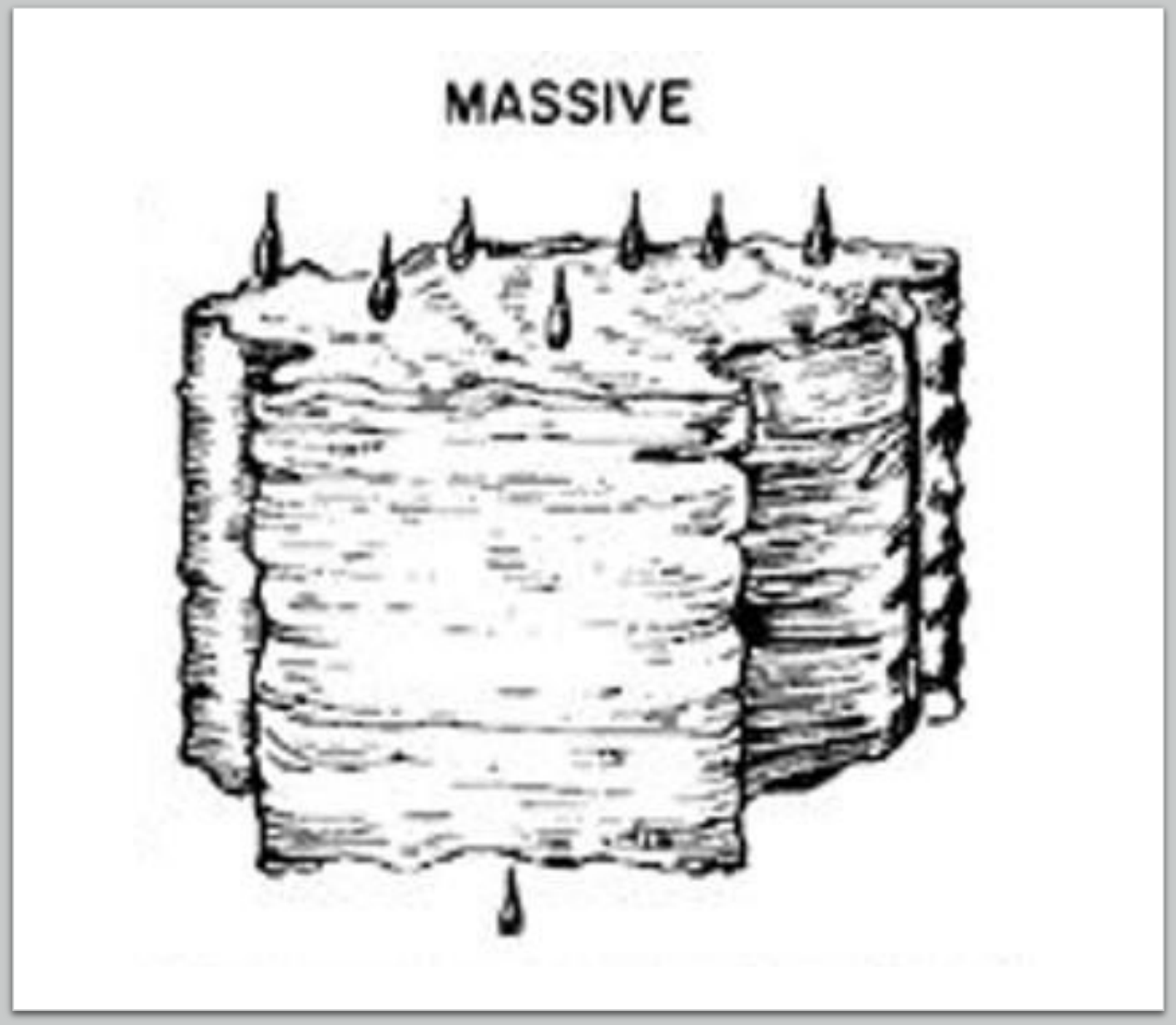


"Structureless" Soil Types

- **Massive**
- **Single grain**

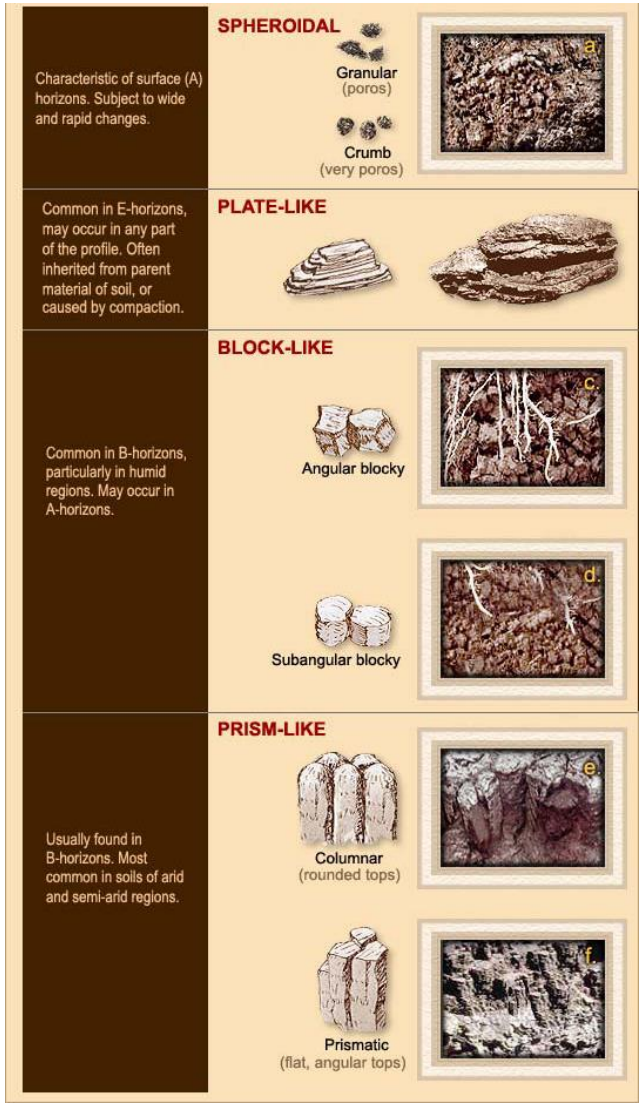
Massive

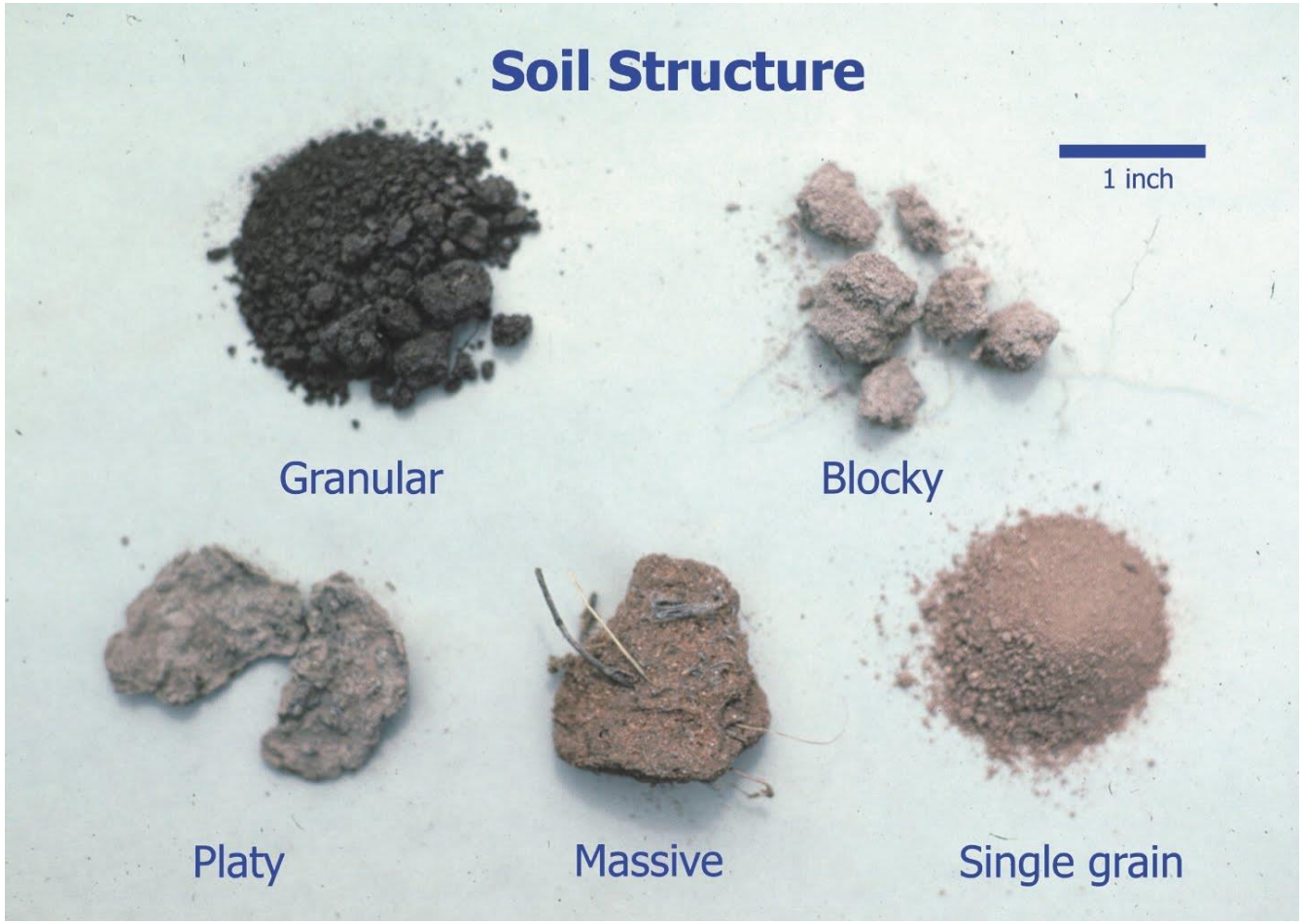
- – compact, coherent soil not separated into peds of any kind. Massive structures in clayey soils usually have very small pores, slow permeability, and poor aeration.



Single grain

in some very sandy soils, every grain act independently, and there is no binding agent to hold the grains together into peds. Permeability is rapid, but fertility and water holding capacity are low.


Characteristic of surface (A) horizons. Subject to wide and rapid changes.
SPHEROIDAL
Granular
(poros)
Crumb
(very poros)
a.
Common in E-horizons, may occur in any part of the profile. Often inherited from parent material of soil, or caused by compaction.
PLATE-LIKE
Common in B-horizons, particularly in humid regions. May occur in A-horizons.
BLOCK-LIKE
Angular blocky
c.
Subangular blocky
d.
Usually found in B-horizons. Most common in soils of arid and semi-arid regions.
PRISM-LIKE
Columnar
(rounded tops)
e.
Prismatic
(flat, angular tops)
f.


Soil Structure
1 inch
Granular
Blocky
Platy
Massive
Single grain

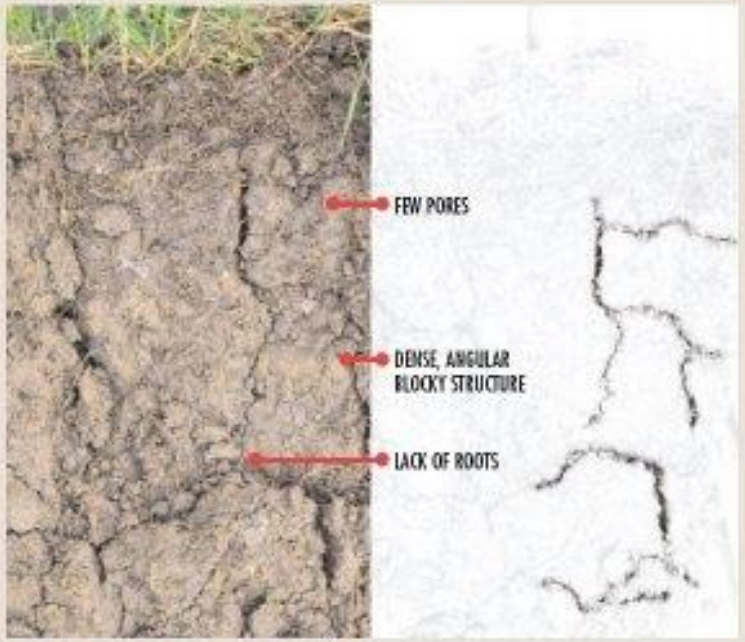
Granular structure – only 1–10 mm units
Found in the top soil

Blocky structure – 5–50 mm units
Found in subsoil of well structured soils

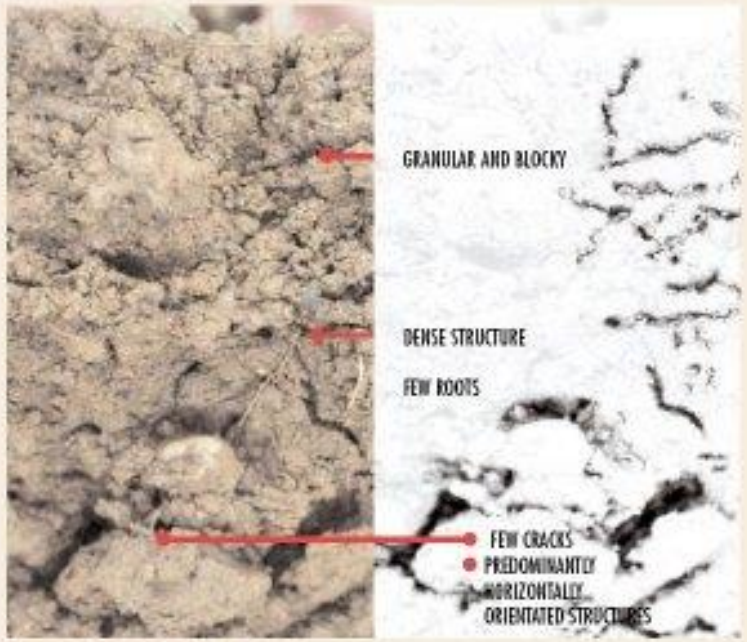
Platy structure – found when soil is compacted, e.g. if there is a plough pan

Massive prismatic structure, few cracks for movement or root growth. Found in subsoil heavy clays

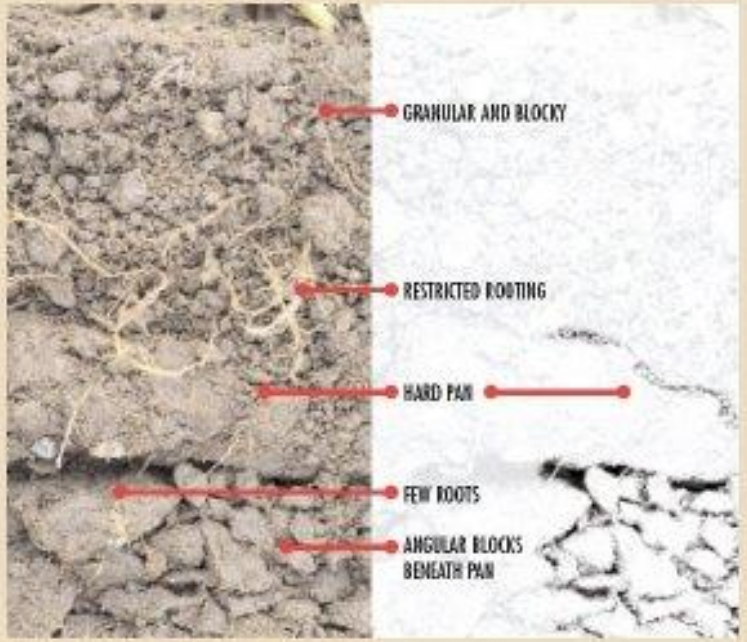
CLAY



SANDY CLAY LOAM

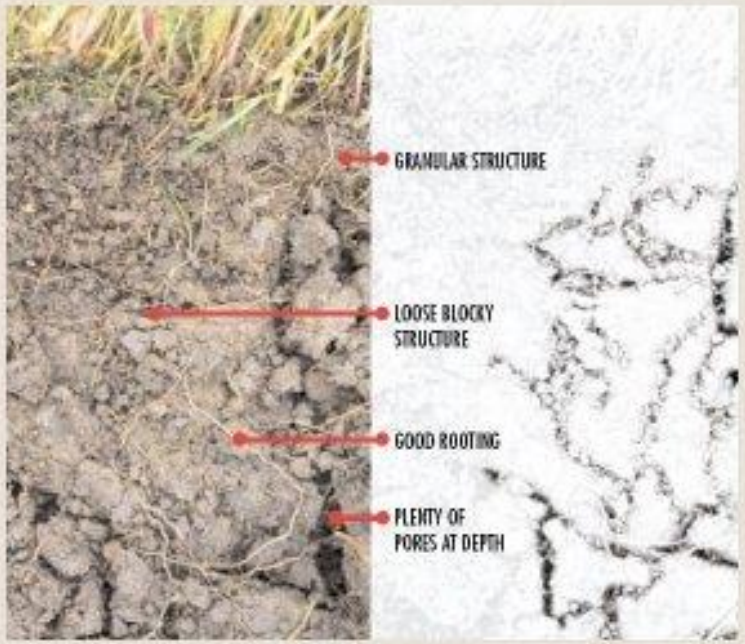


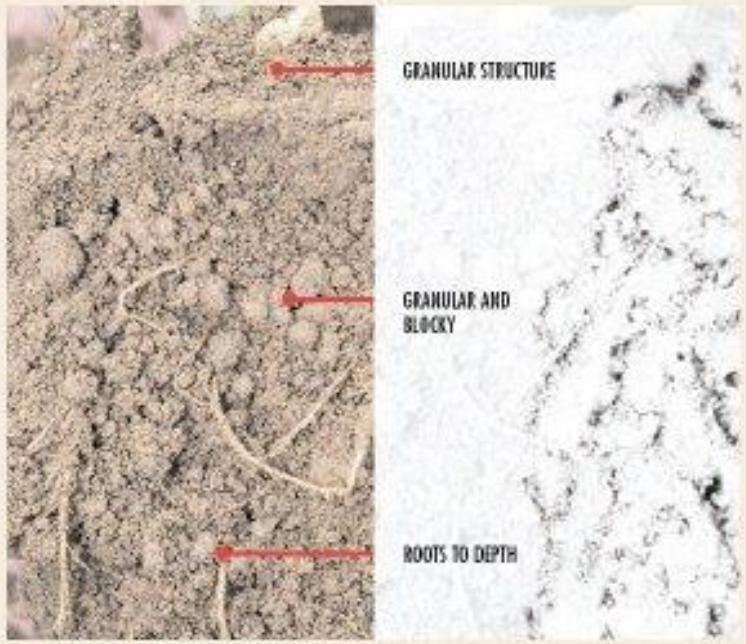
SANDY LOAM

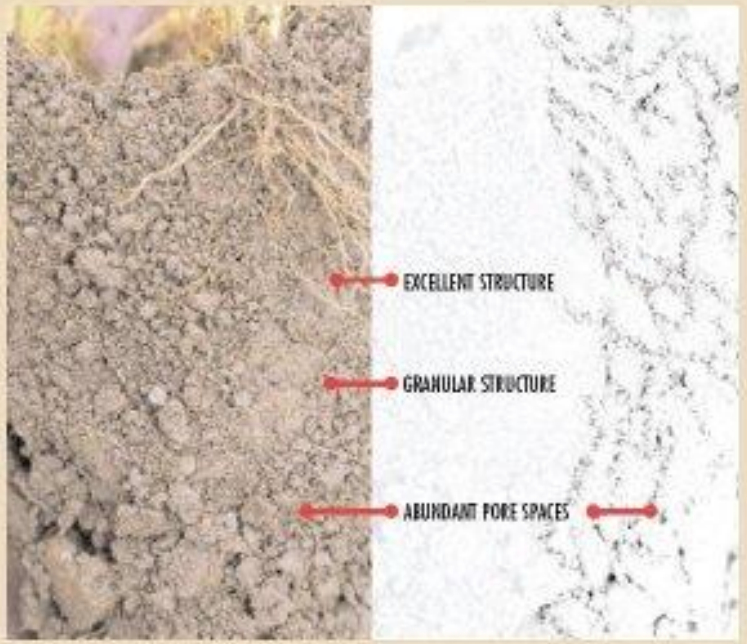


POOR STRUCTURE

GOOD STRUCTURE







- Soil structure influences many important soil properties such as the rate of water infiltration, water retention, aeration, and drainage, because of its effects on pore size distribution.

SOIL CONSISTENCE

refers to the ease with which an individual ped can be crushed by the fingers. Soil consistence, and its description, depends on soil moisture content.

Air Dry Consistency

- Air dry state consistency is measured by soil's resistance to rupture or to fragmentation when squeezed. It is characterized by rigidity, brittleness, max. resistance, tendency to crust to powder and inability of crushing material to cohere again when pressed together.

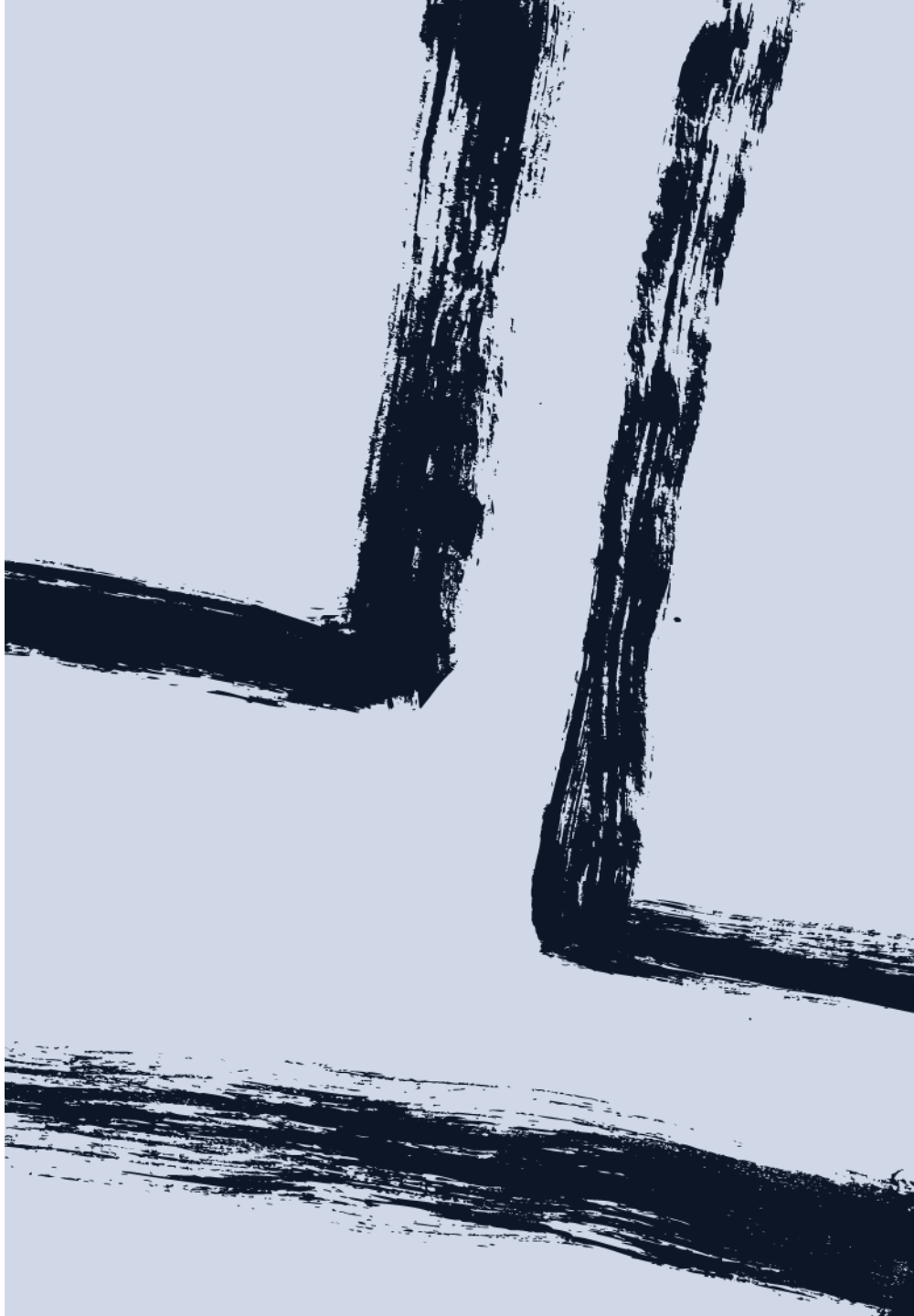
Class	Description
Loose (Sand)	Separate from each other when soil is non-coherent Symbol “L”, “LO” or “lo”.
Soft (<8N) (Loam)	Soil crushes under very low pressure/ weakly coherent
Slightly Hard (8 to <20N)	Soil material crushes – low pressure – little resistance
Moderately Hard (20 to <40N)	Soil material crushes – moderate pressure – resistance
Hard (40 to <80N) (Clay Loam)	Soil material crushes under strong pressure Break between hands
Very Hard (80 to <160N) (Clay)	Cannot be crushed between thumb and forefinger but between hands with difficulty.
Extremely Hard	Pressure applied by foot with full body or with the help of hammer so depends upon cementation.

Wet Consistency

- Wet state consistency is measured by soil’s stickiness and plasticity.

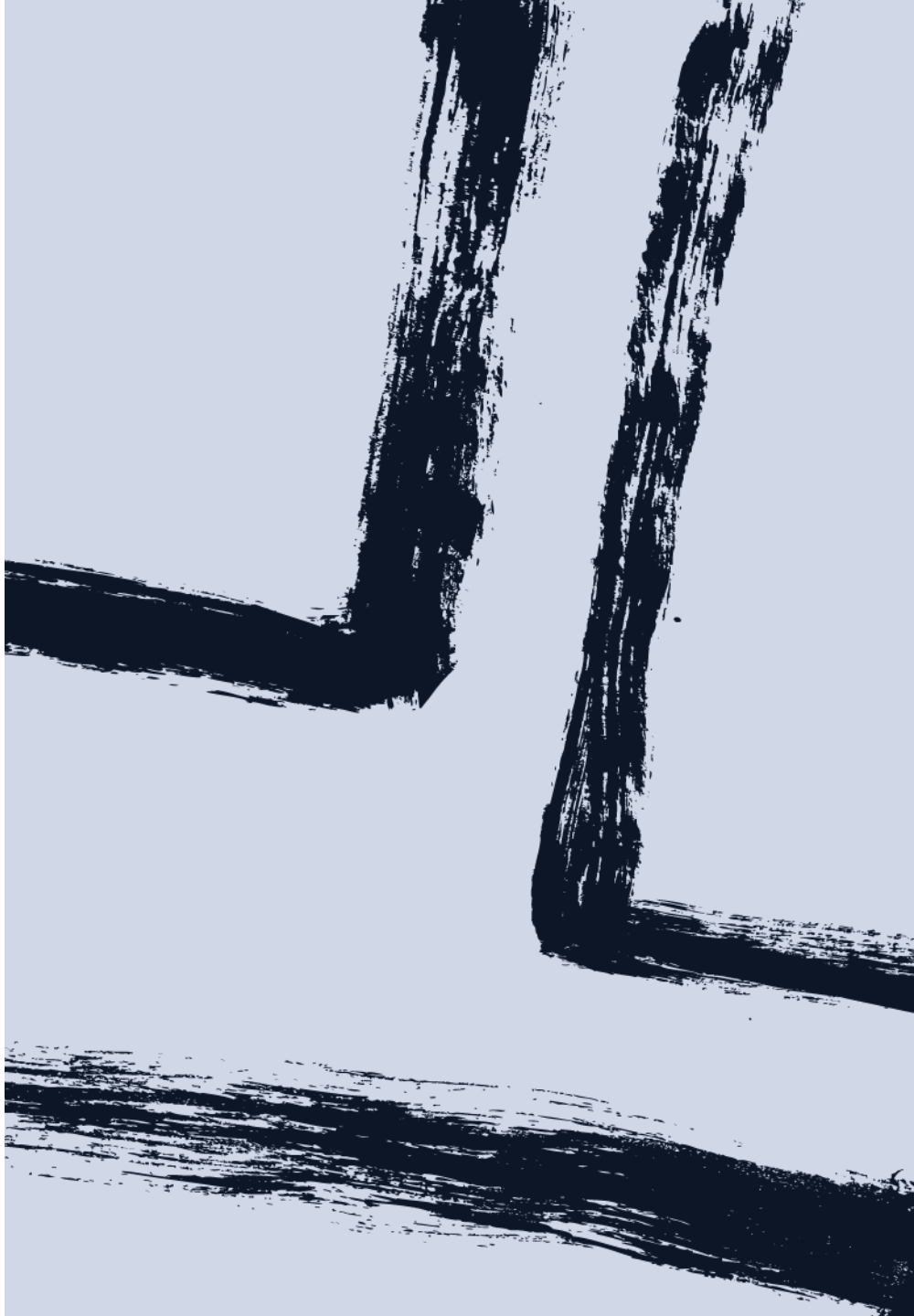
Stickiness

- the capacity of soil to adhere to other objects.
- Estimated at moisture content that displays maximum adherence between thumb and forefinger.



Stickiness Classes

- **Non-Sticky** – little o no soil adheres to fingers after release of pressure.
- **Slightly Sticky** – Soil adheres to one finger but other remain clean after release of pressure with little stretching on separation f fingers.
- **Moderately Sticky** – soil adheres to both fingers after release of pressure with some stretching on separation of fingers.
- **Very Sticky** – soil adheres firmly to both finger and thumb after release of pressure with stretches greatly on separation of fingers.

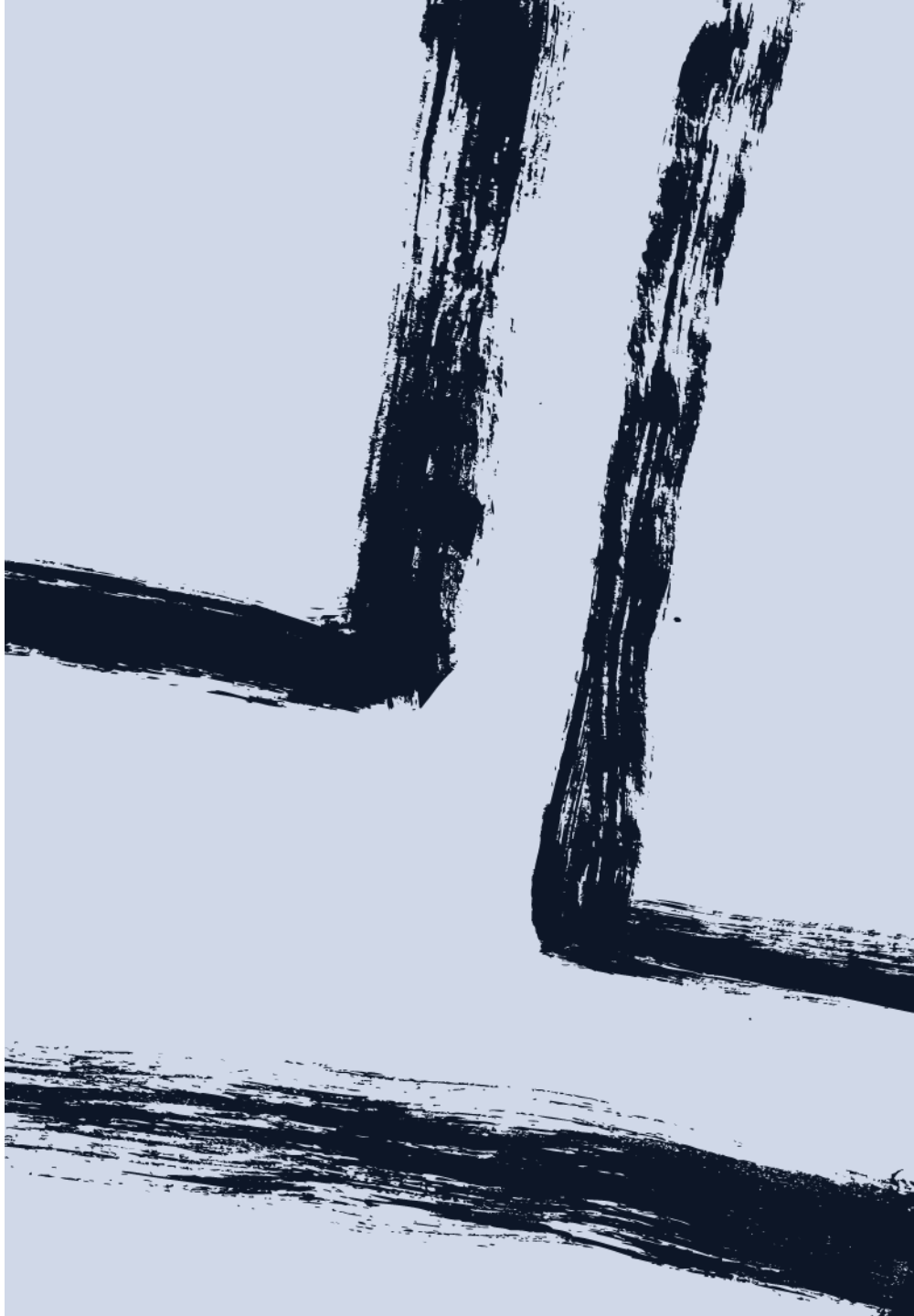


Very Sticky

Moderately-Sticky

Plasticity

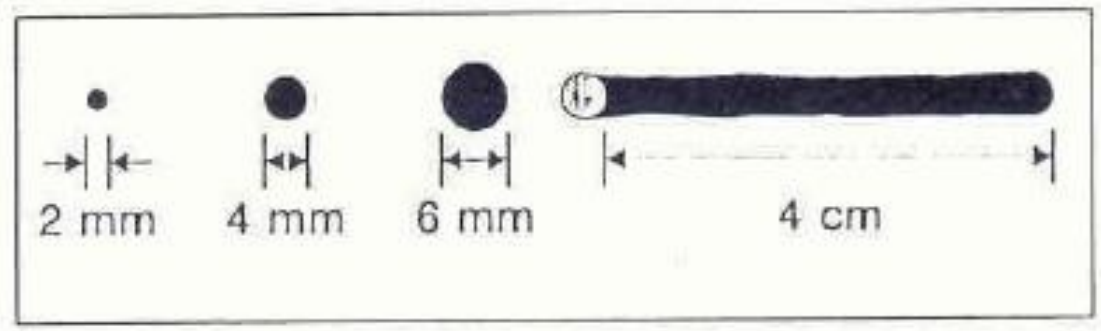
- Degree a soil can be molded or reworked causing deformation without rupturing. We take soil material in wet condition and roll it between thumb and forefinger and then observe whether rod or wire is formed.



Plasticity Classes

- **Non-plastic** – will not form a 6mm diameter, 4cm long wire, or if formed, cannot support itself when held on hand.
- **Slightly plastic** – 6mm dia, 4cm long wire supports itself, 4mm dia, 4cm long wire does not.
- **Moderately Plastic** – 4mm dia, 4cm long wire supports itself, 2mm dia, 4cm long wire does not.
- **Very plastic** – 2mm dia, 4cm long wire supports itself.

Plasticity

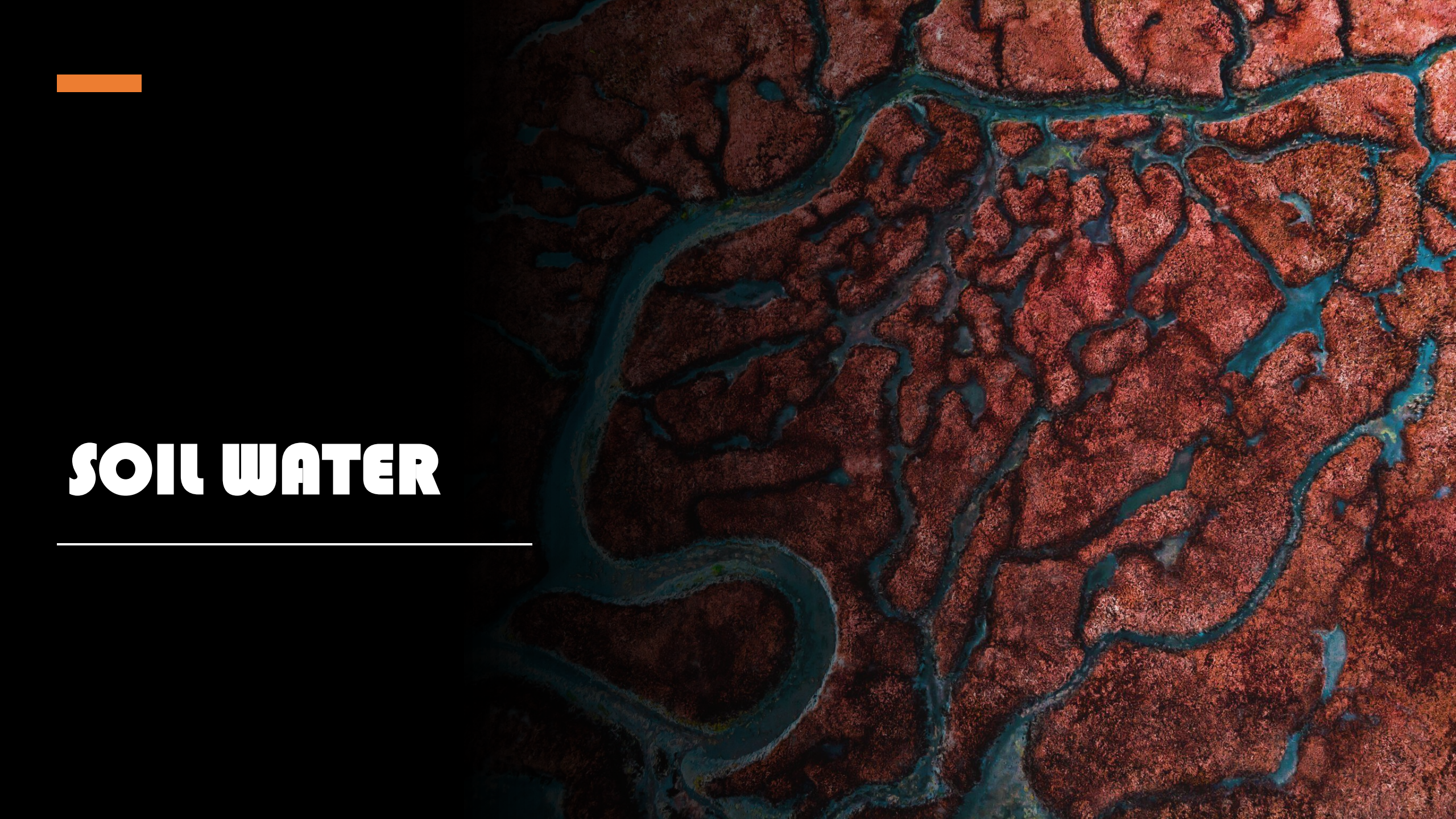


Moist Consistency

- It is a midway between air dry consistency and field capacity.
- It is the resistance to squeezing forces between thumb and forefinger

Class	Description
Loose (0)	Non-coherent
Very Friable (<8N)	Soil Material crushes very easily under very gentle pressure
Friable (BEST) (8 to <20N)	Soil material crushes under gentle pressure
Firm (20 to <40N)	Under moderate pressure between thumb and forefinger
Very Firm (40 to 80N)	Strong pressure is required
Extremely Firm (80 to <160N)	Can’t crush

SOIL WATER

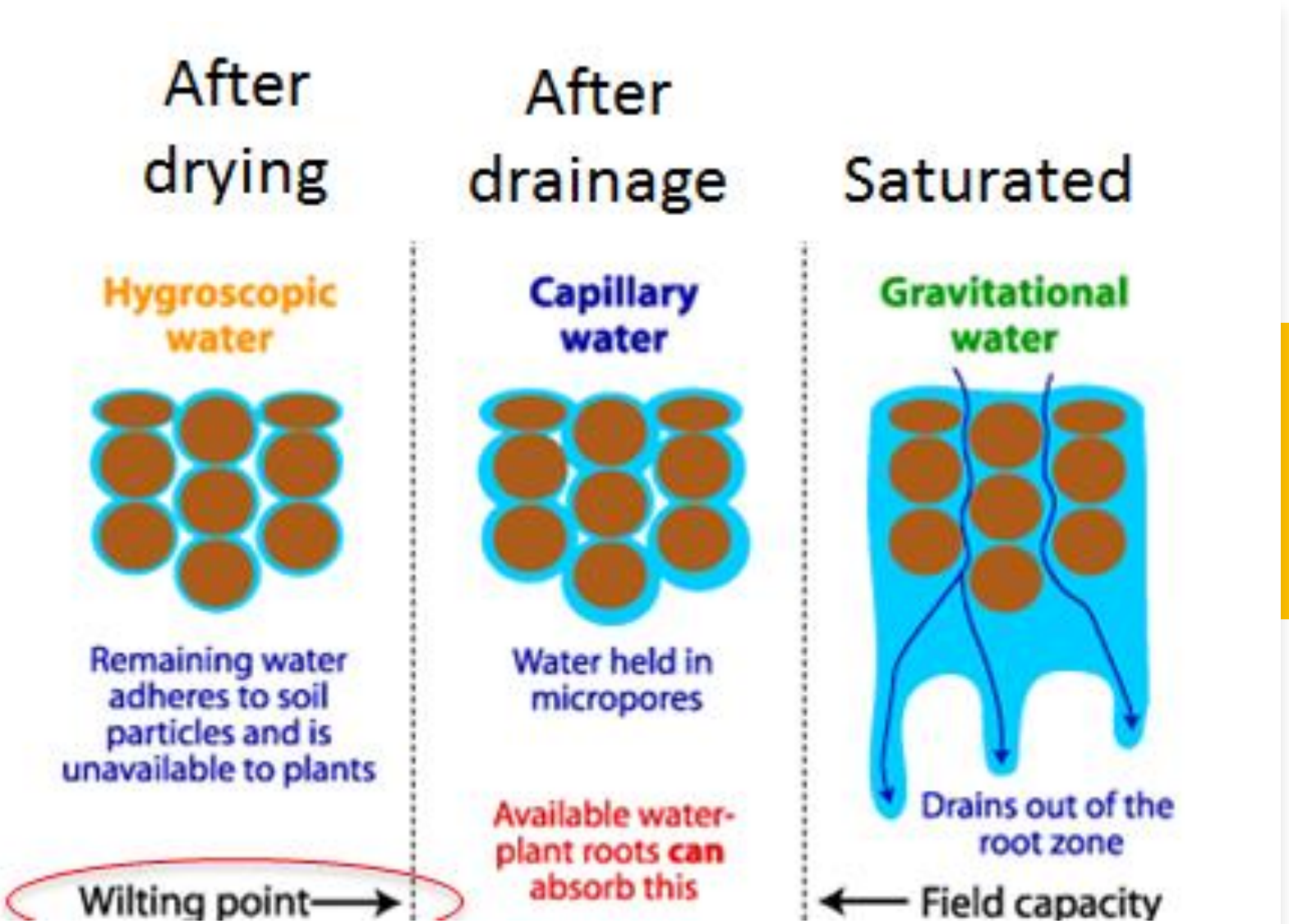


Soil water can be classified into three kinds:

HYGROSCOPIC WATER

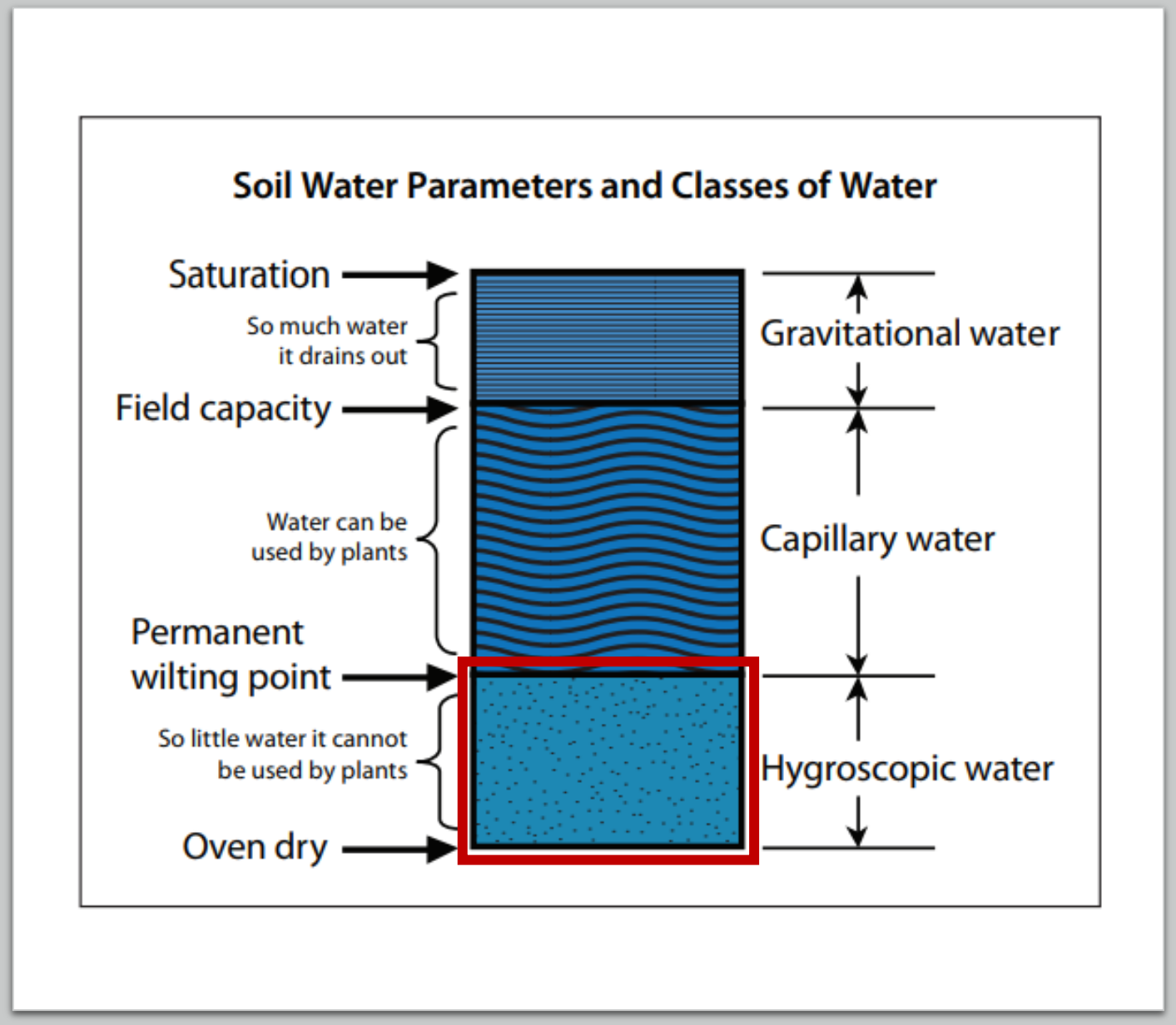
CAPILLARY WATER

GRAVITATIONAL WATER


After drying
After drainage
Saturated
Hygroscopic water
Capillary water
Gravitational water
Remaining water adheres to soil particles and is unavailable to plants
Water held in micropores
Drains out of the root zone
Available water- plant roots can absorb this
Wilting point
Field capacity

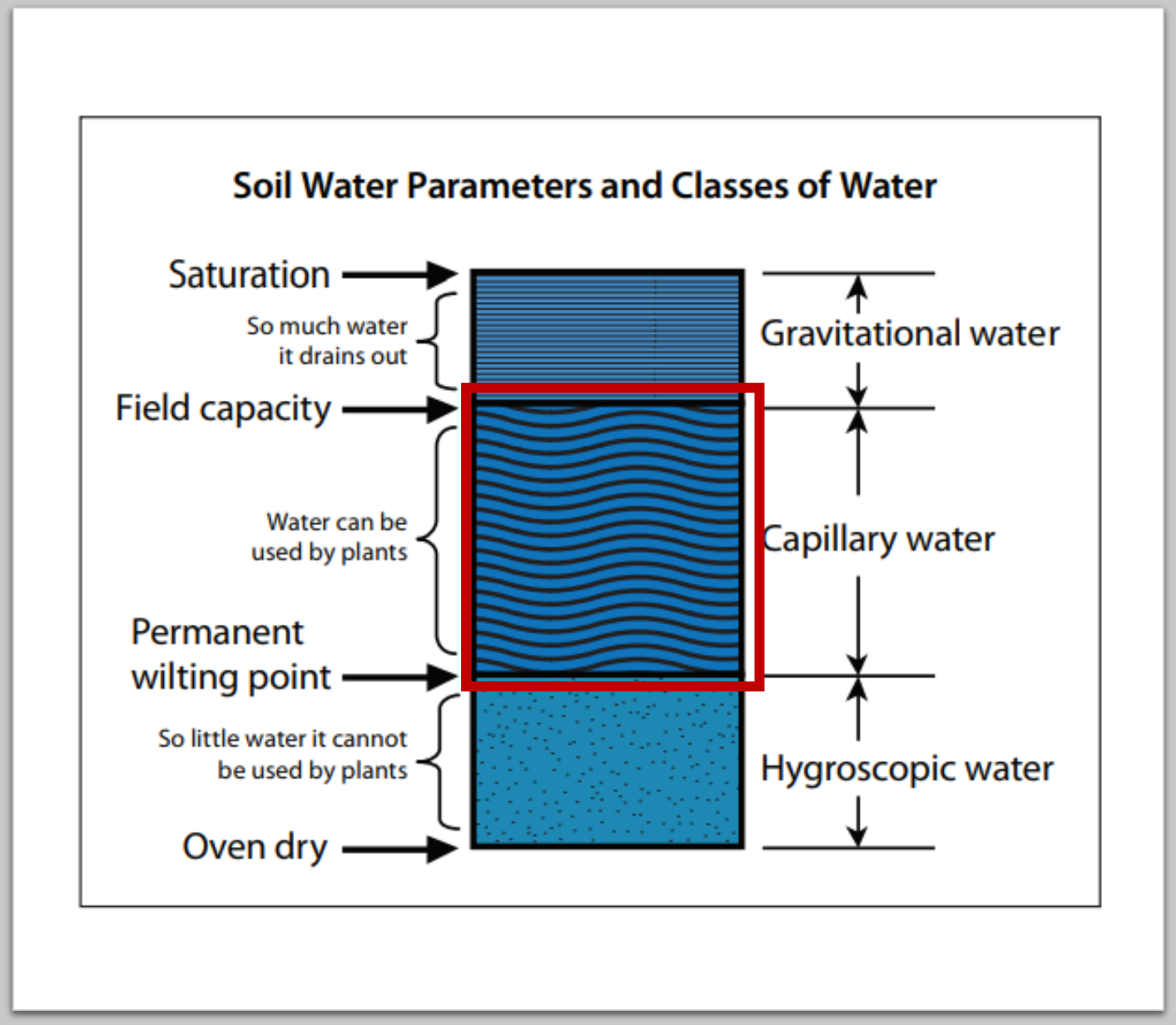
Hygroscopic Water

- This part of the water is adsorbed from an atmosphere of water vapor as a result of attractive forces in the surface of the soil particles; it is unavailable to plants.



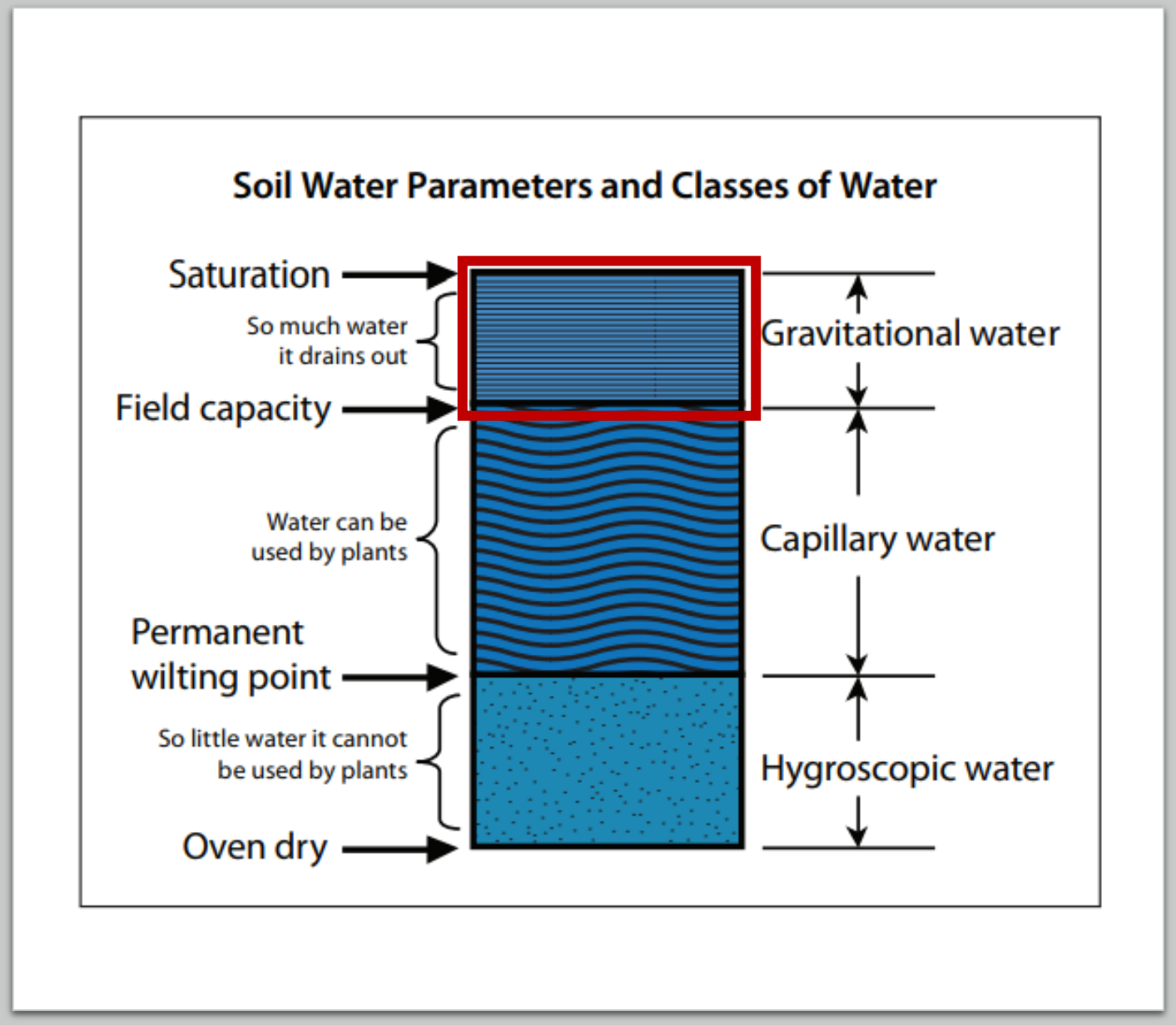
Capillary Water

- This water is held in the capillary spaces and as a continuous film around the soil particles. It is the water which forms the soil solution, which contains the soluble products of the soil and is the main nutrient medium for plant roots.



Gravitational Water

- This water is not held by the soil, but drains under the influence of gravity, and can remove cations and other soluble nutrients that are not adsorbed by the colloidal mass of the soil.



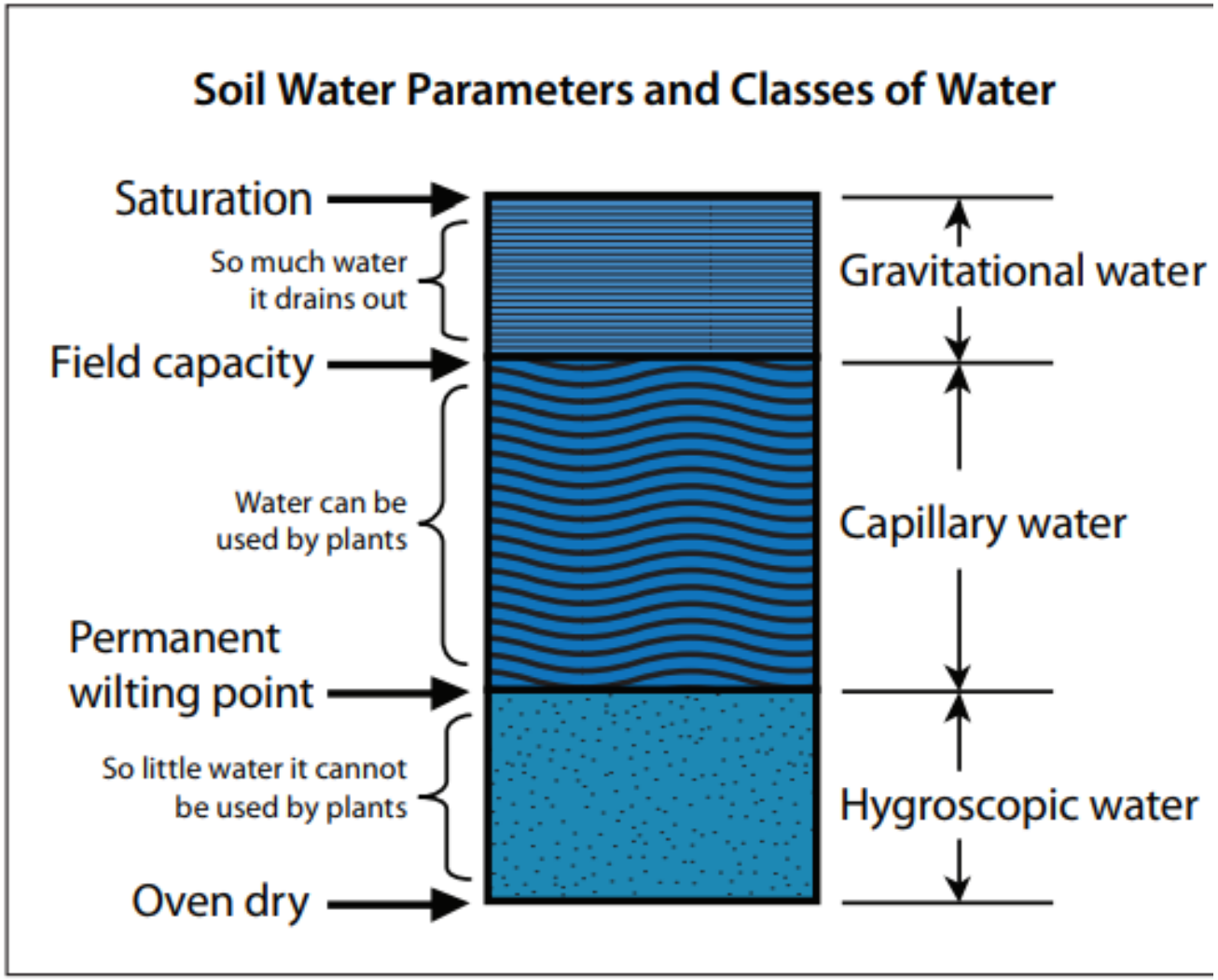


Figure 1. Soil water parameters and classes of water.

field capacity

- The maximum water that a soil can hold without losing water due to drainage.

SOIL CHARACTERIZATIONS CARRIED OUT IN FIELD

- SOIL TEXTURE
- SOIL STRUCTURE
- SOIL COLOR
- SOIL CONSISTENCE
- BULK DENSITY
- SOIL WATER
- SOIL TEMPERATURE
- SOIL FERTILITY

SOIL COLOR

- The color of soil is determined by the chemical coatings on soil particles, the amount of organic matter in the soil, and the moisture content of the soil.

Dark or black.

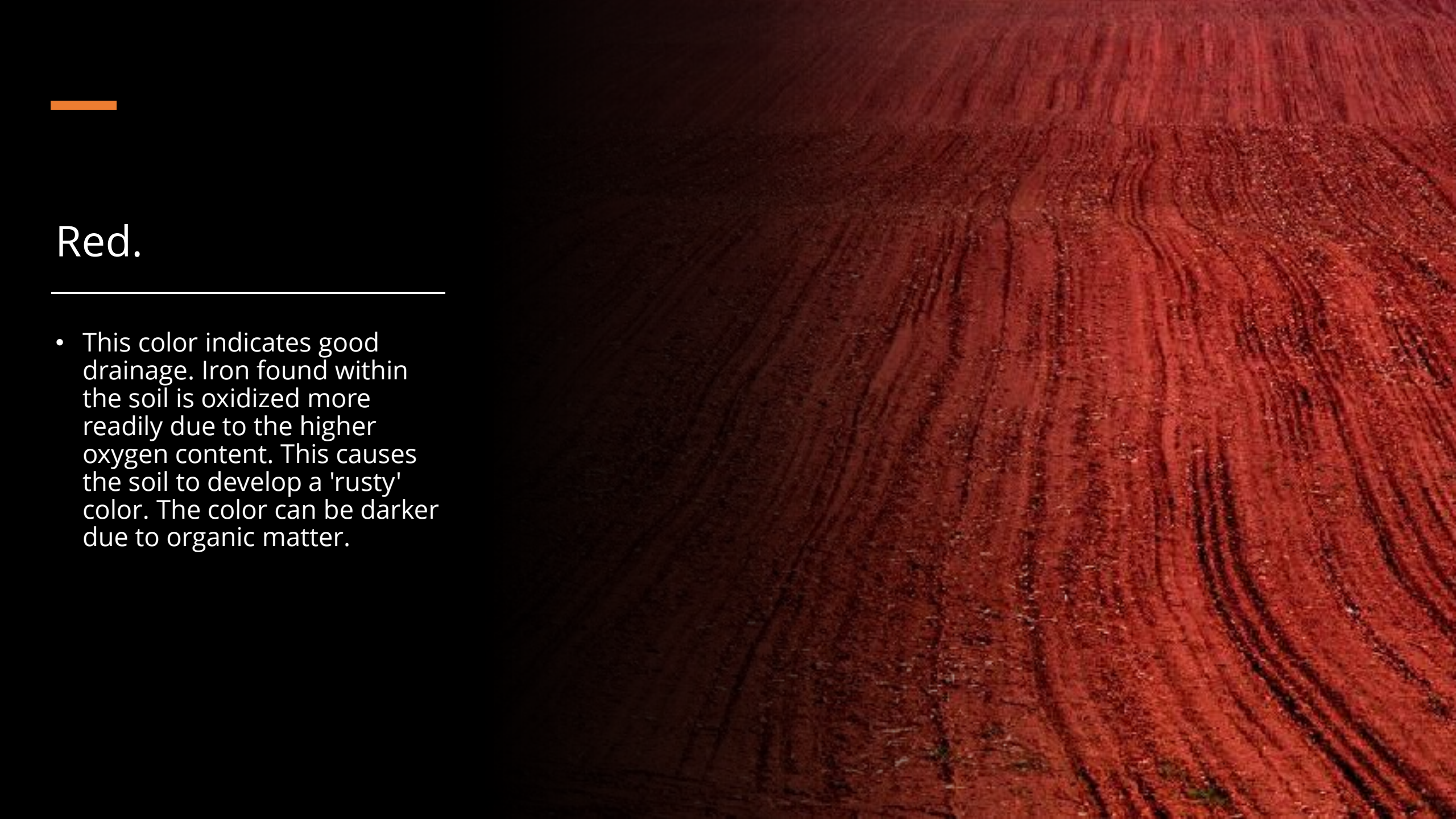
- usually due to the presence of organic matter, so that the darker the surface horizon more organic matter content is assumed

White/pale/bleached

- These soils are often referred to as bleached or 'washed out'. The iron and manganese particles have been leached out due to high amounts of rainfall or drainage.

Red.

- This color indicates good drainage. Iron found within the soil is oxidized more readily due to the higher oxygen content. This causes the soil to develop a 'rusty' color. The color can be darker due to organic matter.



Yellow/Yellowish brown/orange

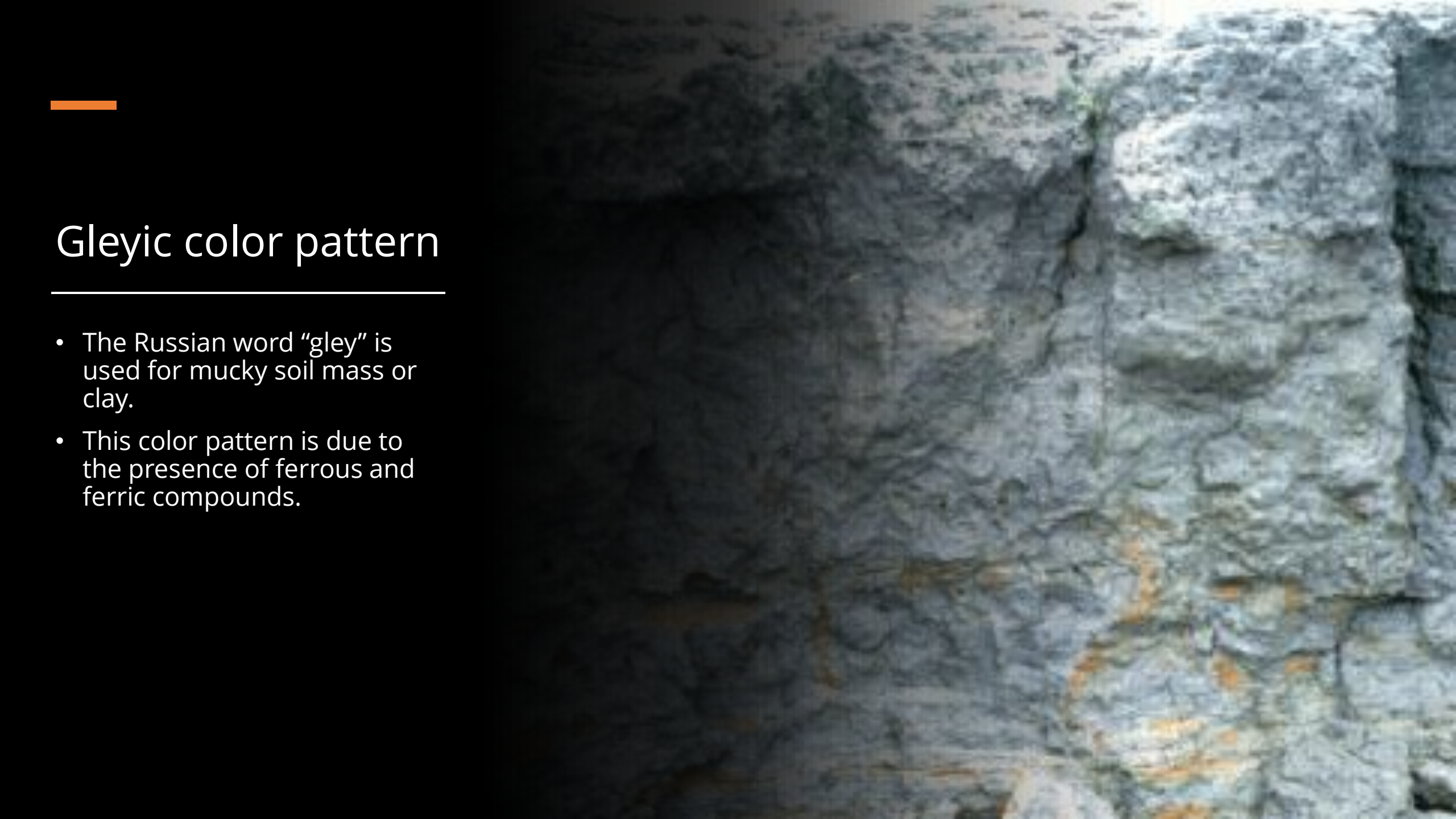
These soils often have poorer drainage than red soils. The iron compounds in these soils are in a hydrated form and therefore do not produce the 'rusty' colour

Brown

Soils associated with moderate organic matter level and iron oxides.

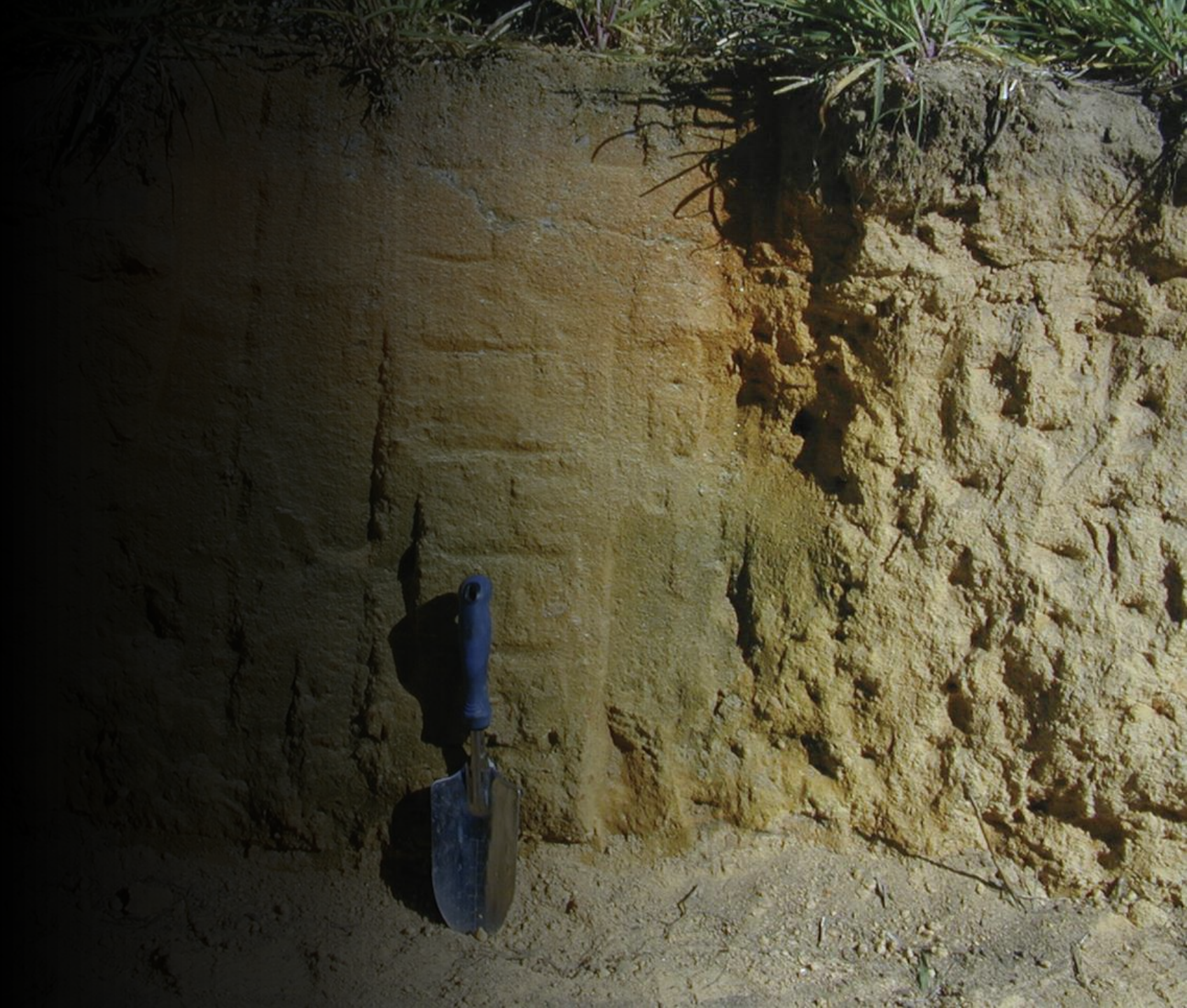
Gleyic color pattern

- The Russian word “gley” is used for mucky soil mass or clay.
- This color pattern is due to the presence of ferrous and ferric compounds.

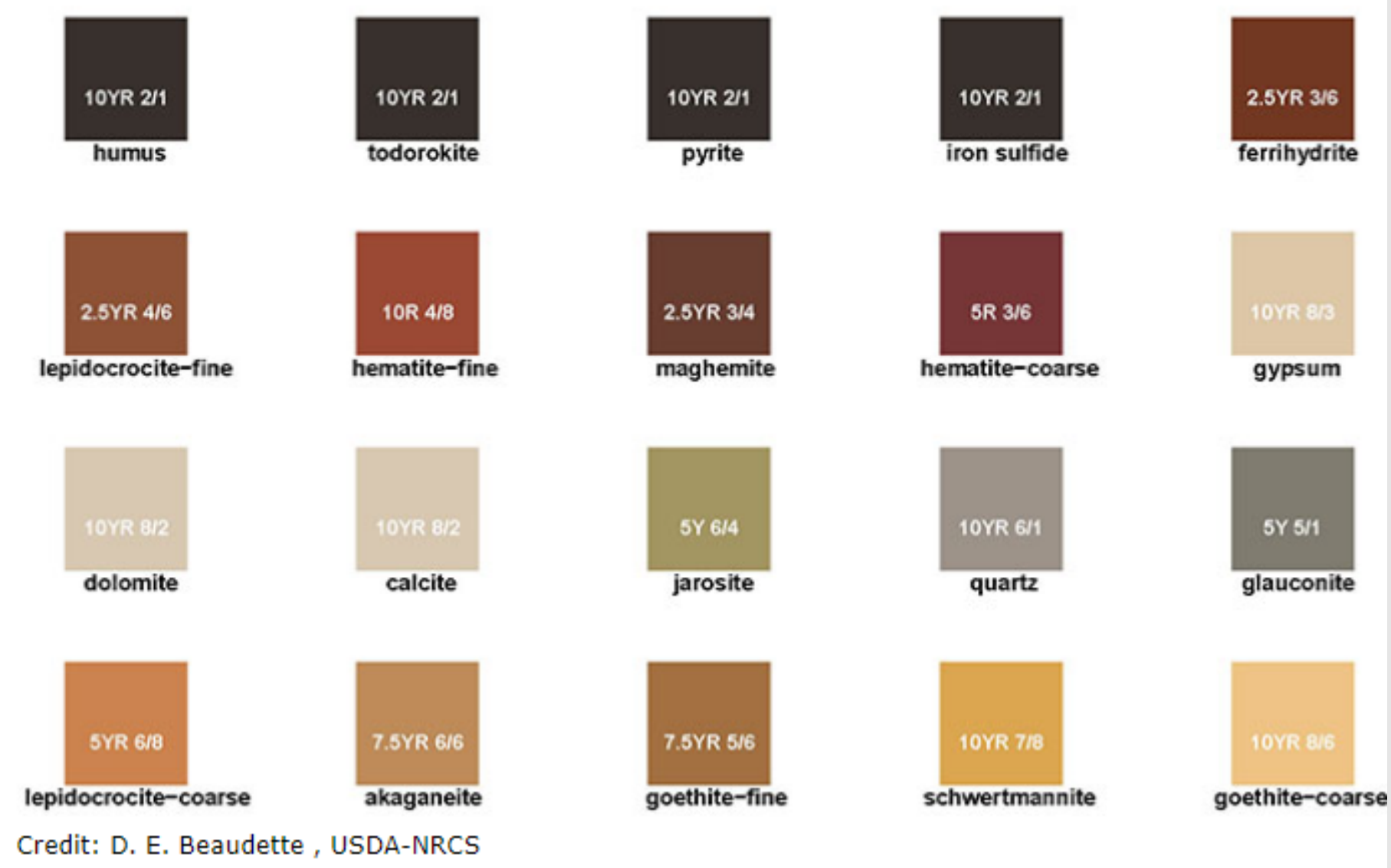


Green.

- These soils are associated with very poor drainage or waterlogging. The lack of air in these soils provides conditions for iron and manganese to form compounds that give these soils their color.



Common Pigmenting Agents In the SOIL



Credit: D. E. Beaudette , USDA-NRCS

Munsell Color System

- method of designating colors based on a color arrangement scheme developed by the American art instructor and painter Albert H. Munsell.
- Used by soil scientists in assessing the makeup of the soil in the field.

Image from: https://munsell.com/

- the color of a soil sample is compared to standard color samples, so that three parameters can be identified: **hue**, **value** and **chroma**.
- Optimum conditions for the assessment of soil color include **direct sunlight**, **with light at right angle to the charts** and **soil moist**.

Hue

- Hue is that attribute of a color by which we distinguish red from green, blue from yellow, etc. There is a natural order of hues: red, yellow, green, blue, purple.
- Gradation of each hue may be expressed as 2.5, 5, 7.5 and 10. The purest hue is 5, and lower and higher grades indicate mixtures of other hues.

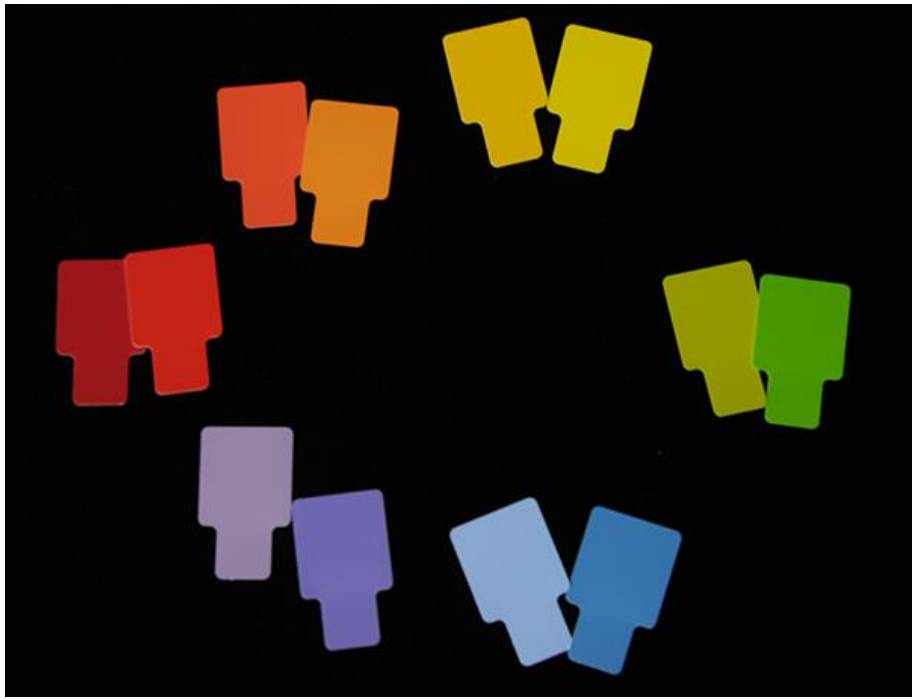


Image from: https://munsell.com/

Value

- indicates the lightness of a color.
- The scale of value ranges from 0 for pure black to 10 for pure white. Black, white and the grays between them are called “neutral colors”. They have no hue. Colors that have a hue are called “chromatic colors.”

Image from: https://munsell.com/

Chroma

- is the departure degree of a color from the neutral color of the same value.
- The chroma scale ranges from /0 to /10, /12, /14, or more, depending on the sample being examined, with lower chromas indicating increasing grayness.

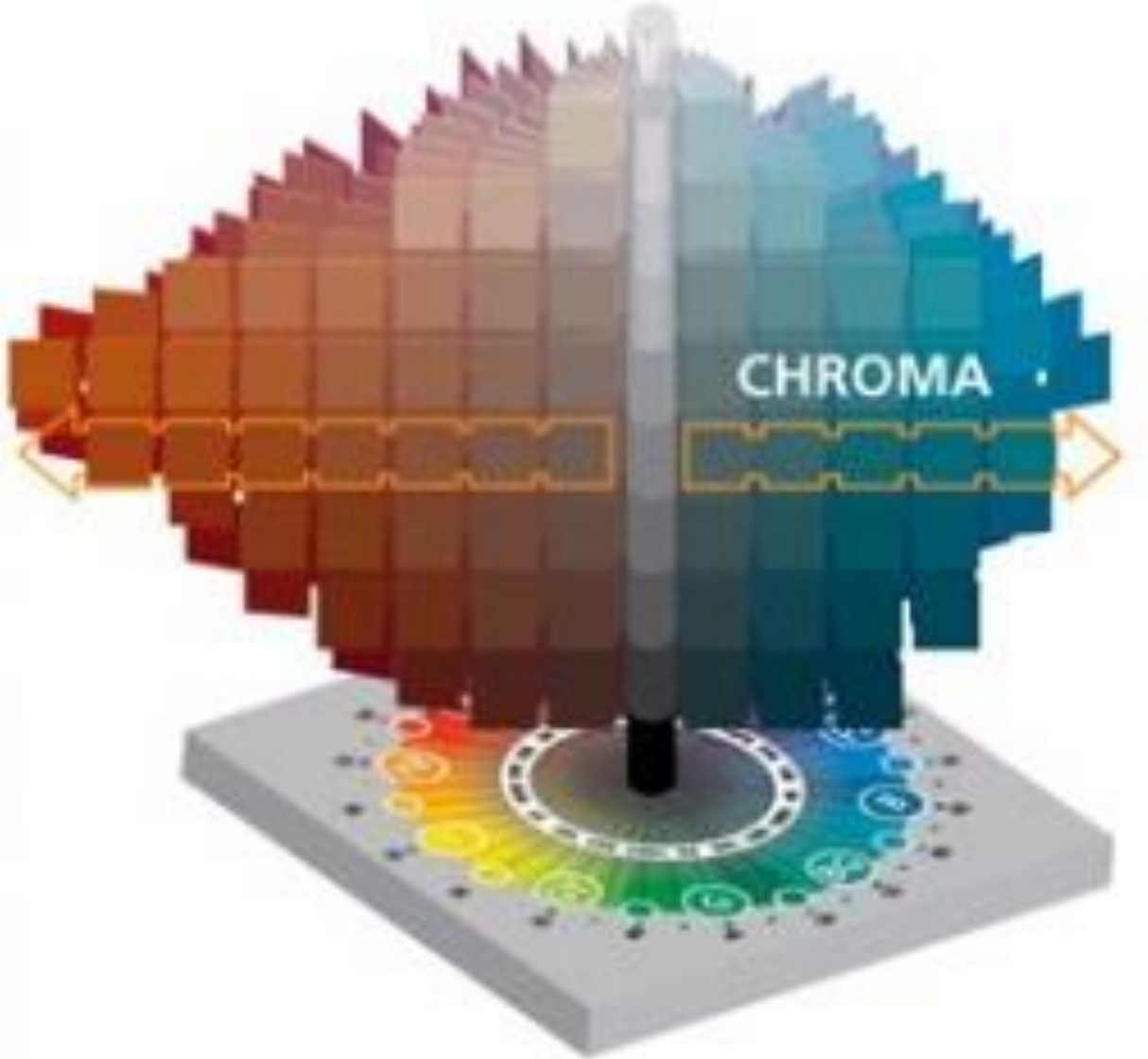


Image from: https://munsell.com/

selecting the correct hue.

the soil sample must be placed behind the apertures of the chart in order to find the most similar color chip.

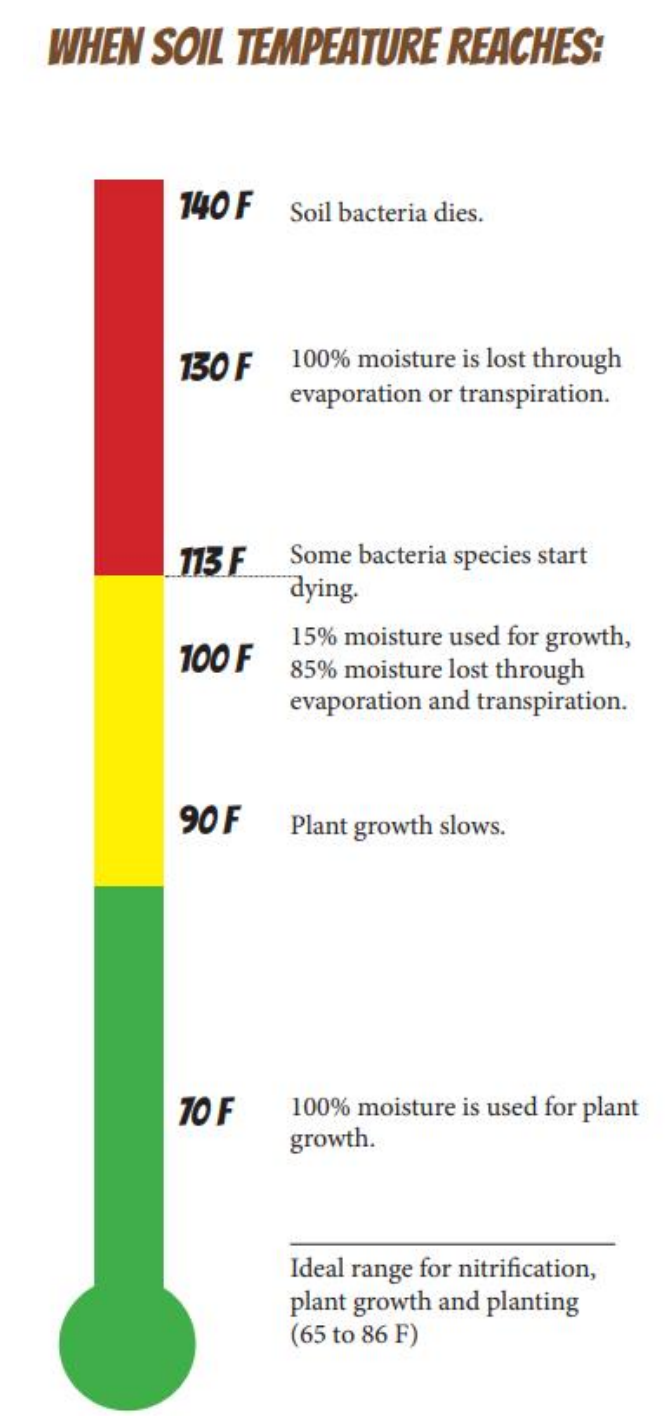
Munsell Soil Book of Color

SOIL TEMPERATURE

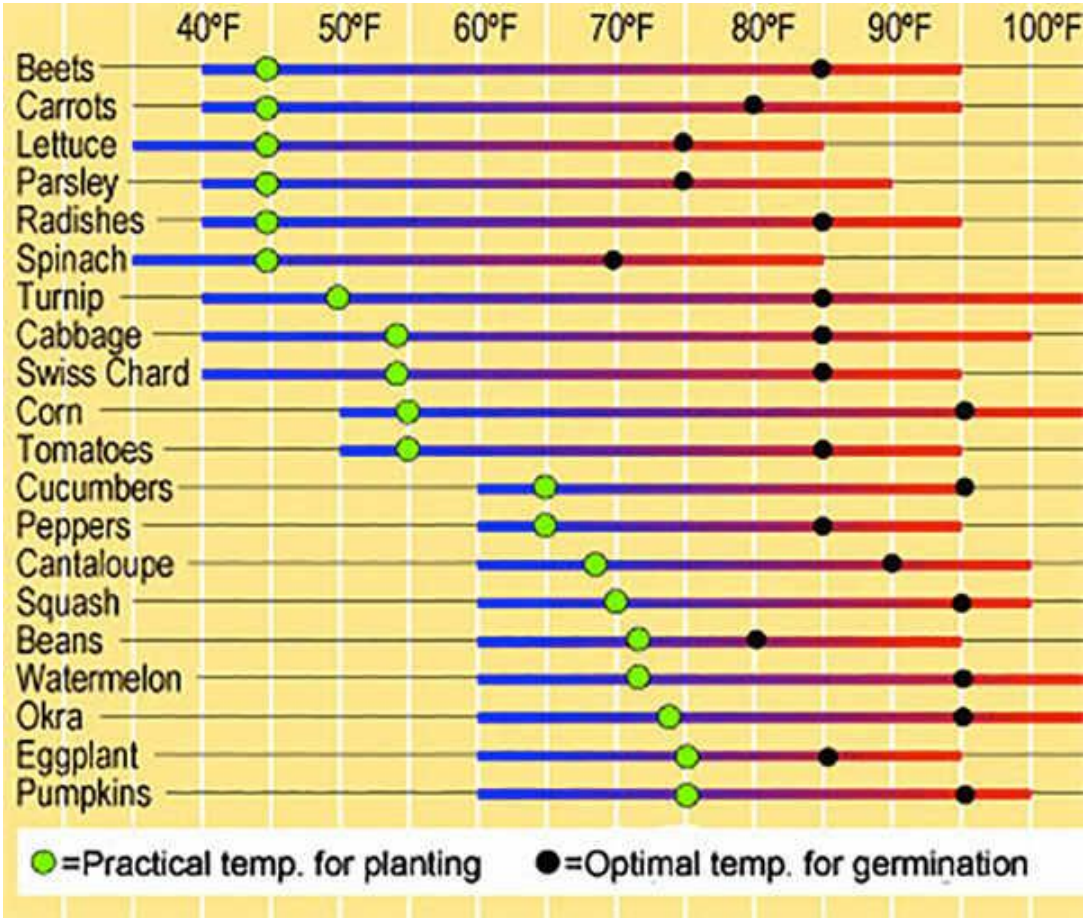
- factor that drives germination of seeds.
- directly affects plant growth.
- Most soil organisms function best at an optimum soil temperature.
- impacts the rate of nitrification.
- influences soil moisture content, aeration and availability of plant nutrients.

Method of Measuring Temperature

Soil thermometers are the most common tool for measuring soil temperatures.



Garden Vegetable Seed Germination Temperatures



SOIL FERTILITY

- To complete their life cycle, plants need 17 essential nutrients, each in varying amounts. Of these nutrients, three are found in air and water: carbon (C), hydrogen (H), and oxygen (O). Combined, C, H, and O account for about 94% of a plant's weight. The other 6% of a plant's weight includes the remaining 14 nutrients, all of which must come from the soil.

Primary Macronutrients

- nitrogen (N)
- phosphorus (P)
- potassium (K)

Secondary Macronutrients

- magnesium (Mg
- calcium (Ca)
- sulfur (S)

Micronutrients

- boron (B)
- chlorine (Cl)
- copper (Cu)
- iron (Fe)
- manganese (Mn)
- molybdenum (Mo)
- nickel (Ni)
- zinc (Zn)

Primary Nutrients	
Carbon (C)	45
Oxygen (O)	45
Hydrogen (H)	6
Nitrogen (N)	1.5
Potassium (K)	1
Phosphorus (P)	0.2
Secondary Nutrients	
Calcium (Ca)	0.5
Magnesium (Mg)	0.2
Sulfur (S)	0.1
Micronutrients	
Iron (Fe)	0.01
Chlorine (Cl)	0.01
Manganese (Mn)	0.005
Boron (B)	0.002
Zinc (Zn)	0.002
Copper (Cu)	0.0006
Molybdenum (Mo)	0.00001

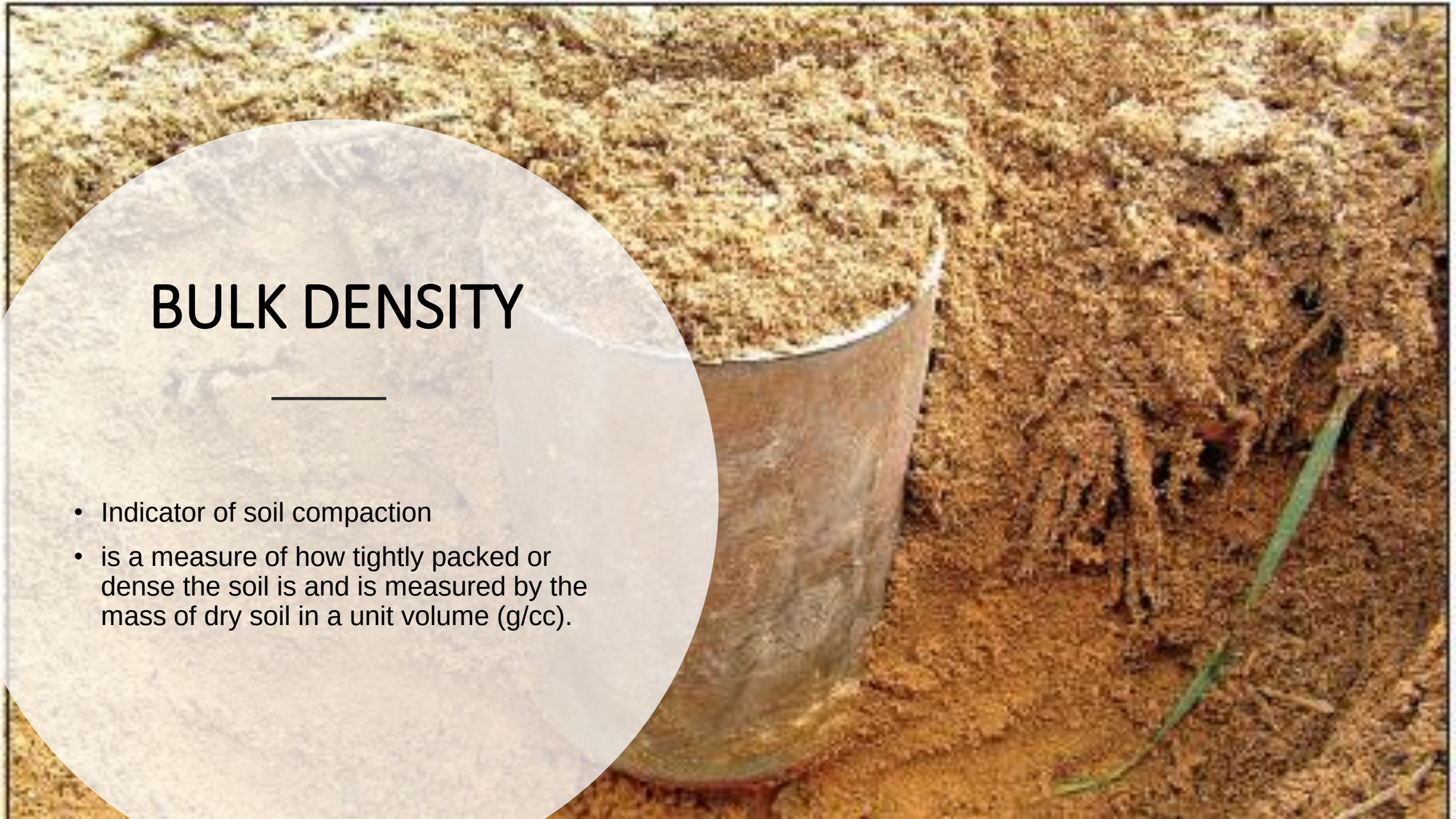
Amounts unknown for Nickel (Ni) and Cobalt (Co)

Relative amounts (out of 100) of the essential nutrients required by most plants.

Nutrient	Why Nutrient is Needed	Deficiency Symptoms	Excess Symptoms	Comments
Nitrogen (N)	• Responsible for rapid foliage growth and green color • Easily leaches from soil • Mobile in plant, moving to new growth	• Reduced growth • Light-green to yellow foliage (chlorosis) • Reds and purples may intensify with some plants • Reduced lateral breaks • Symptoms appear first on older growth	• Succulent growth; leaves are dark green, thick, and brittle • Poor fruit set • Excess ammonia can induce calcium deficiency	• High N under low light can cause leaf curl • Uptake inhibited by high P levels

Nutrient	Why Nutrient is Needed	Deficiency Symptoms	Excess Symptoms	Comments
Phosphorus (P)	• Promotes root formation and growth • Affects quality of seed, fruit, and flower production • Increased disease resistance • Does not leach from soil readily • Mobile in plant, moving to new growth.	• Reduced growth • Leaves dark-green; purple or red color in older leaves, especially on the underside of the leaf along the veins • Leaf shape may be distorted • Thin stems • Limited root growth	Shows up as micronutrient deficiency of Zn, Fe, or Co	• Rapidly fixed on soil particles • When applied under acid conditions, fixed with Fe, Mn, and Al • High P interferes with micronutrient and N absorption • Used in relatively small amounts when compared to N and K • Availability is lowest in cold soils

Nutrient	Why Nutrient is Needed	Deficiency Symptoms	Excess Symptoms	Comments
Potassium (K)	• Helps plants overcome drought stress • Improves winter hardiness • Increases disease resistance • Improves the rigidity of stalks • Leaches from soil • Mobile in plant	• Reduced growth • Shortened internodes • Margins of older leaves become chlorotic and burned • Necrotic (dead) spots on older leaves • Reduction of lateral breaks and tendency to wilt readily • Poorly developed root systems • Weak stalks	Causes N deficiency and may affect the uptake of other nutrients	• High N/low K favors vegetative growth • Low N/high K promotes reproductive growth (flower, fruit) • Calcium excess impedes uptake of K



BULK DENSITY

- Indicator of soil compaction
- is a measure of how tightly packed or dense the soil is and is measured by the mass of dry soil in a unit volume (g/cc).

Why is it important?

- Bulk density reflects the soil's ability to function for structural support, water and solute movement, and soil aeration.

The following practices can lead to poor bulk density:

Consistently plowing or disking to the same depth,

Allowing equipment traffic, especially on wet soil,

Using a limited crop rotation without variability in root structure or rooting depth,

Incorporating, burning, or removing crop residues,

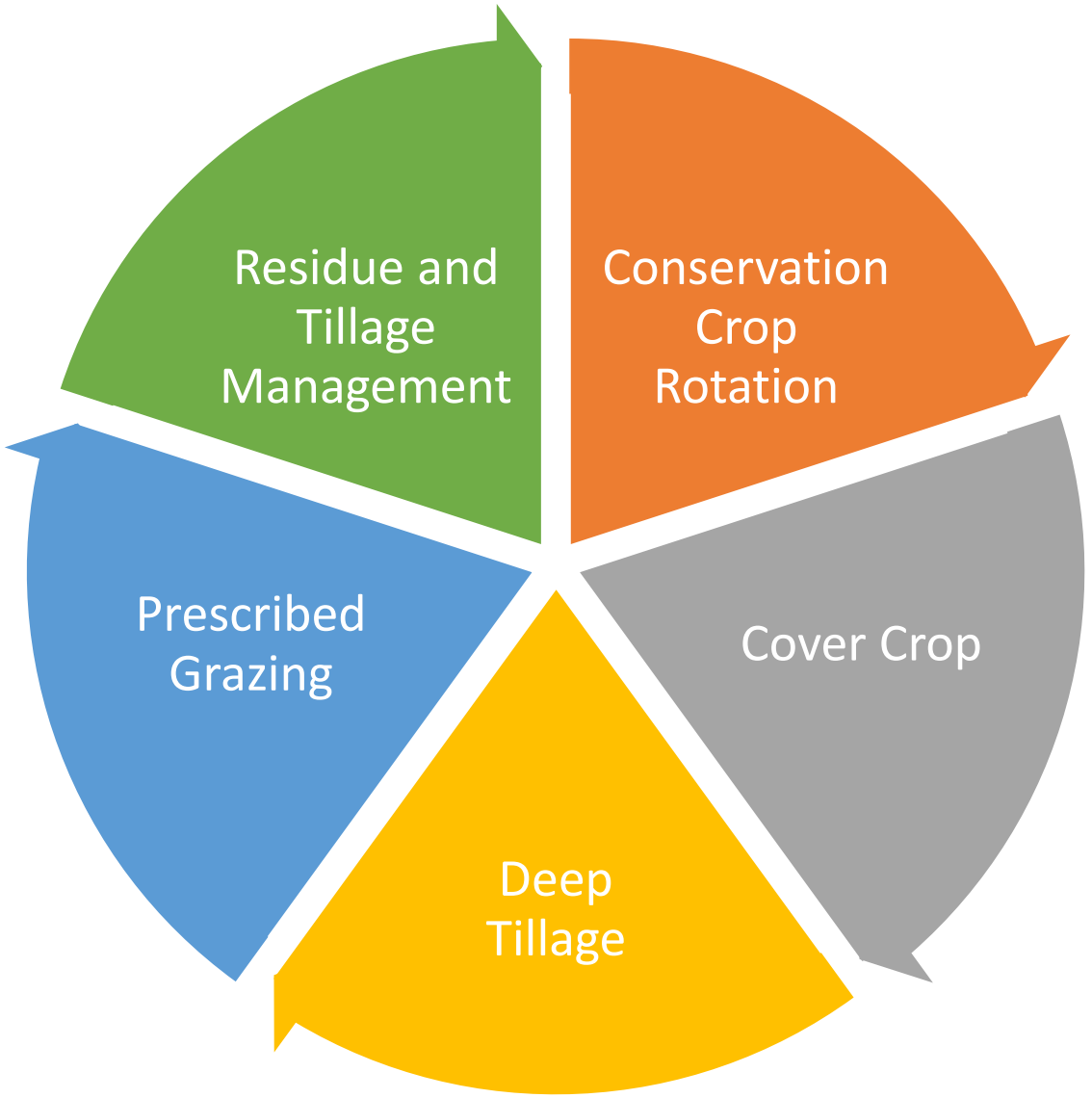
Overgrazing forage plants, and allowing development of livestock loafing areas and trails, and

Using heavy equipment for building site preparation or land smoothing and leveling.

What you can do:

1. Minimize soil disturbance and production activities when soils are wet,
2. Use designated field roads or rows for equipment traffic,
3. Reduce the number of trips across the area,
4. Subsoil to disrupt existing compacted layers, and
5. Use practices that maintain or increase soil organic matter.

Conservation practices resulting in bulk density favorable to soil function include:



General relationship of soil bulk density to root growth based on soil texture.

Soil Texture	Ideal bulk densities for plant growth (grams/cm^3)	Bulk densities that affect root growth (grams/cm^3)	Bulk densities that restrict root growth (grams/cm^3)
Sands, loamy sands	< 1.60	1.69	> 1.80
Sandy loams, loams	< 1.40	1.63	> 1.80
Sandy clay loams, clay loams	< 1.40	1.60	> 1.75
Silts, silt loams	< 1.40	1.60	> 1.75
Silt loams, silty clay loams	< 1.40	1.55	> 1.65
Sandy clays, silty clays, clay loams	< 1.10	1.49	> 1.58
Clays (> 45% clay)	< 1.10	1.39	> 1.47