SOIL TEXTURE

6th semester(Hons.) Paper DSE 4
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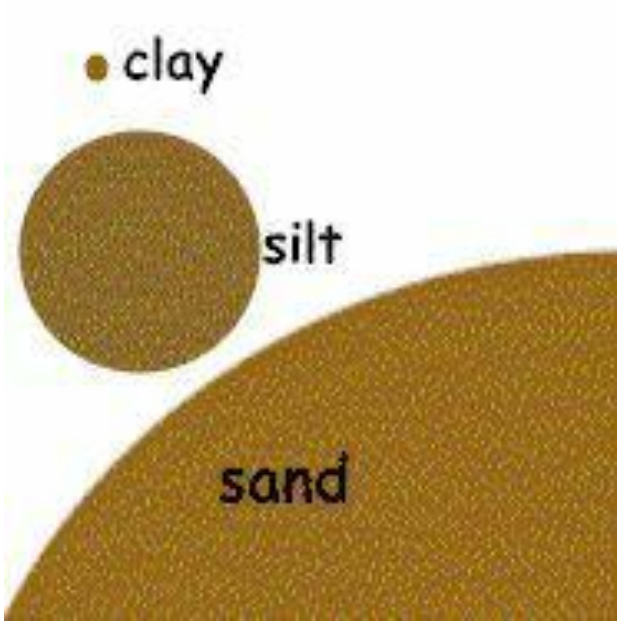
Objectives

Concepts related to soil texture :

- The definition of soil texture, soil separate, and textural class. The relative size of particles defined as sand, silt, and clay.
- How to determine a soil's textural class using the textural triangle when the soil texture is known.
- How to estimate a soil's textural class by the "feel" method.
- Importance of soil texture and its role in agriculture and landuse management

Definition

- *Soil texture* is defined as the relative proportion of sand, silt and clay.
- The ranges of diameters of the three separates are: sand (2.0- 0.05 mm), silt (0.05-.002 mm), and clay (<0.002 mm).
- Stones and gravels are excluded from the textural classes.



Diameter Ranges

Soil Fraction	Soil Separate	Diameter (mm)
Sand	Very coarse sand	1 to 2
	Coarse sand	0.5 to 1
	Medium sand	0.25 to 0.5
	Fine sand	0.1 to 0.25
	Very fine sand	0.05 to 0.1
Silt	Silt	0.002 to 0.05
Clay	Clay	< 0.002

Particle Diameter Size

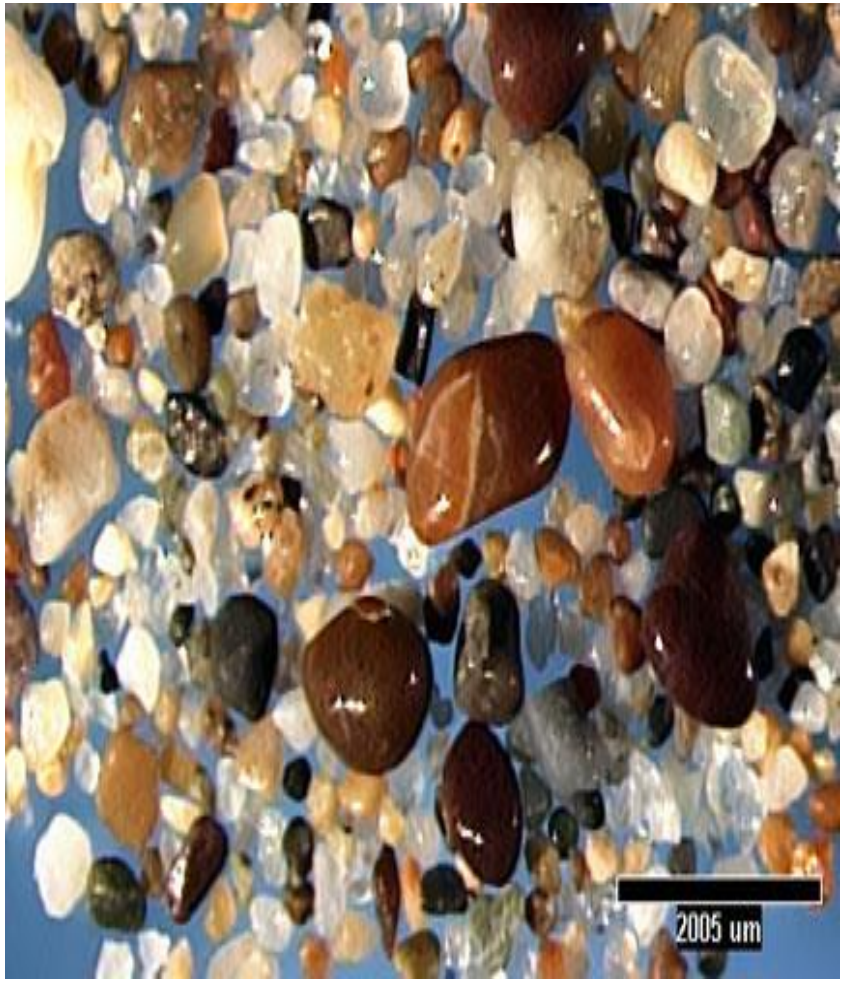
- Soil particle diameters range over 6 orders of magnitude
  - 2 m boulders
  - Coarse fragments > 2 mm
  - Sand < 2 mm to 0.05 mm
  - Silt < 0.05 mm to 0.002 mm
  - Clay < 0.002 m

Coarse Fragment

- > 2 mm
- Gravels, cobbles, boulders
- Not considered part of fine earth fraction (soil texture refers only to the fine earth fraction or sand, silt & clay)
- Boulders left in valley of Big Horn Mts.(Wy) by a glacier.

Sand

- < 2 mm to > 0.05 mm
- Visible without microscope
- Rounded or angular in shape
- Sand grains usually quartz if sand looks white or many minerals if sand looks brown,
- Some sands in soil will be brown, yellow, or red because of Fe and/or Al oxide coatings.

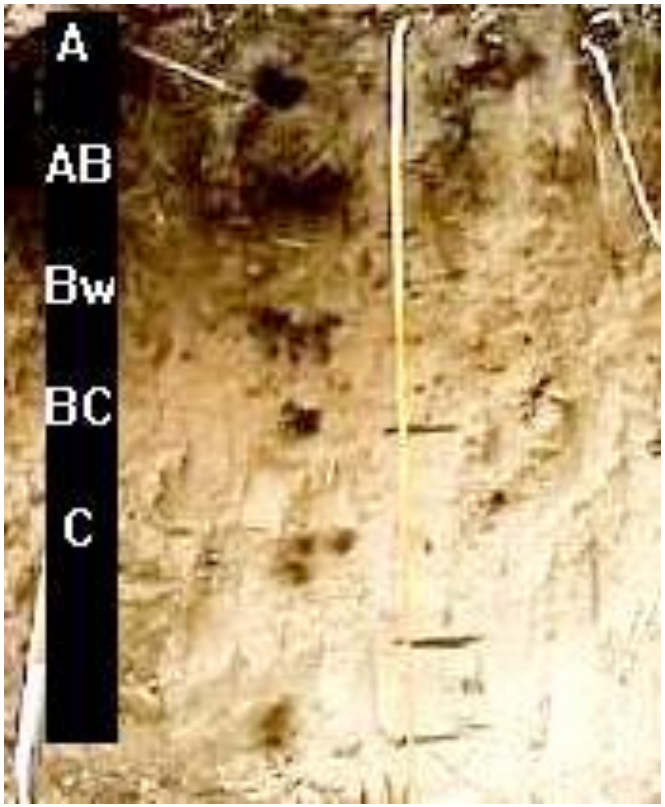


Sand

- Feels gritty
- Considered non-cohesive – does not stick together in a mass unless it is very wet.

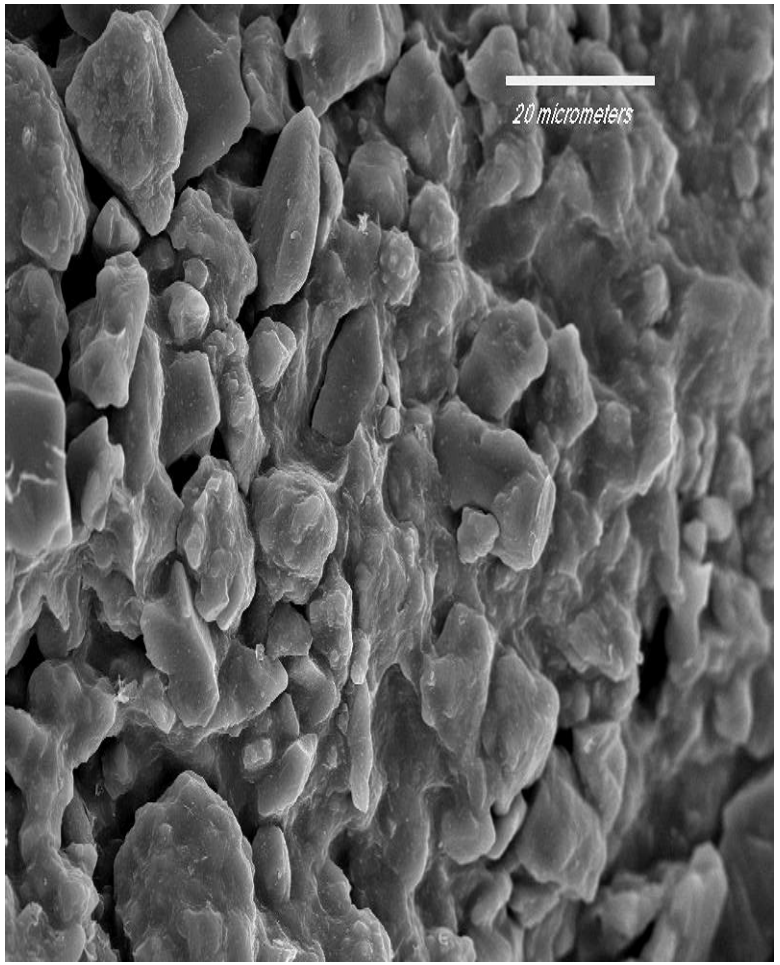
Sand

- Low specific surface area
- Sand has less nutrients for plants than smaller particles
- Voids between sand particles promote free drainage and entry of air
- Holds little water and prone to drought



Silt

- < 0.05 mm to > 0.002 mm
- Not visible without microscope
- Quartz often dominant mineral in silt since other minerals have weathered away.



Silt

- Does not feel gritty
- Floury feel –smooth like silly putty
- Wet silt does not exhibit stickiness / plasticity / malleability

Silt

- Smaller size allows rapid weathering of non quartz minerals
- Smaller particles – retains more water for plants and have slower drainage than sand.
- Easily washed away by flowing water – highly erosive.
- Holds more plant nutrients than sand.

Clay

- Wet clay is very sticky and is plastic or it can be molded readily into a shape or rod.
- Easily formed into long ribbons
- Shrink swell – none to considerable depending on the kind of clay.

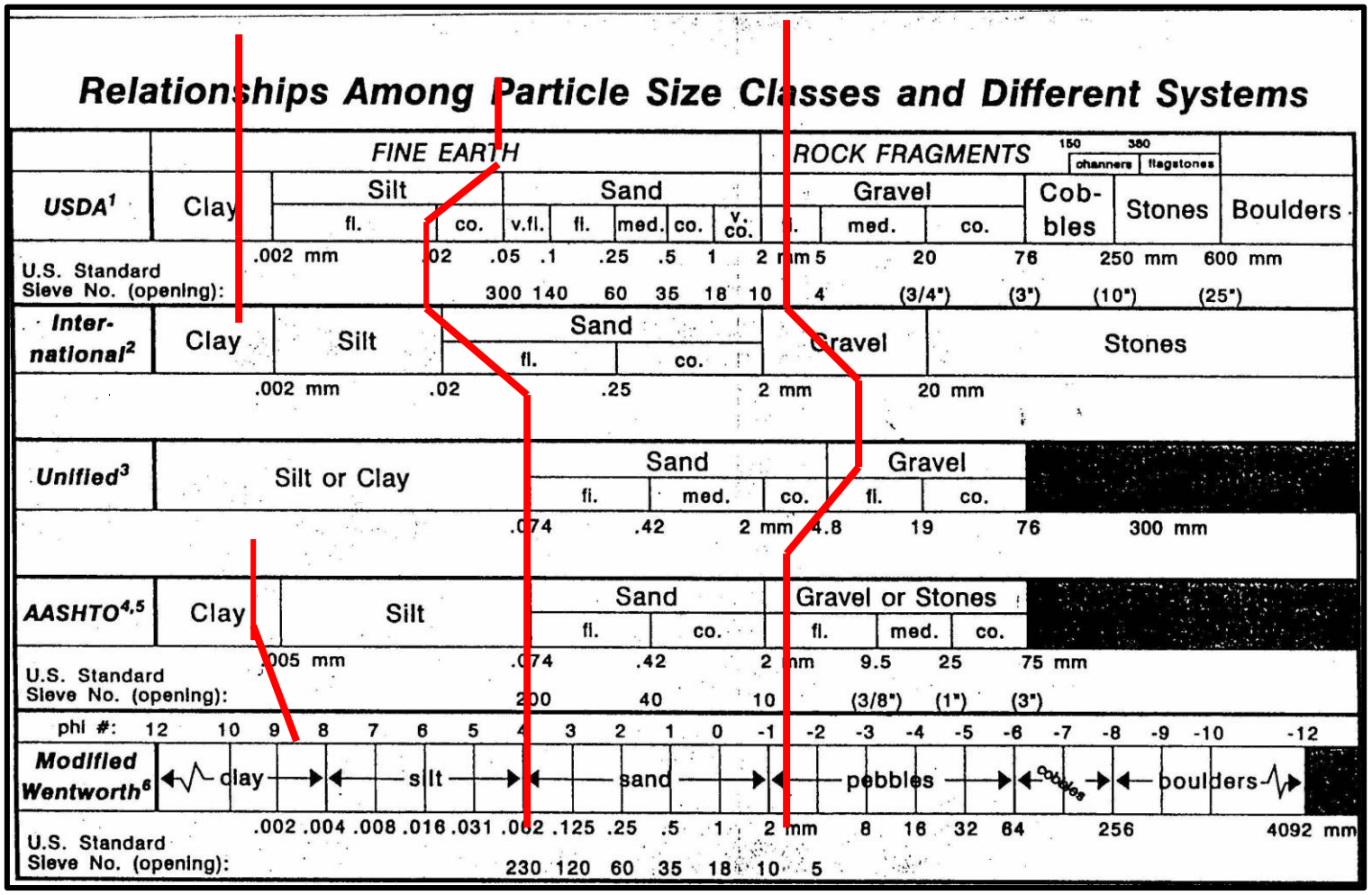
Clay

- Pores spaces are very small and convoluted
  - Movement of water and air very slow
- Water holding capacity
  - Tremendous capacity to adsorb water- not all available for plants.
- Soil strength- shrink/swell affects buildings, roads and walls.
- Chemical adsorption is large

Soil Textural Class

- Soil textural classes are based on the relative proportions of the various soil separates (sand, silt, and clay).
- There are 12 different soil textural classes.
- We use the texture triangle to determine the textural class.

DIFFERENT SOIL TEXTURAL CLASSIFICATION



Particle Size Classification Systems

- **USDA System** – Soil description for agricultural, land-based wastewater disposal, and most environmental applications. (i.e., loam)
- **AASHTO:** American Association of State Highways and Transportation Projects – potential use as road base (i.e., A-1)
- **Unified Soil Classification System (ASTM D2487-92) Engineering** Applications (i.e., SM)
- **Wentworth** (phi #)- Geological and Geotechnical Studies Using screen or sieve size using the phi number. (phi #, sieve no., or mm)

Each system has unique ("jargon" or terminology)

USDA Particle-Size Distribution

- This is the Particle System we will use in the course.
- System is divided into: fine-earth fraction and rock fragments.
- Fine-earth fraction: Finer than 2 mm: This is the information used to describe the soil and is the Soil Textural Class, such as sandy loam. Classification based on weight of 3 soil separates.
- Rock fragments: 2 mm in diameter or larger. These are commonly described as part of the coarse fragment content.
- The rock fragment modifier is based on a volumetric fraction of the soil and is used as a soil modifier. Therefore – Gravels made up 30 % of the volume for a sandy loam the full description would be gravelly sandy loam.

USDA Textural Classes

- Sandy soils (coarse)
  - Fine sand
  - Very fine sand
- Loamy soils (medium)
- Clayey soils (fine)

USDA and NRCS Textural Classes (12)

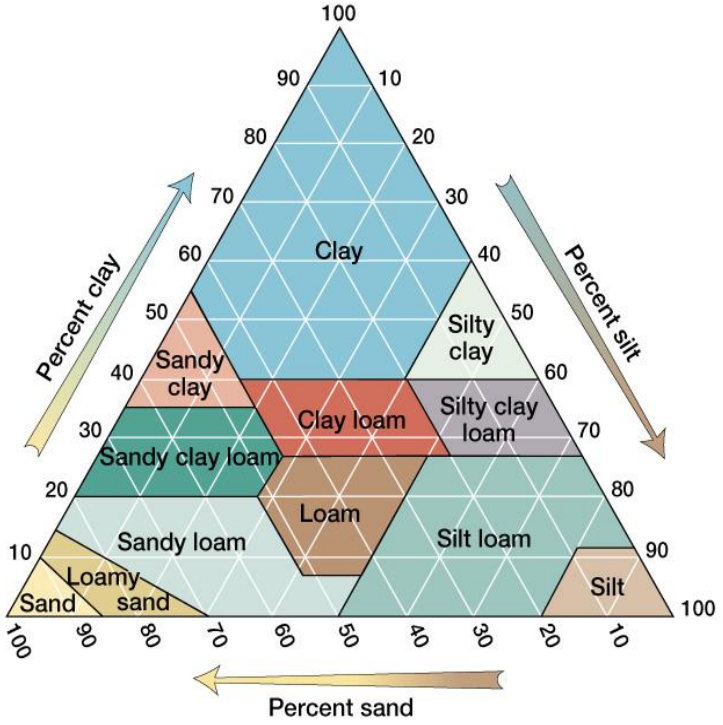
- Sand (S)
- Loamy Sand (LS)
- Sandy Loam (SL)
- Loam (L)
- Silt Loam (SIL)
- Silt (SI)
- Sandy Clay Loam (SCL)
- Silty Clay Loam (SICL)
- Clay Loam (CL)
- Sandy Clay (SCL)
- Silty Clay (SIC)
- Clay (C)

How is the texture of soil determined?

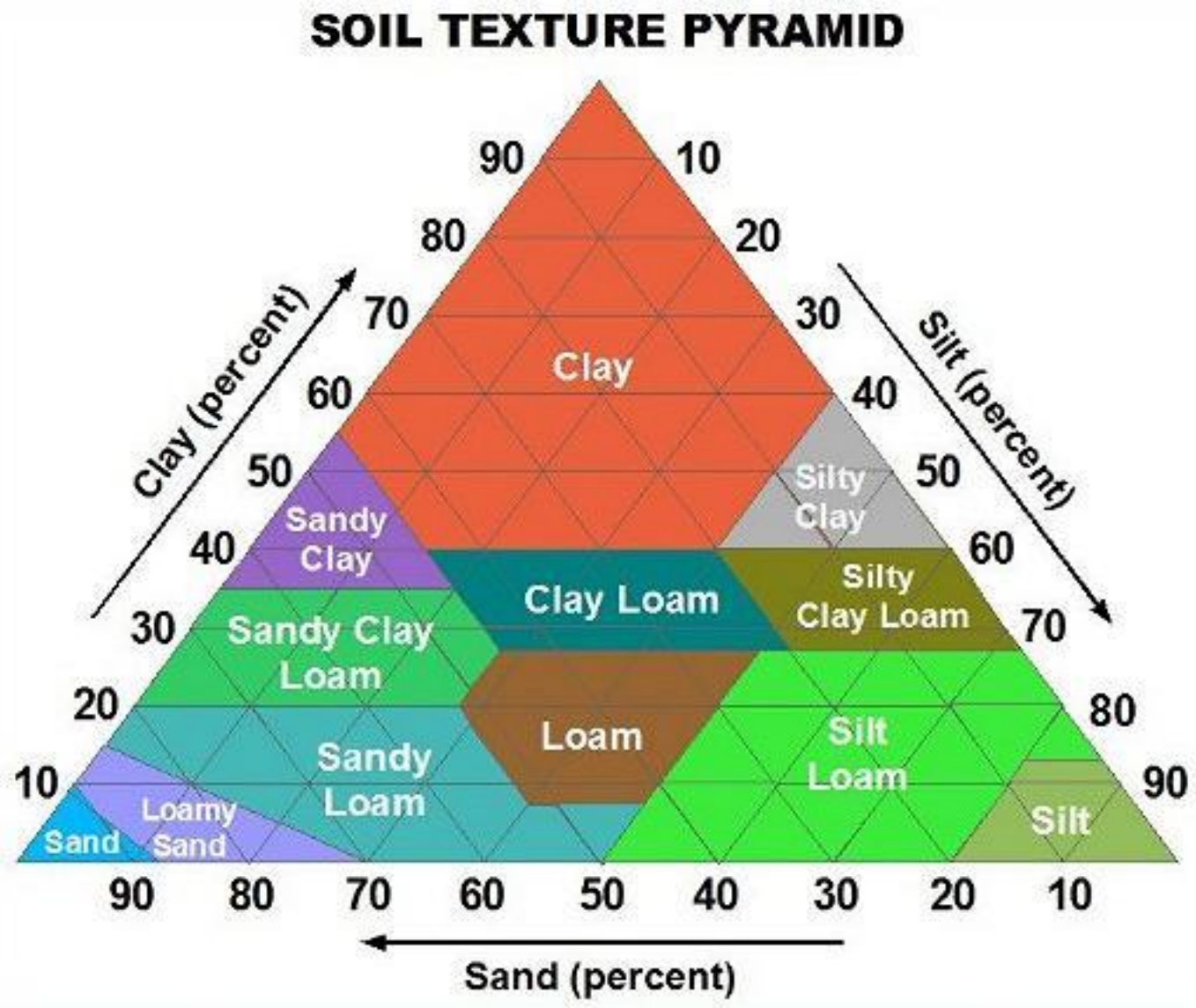
- There are 12 basic textural classes.
  1. Silt
  2. Silt loam
  3. Silty clay loam
  4. ***Loam***, which contains some of all three soil particle sizes
  5. Sandy clay loam
  6. Loamy sand
  7. Sand
  8. Sandy loam
  9. Sandy clay
  10. Clay loam
  11. Silty clay
  12. Clay

Texture Triangle

- The percentage units (0-100%) of sand, silt, and clay are listed along the sides of the triangle.
- Also notice that the relative proportion of sand, silt, and clay always adds up to 100%.



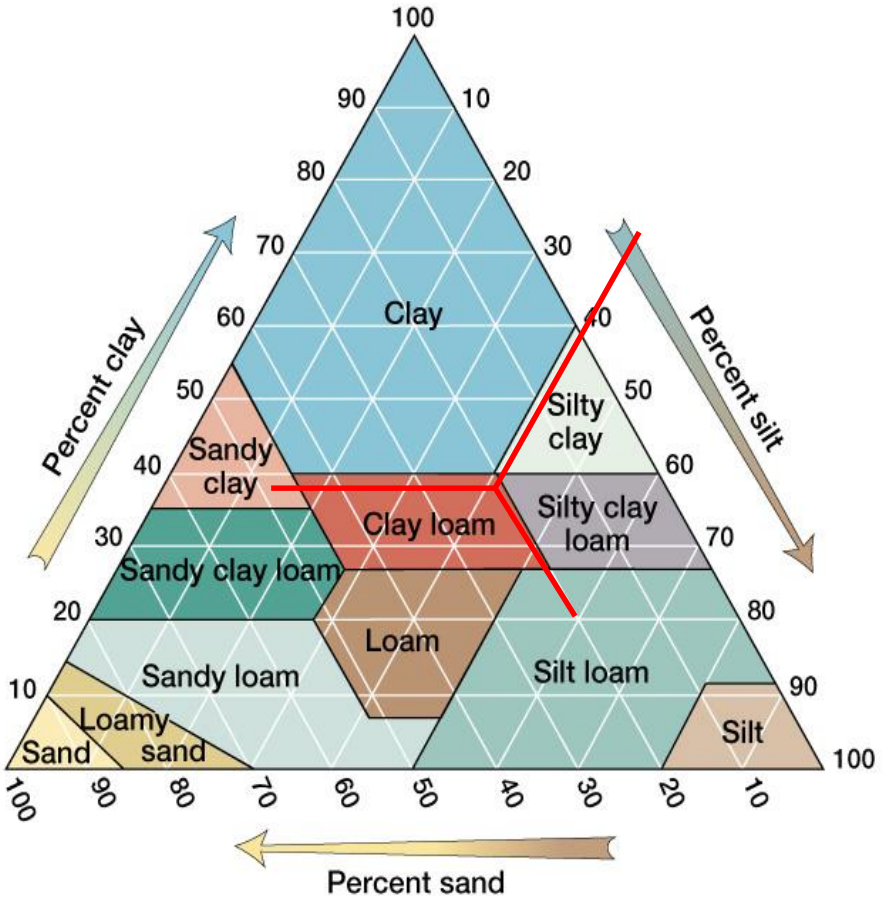
http://www.public.iastate.edu/~arossi/texture%20triangle.jpg



SOIL TEXTURAL PYRAMID : describing the relative proportion of sand ,slit ,clay in various type of soils.

Texture Triangle Example

- Tell me what the textural class is if I have: 42% sand, 3 silt, and 23% clay.
- We would have a ***loam***!!



TEXTURAL CLASSES OF SOILS

SERIAL NUMBER	SOIL CLASSES OR TEXTURAL NAMES	RANGE IN RELATIVE PERCENTAGE OF SOIL SEPARATES		
		SAND	SLIT	CLAY
1	Sandy soil	85-100	0-15	0-10
2	Loamy sand	70-90	0-30	0-15
3	Sandy loam	43-80	0-50	0-20
4	Loam	23-52	28-50	7-27
5	Slit loam	0-50	50-88	0-27
6	Slit	0-20	8-10	0-12
7	Sandy clay loam	45-80	0-28	20-35
8	Clay loam	20-45	15-53	27-40
9	Slity clay loam	0-20	40-73	27-40
10	Sandy clay	45-65	0-20	35-45
11	Slit clay	0-20	40-60	40-60
12	clay	0-45	0-40	40-100

The 21 Subclasses in Soil Texture

- There are 12 soil texture classes.
- When a sand modifier is added there can be 21 total subclasses, but 22 subclasses if very coarse sandy loam is included.

Fraction	**Size** (mm)
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05

Soil Texture Subclasses

SANDS (5)

- Very Coarse Sand (VCOS)
- Coarse Sand (COS)
- Sand (S)
- Fine Sand (FS)
- Very Fine Sand (VFS)

LOAMY SANDS (4)

- Loamy Coarse Sand (LCOS)
- Loamy Sand (LS)
- Loamy Fine Sand (LFS)
- Loamy Very Fine Sand (LVFS)

Soil Texture Subclasses

SANDY LOAMS (4)

- Coarse Sandy Loam (COSL)
- Sandy Loam (SL)
- Fine Sandy Loam (FSL)
- Very Fine Sandy Loam (VFSL)

LOAMS (3)

- Loam (L)
- Silt Loam (SIL)
- Silt (SI)

Soil Texture Subclasses

CLAY LOAMS (3)

- Sandy Clay Loam (SCL)
- Clay Loam (CL)
- Silty Clay Loam (SICL)

CLAYS (3)

- Sandy Clay (SC)
- Silty Clay (SIC)
- Clay (C)

Using Rock Fragment Modifiers

- Divided into Spherical (cube like) and Flat Units

- Less than 15 percent: No adjective or modifier terms are used.
- 15 to 35 percent: The dominant kind of rock fragment is used as an adjective ie. "gravelly loam".
- 35 to 60 percent: An adjective term with the word "very" is used ie. "very gravelly loam".
- More than 60 percent: An adjective term with the word "extremely" is used i.e., "extremely gravelly loam."

Changes in soil texture

- Over long periods (1000s yrs) pedologic processes alter soil horizon textures.
- As soils get older sand weathers to silt and silt weathers to clay….therefore old soils have more clay.

Organics in Soil Texture

- Sand, silt, and clay are the only particles used to determine soil texture.
- Soil texture refers only to the mineral fraction of the soil.
- Organic matter is not considered when determining texture or textural class.
- A precise analysis of soil texture requires that organic matter be removed.

Properties Related to Texture

- Porosity
- Permeability
- Infiltration
- Shrink-swell
- Water Holding Capacity
- Erodibility

General Influence of Soil Separates on Properties and Behaviors of Soils

Property/Behavior	Sand	Silt	Clay
Water holding	Low	Med-high	high
Aeration	Good	Med	Poor
OM decomposition	Fast	Med	Slow
Water erosion pot.	Low	High	Low
Compactability	Low	Med	High
Sealing (ponds, ect)	Poor	Poor	Good
Nutrient supplying*	Poor	Med-high	High
Pollutant leaching	High	Med	Low

PROPERTIES

- Loamy soil are a balance between sand , slit and clay particles and considered as the most desirable soils for agricultural.
- Sandy soil have coarse texture .They hold water and mineral poorly . Water and air penetrate easily thats why ,they warm readily in spring and cool quickly in autumn.
- Clayey soil hold large volume of water and retain minerals . They are very slow to warm in spring and cool more slowly in autumn.
- Slity soil are intermediate in characteristics and properties between sandy and clayey soil.

WHY DIFFERENT SOIL TEXTURES HAVE THE PROPERTIES THEY DO ?

- Sand and slit are generally irregular in shape ,ranging from rectangular or blocky to chunky ,spherical shapes.
- Clay particles are made up of two to three flat crystalline plates , layered or laminated together. These particle can be hexagonal in shape with distinct edges , or they may form irregularly shaped flakes or even rods.
- Allophane (an amorphous material) have same tiny size as clay particle and is prevalent in soils developed from volcanic ash.

Soil Texture and Surface Area

- As particle size decreases, surface area increases
  - Clay has about 10,000 times as much surface area as sand
- Has a big effect on:
  - Water holding capacity
  - Chemical reactions
  - Soil cohesion
  - Ability to support microorganisms

Organic Matter & Humus

- **Organic Matter** is derived from decomposing plant and animal remains
- **Humus** is the dark, moist layer found on the top of a soil profile. This is because it is made up of dead and decaying matter. It is fairly fertile in that the decay process adds nutrients to the soil that plants love to soak up.

Parent Material

- Rock or original source of soil particles
- Effects soil quality
- Glacial outwash sands tend to be infertile, or hold few minerals and nutrients important for tree growth.
- Soils derived from other sources may be relatively rich in minerals and nutrients.
- Usually a combination of weathered parent materials and organic matter make a soil.

Importance of Soil Texture

- Soil texture is one of the most important properties of a soil, and it greatly affects land use and management.
- It affects the amount of water and nutrients that a soil can hold and supply to plants.
- Soil physical properties such as structure, and movement of air and water through the soil are affected by texture.

ROLE OF SOIL TEXTURE

- Soil texture is a qualitative classification tool used in both the field and laboratory to determine classes for agricultural soils based on their physical texture.
- It directly influences soil-water relationship ,aeration and root penetration through its relationship with interpartical pore space.

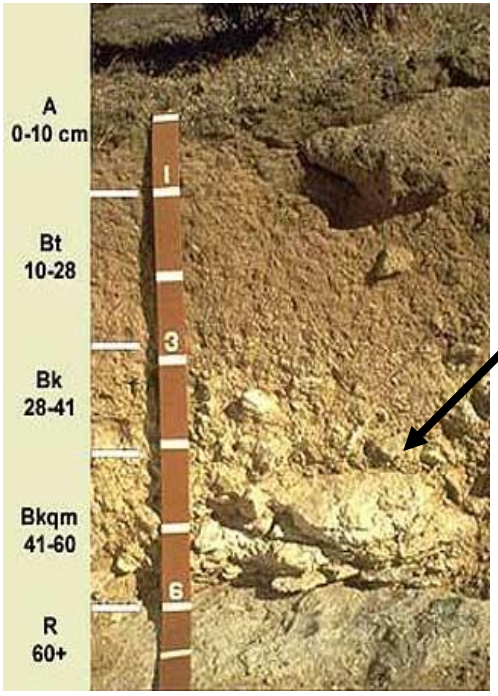
- Soil texture is of ecological interest ,for the dominant particle size present in any area have a effect on the flora and fauna of an area.
- It affects the nutritional status of soil
- The presence of fine textured soil in lower part of soil body may partially compensate for coarser soil in upper layers , through a mixture of fine coarse soil particles can combine many of the advantages provided by either type texture.

Soil Texture = %Sand, Silt & Clay in a soil.

- Soil texture is the single most important physical property of the soil. Knowing the soil texture alone will provide information about:
- 1) water flow potential,
- 2) water holding capacity,
- 3) fertility potential,
- 4) suitability for many urban uses like bearing capacity

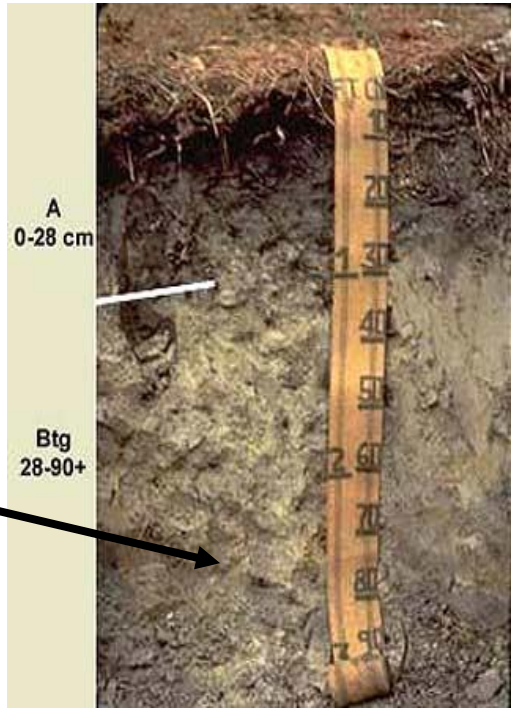
What affects soil texture?

- The parent material, as modified by weathering and soil- forming processes, determines a soil horizon's texture.



Residuum (or bedrock)

Marine Sediments



HOW THESE PARTICLES CAN BE SEPARATED

- To separate the particle of different sizes ,the organic matter of soil is oxidized and inorganic cementation is removed to breakdown structural aggregation.
- Fine fractions are removed from coarser material by sedimentation technique.
- Coarse fraction is dried and graded by sieving.

- Stones and gravels are retained by 2.0 mm perforated plate sieve , the coarse sand retain on a 70 mesh wire sieve (0.23 mm per opening) while the fine sand passes through the 70 mesh.
- Slit and clay fractions are graded according to sedimentation velocity in a liquid column.

Mesh: A barrier made of connected strands of metal, fiber, or other flexible material; similar to web or net

Determining Soil Texture - Feel Method

- Wet soil in hand
- Make ribbon
- Length of ribbon indicates clay content
- Grit or lack of grit indicates sand or silt
- Smoothness indicates silt

How is the texture of soil determined?

- The relative amounts of sand, silt, and clay may also be determined in the field using the ribbon method.
- Five textural classes may be determined using the ***ribbon method***.

1. In fine-textured soil, a ribbon forms easily and remains long and flexible.
2. In moderately fine-textured soil, a ribbon forms but breaks into pieces ¾ to one–inch long.

How is the texture of soil determined?

3. No ribbon forms in medium-textured soil. The sample breaks into pieces less than ¾–inch long. The soil feels smooth and talc-like.

4. No ribbon forms in moderately coarse-textured soil. The sample feels gritty and lacks smoothness.

5. No ribbon forms in coarse–textured soil. The sample is composed almost entirely of gritty material and leaves little or no stain.

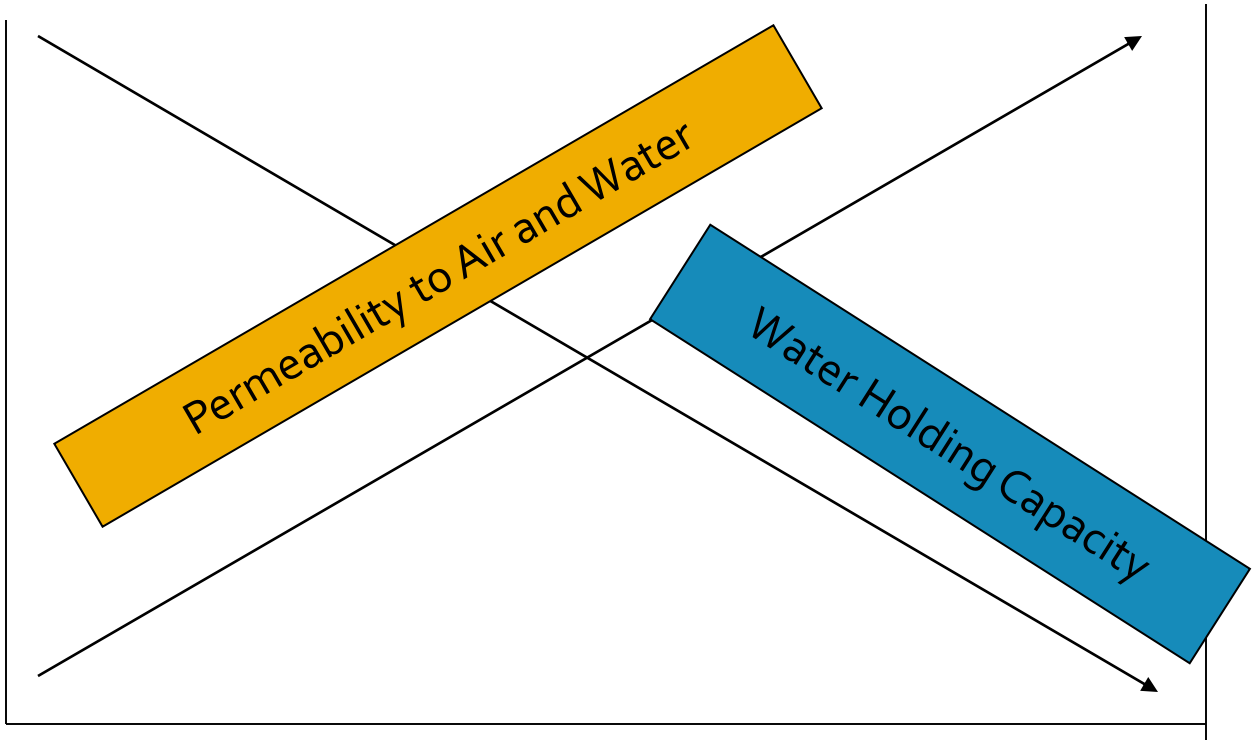
The Ribbon Method

- a. Fine-textured a ribbon forms easily and remains long and flexible.
- b. Moderately fine textured - a ribbon forms but breaks into pieces ¾ to 1 inch long.
- c. Medium textured - no ribbon forms. The sample breaks into pieces less than ¾ inch long. The soil feels smooth and talc-like.
- d. Moderately coarse textured - no ribbon forms. The sample feels gritty and lacks smoothness.
- e. Coarse textured - no ribbon forms. The sample is composed almost entirely of gritty material and leaves little or no stain.


Soil does not form a cast:
Textural class is SAND


Forms a cast of moist soil material.
Textural class is LOAMY SAND

Water Holding & Soil Texture



Fine Texture

Medium Texture

Coarse Texture

Hydrometer Method

The Bouyoucos hydrometer method of mechanical analysis used in routine work, where quick measurements are necessary and extreme accuracy is not required.

The method is based on the fact that water containing material in suspension has greater density than pure water. The more material in suspension, the greater the density.

The Bouyoucos hydrometer measures the density of the suspension. The higher the hydrometer floats, the greater the density of the suspension.

Requirements:

1) Hydrometer- reading in grams
2) Electronic Balance
3) Dry Soil – 40 to 60 grams
4) Dispersing Agent
5) Use of an Oxidizing Agent (H_2O_2)
6) 1000 ml volumetric cylinder
7) Readings at 40 seconds and 3 hours
8) Temperature Correction

Sieve Analysis
Particle-Size Distribution

- Particle size distribution describes the abundance (by weight) of the various size particles that constitute the mineral portion of soil materials.
- The distribution of the size based on mm, pH #, or sieze size is used for more detailed geological, engineering, and geotechnical applications.
- Distribution of Particles for (Sand) can be used to estimate the permeability using the Hazen equations.
- Laboratory Method

Pipette Method

•The pipet method utilizes Stoke's Law by the extraction of subsamples of the soil suspension at a given depth after a predetermined settling time for each size fraction of interest.

•As time passes, larger particles pass by the sampling depth, and smaller and smaller size fractions can be sampled.

•After extracting the sample, it is dried weighed, and a calculation can be done to determine the percentage of the total soil in suspension present in each sample.

• The pipet method is very accurate, but also time consuming. Pretreatment of the sample may include the use of dispersing chemicals or oxidizing agents.

$V = (2gr^2)(d_1-d_2)/9\mu$ (Stokes Law)

Where,

V = velocity of fall (cm sec^{-1}), g = acceleration of gravity (cm sec^{-2}),

r = "equivalent" radius of particle (cm), dl = density of particle (g cm^{-3}),

d_2 = density of medium (g cm^{-3}), and μ = viscosity of medium (dyne sec cm^{-2}).