

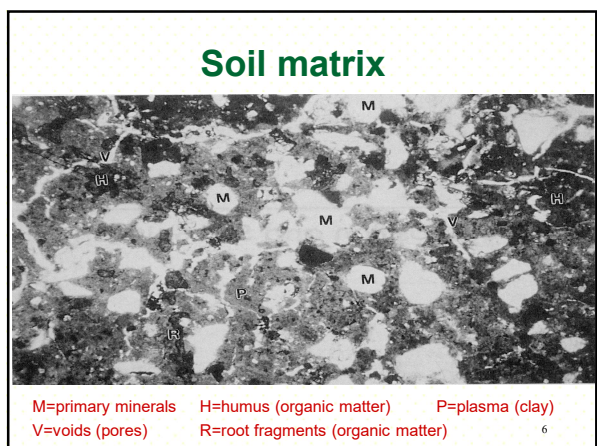
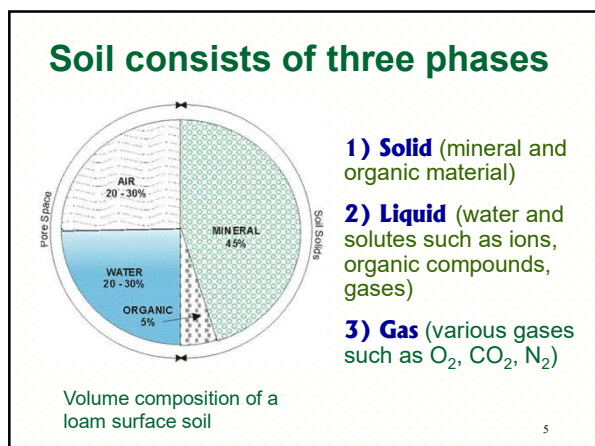
Soil physics is the branch of soil science that deals with the state and transport of matter and transformations of energy in the soil

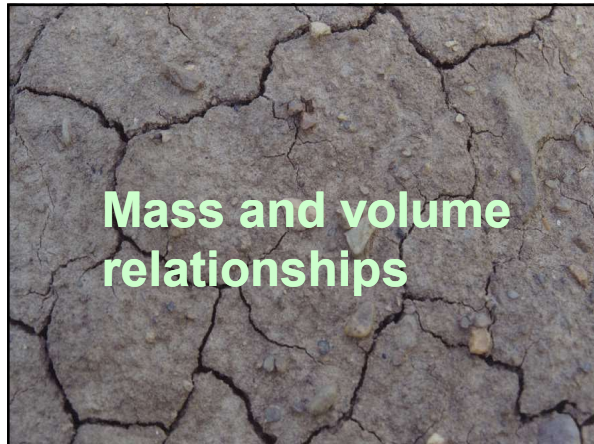
2

Lecture outline

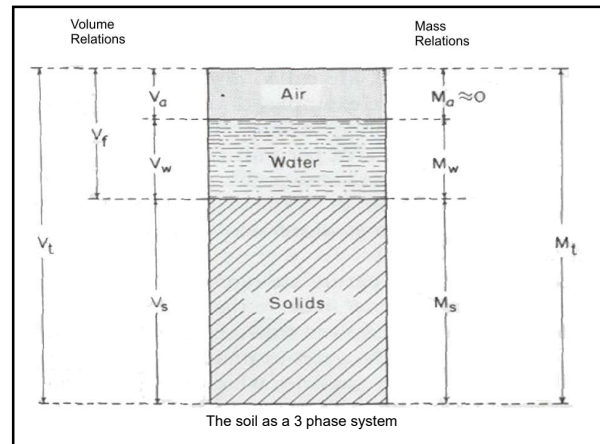
- A. Soil as a 3-phase system
- B. Mass and volume relationships of soil constituents
- C. Soil particles and soil texture

3





Mass and volume relationships



Density of solids or particle density (ρ_s)

- In most mineral soils particle density is ~ 2600 to 2700 kg/m^3 (or 2.6 to 2.7 g/cm^3)
- Density of **organic matter** is $\sim 1300 \text{ kg/m}^3$
- Density of **water** is $\sim 1000 \text{ kg/m}^3$
- Density of **air** is negligibly small

$$\rho_s = \frac{M_s}{V_s} \quad \begin{array}{l} M_s = \text{mass of solids} \\ V_s = \text{volume of solids} \end{array}$$

9

Bulk density (ρ_b)

- In most mineral soils bulk density is about $1300\text{-}1350 \text{ kg/m}^3$

$$\rho_b = \frac{M_s}{V_t} = \frac{M_s}{V_a + V_w + V_s} \quad \begin{array}{l} M_s = \text{mass of solids} \\ V_t = \text{total soil volume} \end{array}$$

10

Bulk density vs. particle density

In the field, one cubic meter of a certain soil appears as...

Solids and pore spaces: 1.33 Mg

To calculate bulk density of the soil:

Volume = 1 m^3 (solids + pores) Weight = 1.33 Mg (solids only)

Bulk density = $\frac{\text{Weight of oven dry soil}}{\text{Volume of soil (solids + pores)}}$

Therefore

Bulk density, $D_b = \frac{1.33}{1} = 1.33 \text{ Mg/m}^3$

If all the solids were compressed to the bottom, the cube would look like...

1/2 pore spaces 1/2 solids: 1.33 Mg

To calculate particle density of the soil:

Volume = 0.5 m^3 (solids only) Weight = 1.33 Mg (solids only)

Solid particle density = $\frac{\text{Weight of solids}}{\text{Volume of solids}}$

Therefore

Solid particle density, $D_p = \frac{1.33}{0.5} = 2.66 \text{ Mg/m}^3$

12

Porosity (f)

- In most mineral soils porosity is about $0.3\text{-}0.6$ (30-60%)

$$f = \frac{V_f}{V_t} = \frac{V_a + V_w}{V_a + V_w + V_s} \quad \begin{array}{l} V_f = \text{volume of pores} \\ V_t = \text{total soil volume} \end{array}$$

12

Soil water content on a volume basis (θ_v)

$$\theta_v = \frac{V_w}{V_t}$$

V_w = volume of water
 V_t = total soil volume

$$\theta_v = \frac{V_w}{(V_s + V_f)}$$

V_w = volume of water
 V_s = volume of solids
 V_f = volume of pores

13

Soil water content on a mass basis (θ_m)

$$\theta_m = \frac{M_w \text{ (g)}}{M_s \text{ (g)}}$$

M_w = mass of water
 M_s = mass solids

Convert from gravimetric to volumetric soil water content:

$$\theta_v = \frac{\theta_m \times \rho_b}{\rho_{\text{water}}}$$

14



Soil particles and soil texture

2 mm - “Magic” number in soil science



16

Size of soil mineral constituents

- **Fine earth (primary) particles** (sand, silt, and clay) have diameter smaller than 2 mm
- **Coarse fragments** (stones, cobbles, and gravel) have diameter larger than 2 mm



Classification of soil particles according to their size

International Society of Soil Science	Clay	Silt	Sand		Gravel	
			Fine	Coarse		
	0.002	0.02	0.2	2.0		
	0.002	0.05	0.10	0.25	0.5	

United States Department of Agriculture	Clay	Silt	Very fine	Fine	Med.	Coarse	Very coarse	Gravel
			Sand					

Canadian classification	fine clay	silt	very fine	fine	med.	coarse	very coarse	gravel
			sand					

0.0002

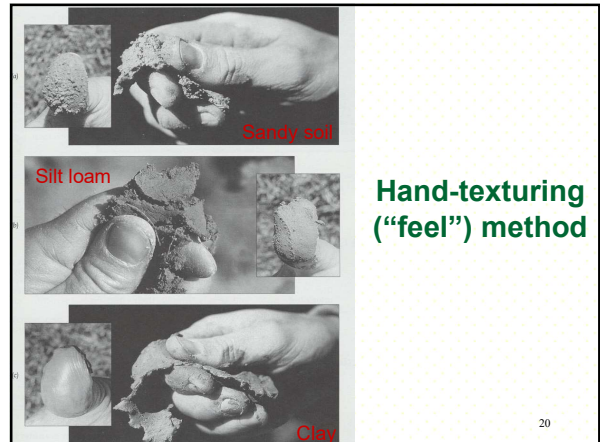
Particle diameter (mm) log scale

18

Soil texture

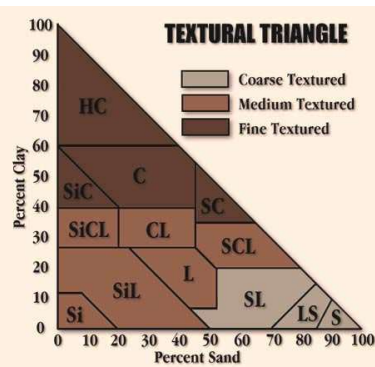
—refers to the relative proportions of sand, silt, and clay in a soil

19



20

Soil textural classes



C = Clay
L = Loam
Si = Silt
S = Sand

21



What other soil properties are affected by soil texture?

22