# Soil Physics - SOLIDS (1)

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



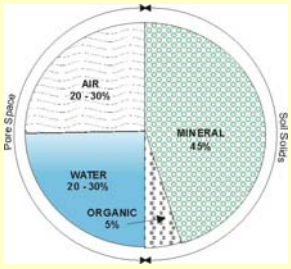
## Lecture outline

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



# Soil as a three-phase system

## Soil consists of three phases




Volume composition of a loam surface soil

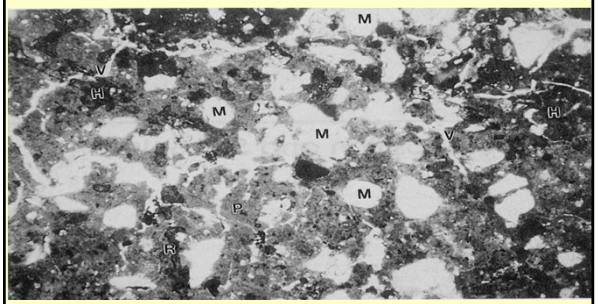
1) **Solid** (mineral and organic material)

2) **Liquid** (water and solutes such as ions, organic compounds, gases)

3) **Gas** (various gases such as $O_2$, $CO_2$, $N_2$)



## Soil matrix




M=primary minerals H=humus (organic matter) P=plasma (clay)
V=voids (pores) R=root fragments (organic matter)

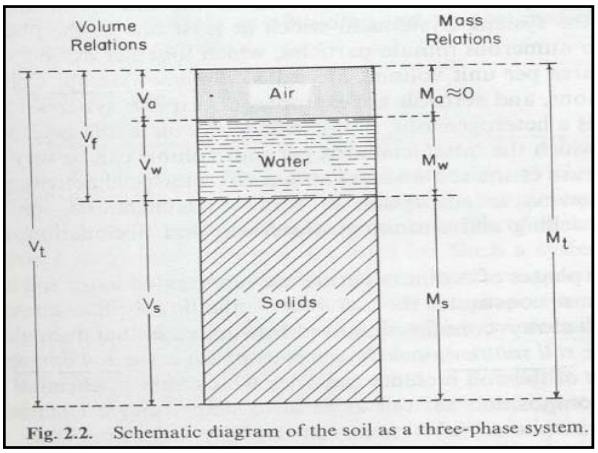



Fig. 2.2. Schematic diagram of the soil as a three-phase system.

## Density of solids or particle density ($\rho_s$)

- 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 ~ 1300 kg/m$^3$
- Density of **water** is ~ 1000 kg/m$^3$
- Density of **air** is negligibly small

$$\rho_s = \frac{M_s}{V_s}$$

$M_s$ = mass of solids
$V_s$ = volume of solids



## Bulk density ($\rho_b$)

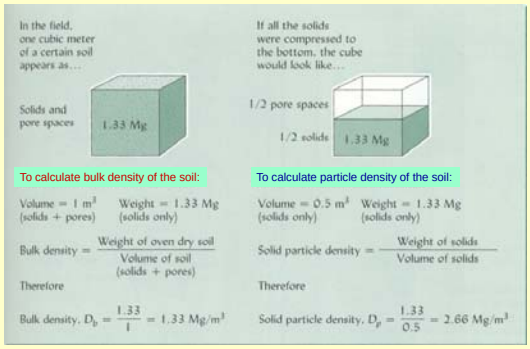
- In most mineral soils bulk density is about 1300-1350 kg/m$^3$

$$\rho_b = \frac{M_s}{V_t} = \frac{M_s}{V_a + V_w + V_s}$$

$M_s$ = mass of solids
$V_t$ = total soil volume



## Bulk density vs. particle density




## Porosity (*f*)

- In most mineral soils porosity is about 0.3-0.6 (30-60%)

$$f = \frac{V_f}{V_t} = \frac{V_a + V_w}{V_a + V_w + V_s}$$

$V_f$ = volume of pores
$V_t$ = total soil volume

## Soil water content on a vol. basis ($\theta$)

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

$V_w$ = volume of water
$V_t$ = total soil volume

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

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

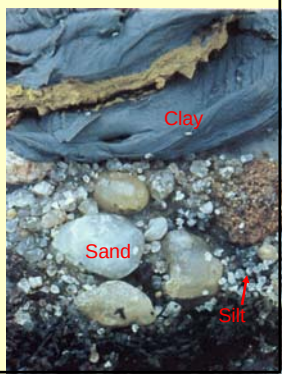



## 2 mm - "Magic" number in soil science

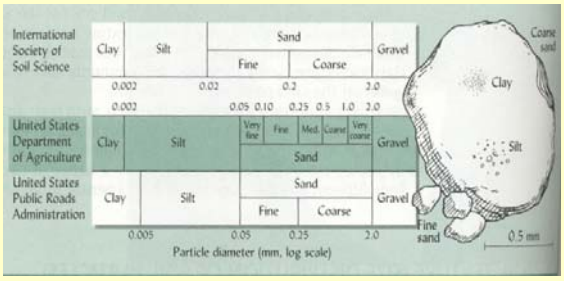



## Size of soil mineral constituents

- **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





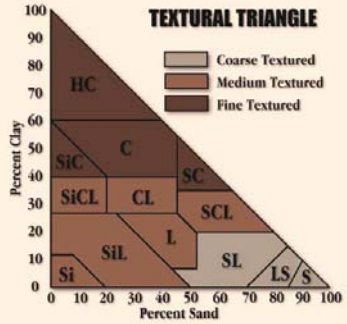

## Soil texture

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


## Hand-texturing ("feel") method



## Soil textural classes




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



## Why do we study soil texture?