# Physical properties of Soil

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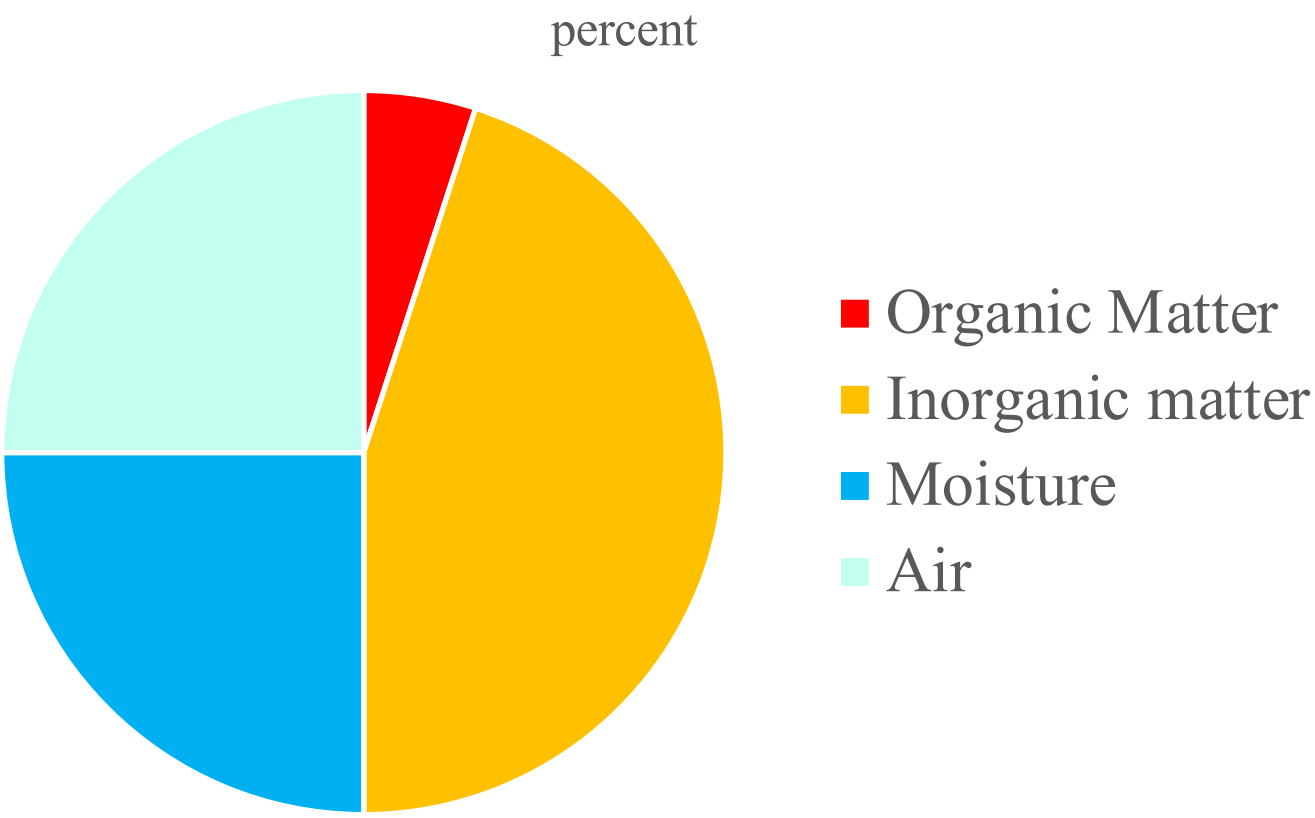
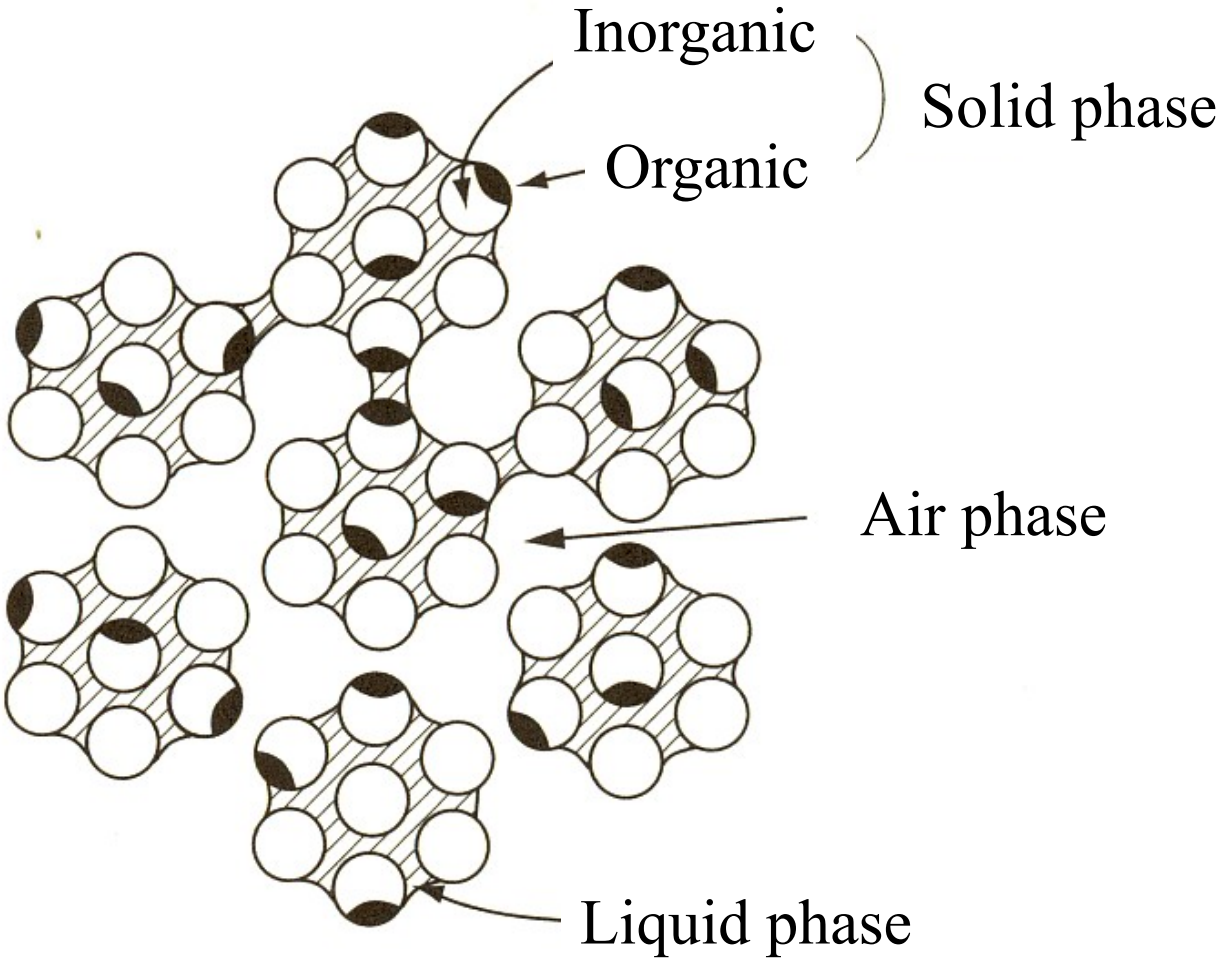
http://timetraveler.html.xdomain.jp

# Composition of Soil



# Three phases of soil



# Specific gravity and Porosity

## True specific gravity

Inorganic soil　2.6～2.8 g $cm^{-3}$

(Quartz: 2.6 g $cm^{-3}$)

Lower in organic soil.

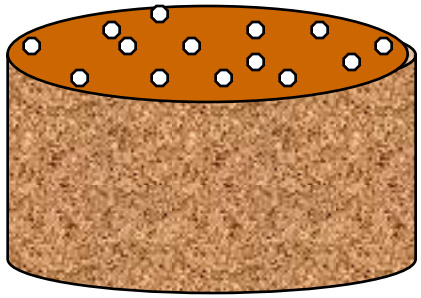
Higher in soils with colored minerals.

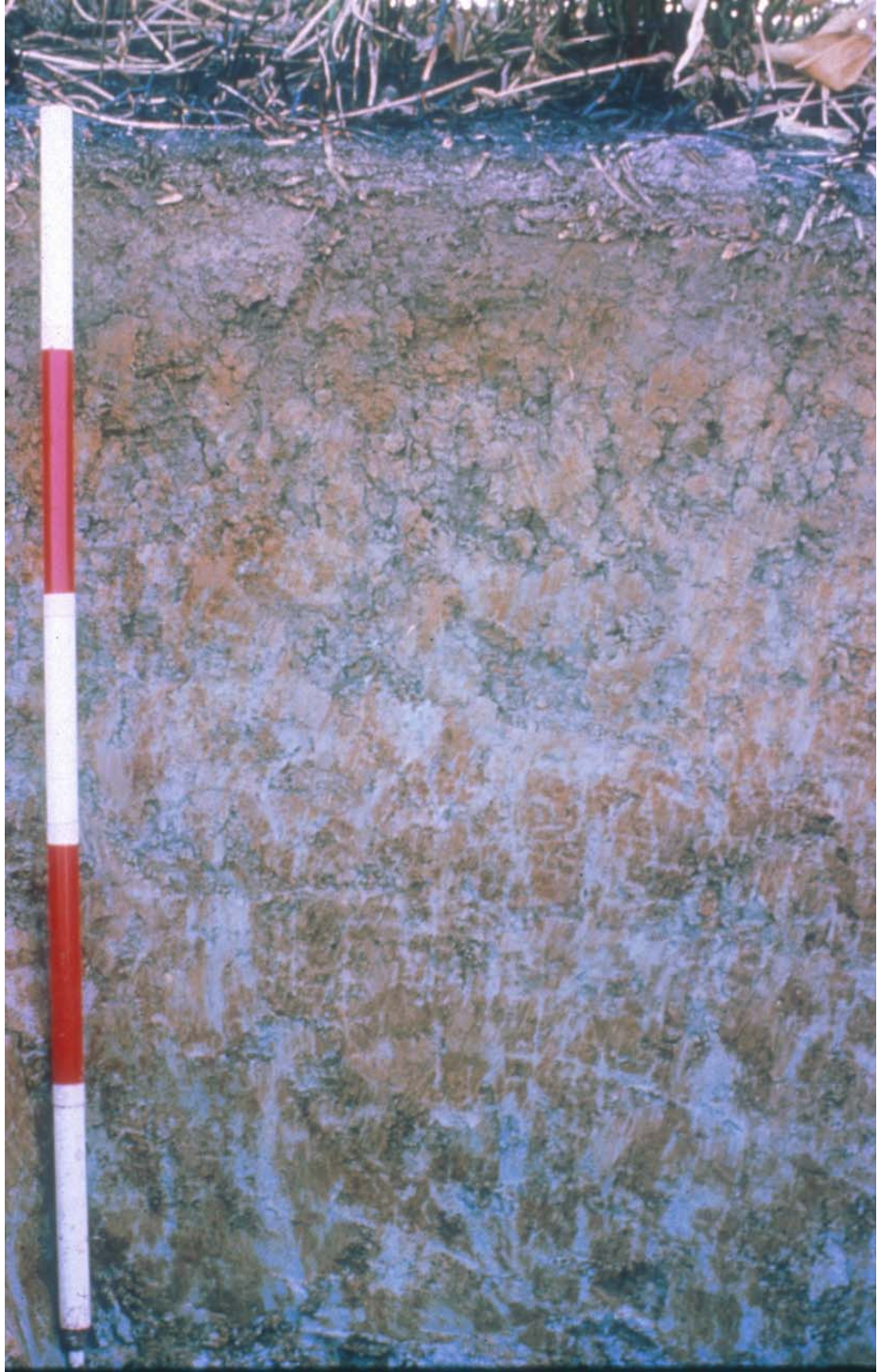
( >3.0 $cm^{-3}$ )

# Bulk density

Density of undisturbed soil including the pore space.

| | |
|---|---|
| Sandy soil | 1.1～1.8 |
| Volcanic ash soil | 0.5～0.8 |
| Peat soil | 0.2～0.6 |





# Hard soil

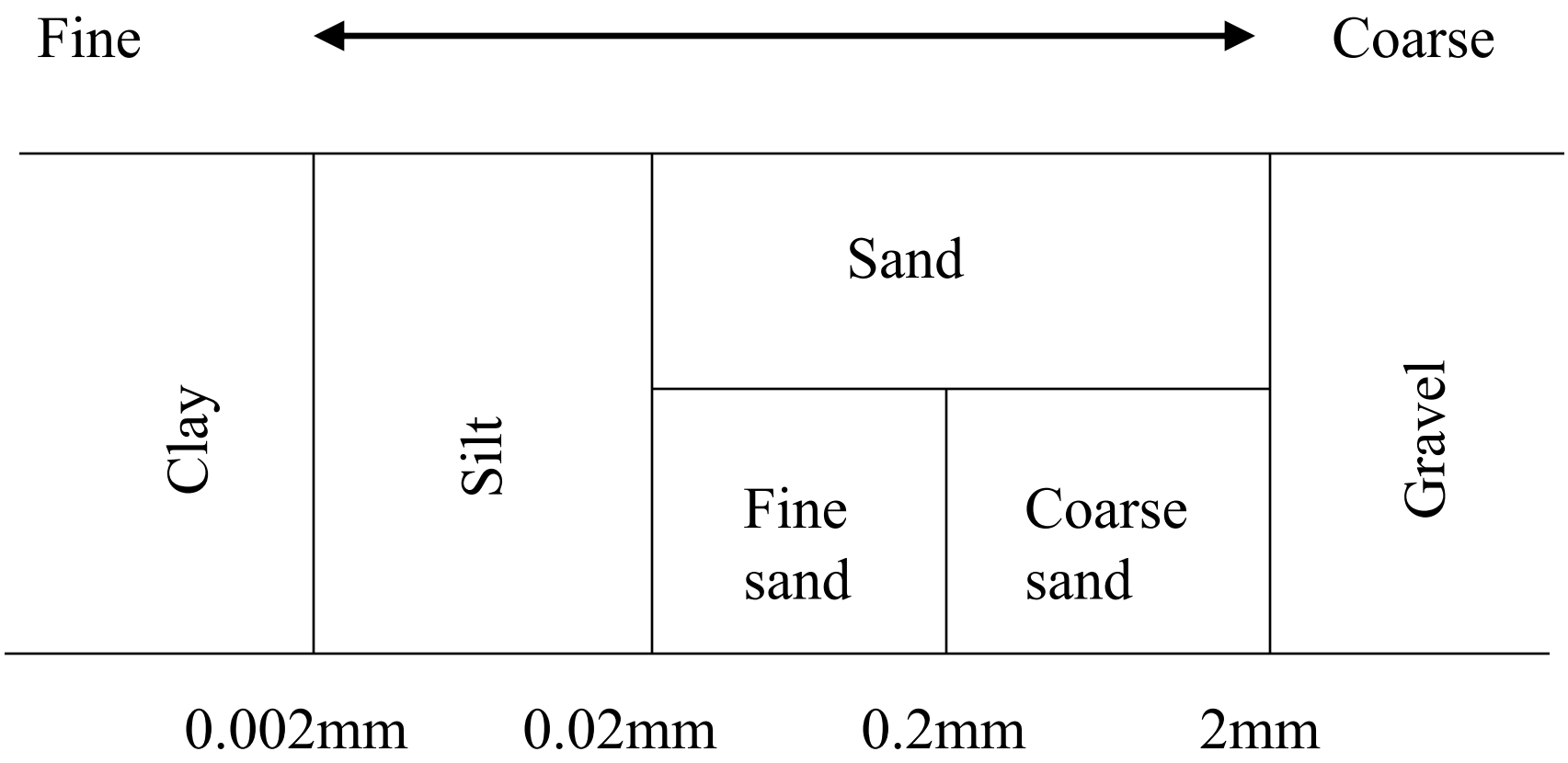
Bulk density: 1.1

Gray terrace soil in Takikawa, Hokkaido

# Soft soil

Bulk density: 0.6

Volcanic ash soil in Obihiro University of Agriculture and Veterinary Medicine



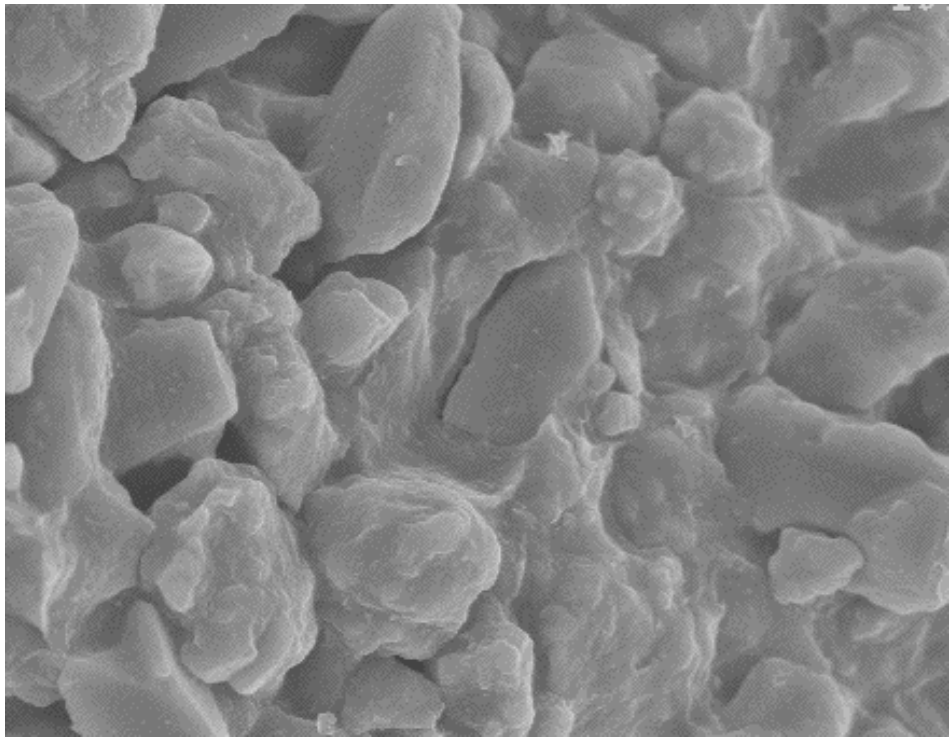

# Division of soil particles by the International Method.

Soil particles are formed by the weathering of rocks.

- By observing sand particles, original rock of the soil can be recognized.

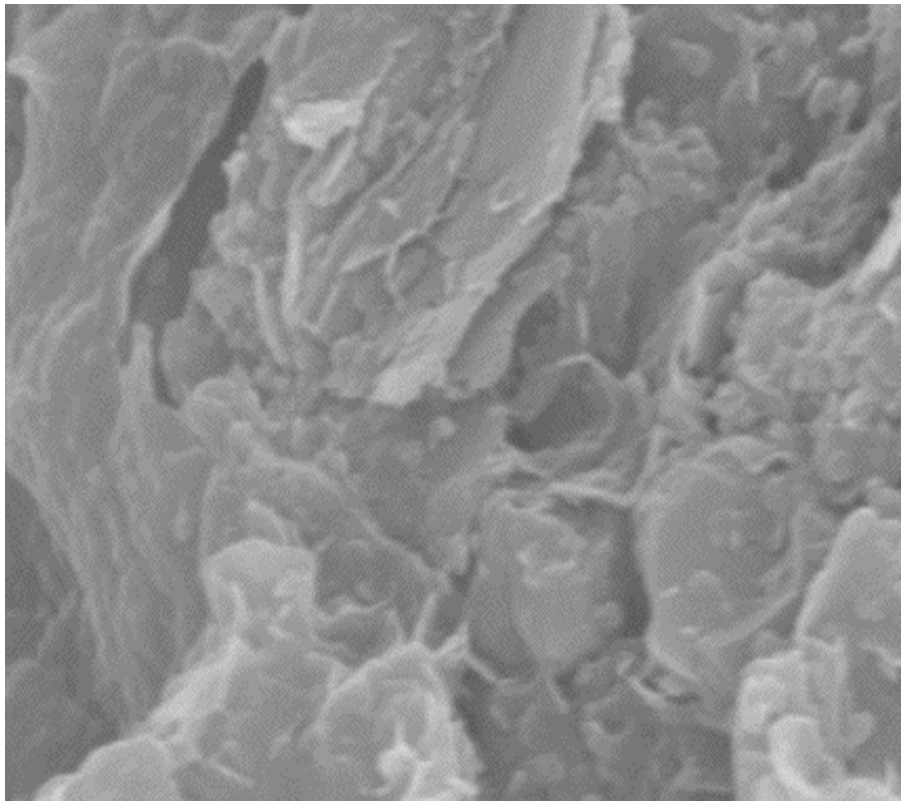
# Particles of silt

- Size of silt is 0.002mm-0.020mm
- Most of silt particles are quartz. Other minerals have been lost by weathering.
- Silt has smooth feeling.



# Clay: Finest soil particle

- Shaped like flake
- Clay is formed by the recombination of silicates and aluminum hydroxides. It is not the finely ground silt.
- Diameter of clay is less than 0.002mm.



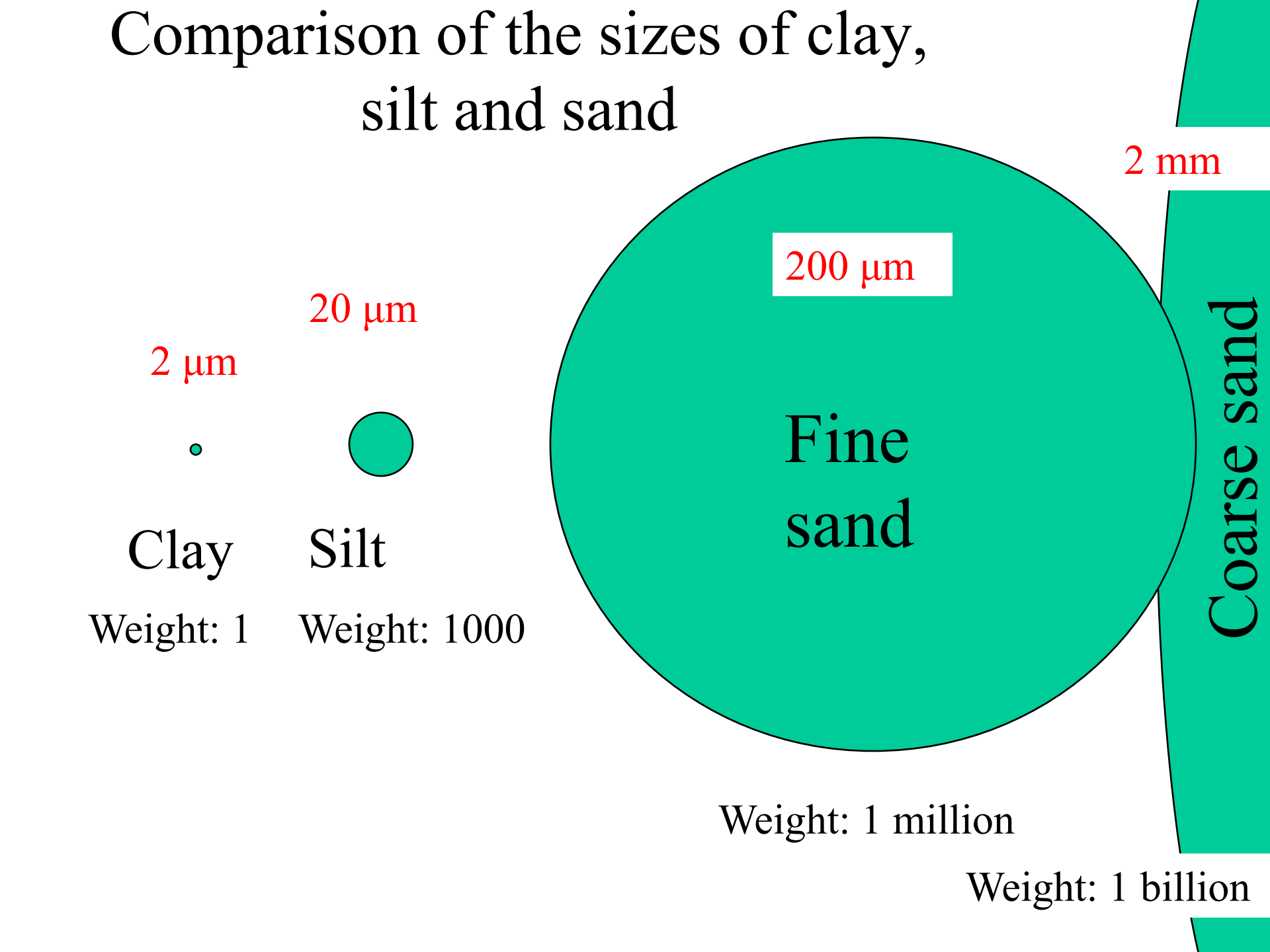
# Clay

- Wet clay has high stickiness and plasticity. Its form can be made freely.
- Fine and long strings can be formed.
- Expand and Shrink depending on the types of clay.

# Problem of clayey soil

- Sticky when wet.
- Very hard when dry.

# Comparison of the sizes of clay, silt and sand



# Relationships between the composition of soil constituents and the surface area (example)

| | Diameter | Weight % | Surface area % |
|---|---|---|---|
| Sand | 100 μm | 33% | 0.1% |
| Silt | 20 μm | 33% | 1% |
| Crystalline clay | 1 μm | 32% | 14% |
| Allophane | 0.005 μm | 1% | 85% |

# Soil texture

Soil texture is defined by the relative percentages of sand, silt and clay in the soil.


**From the soil textue,**

1) Permeability of water

2) Water holding capacity

3) Soil fertility

4) Ability of the land to support buildings

**can be judged.**

# Terms showing soil textures

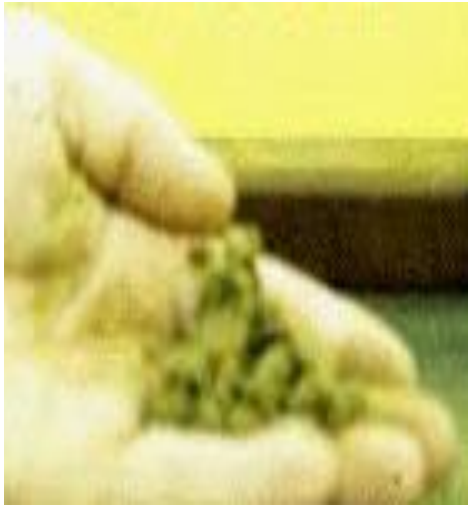
- **Clay: Soil rich in clay**
- **Loam: Soil with proper compositions of clay, silt and sand. Such soil is fertile.**
- **Sand: Soil rich in sand**

# How to judge soil texture in the field?

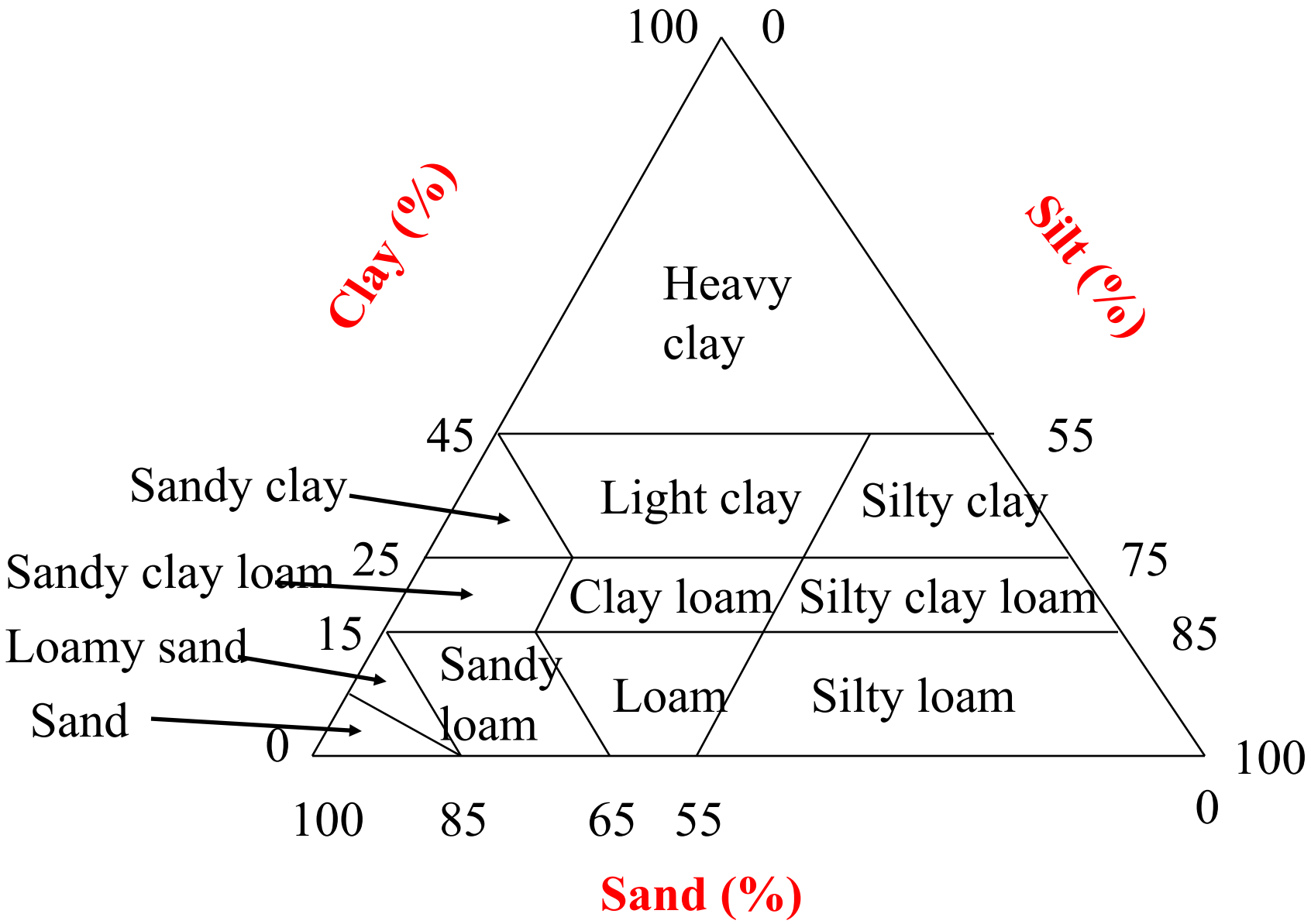
| Soil texture | Feeling |
|---|---|
| Sandy soil | Feel only sand. Not sticky. |
| Sandy loam | Feel sand strongly. Stickiness is slightly recognized. |
| Loam | Feel sand moderately. Feel also stickiness. Feel sand and clay to the same extent. |
| Silt loam | Feel like wheat powder. Do not feel sand so much. |
| Clay loam | Slightly feel sand, but considerably sticky. |
| Light clay | Feel almost no sand. Very sticky. |
| Heavy clay | No sand. Very sticky. |

# Soil texture in the field: Difference between sandy loam and loamy sand

Sandy loam:
With plasticity



Loamy sand:
Easily collapsed

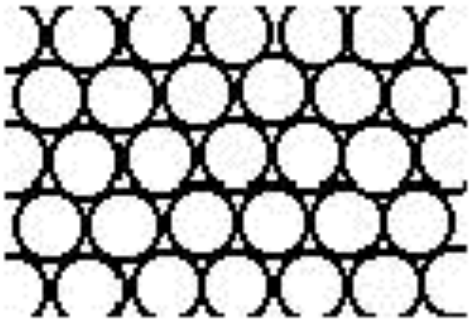



Expression of soil texture by triangle diagram

# Soil aggregate

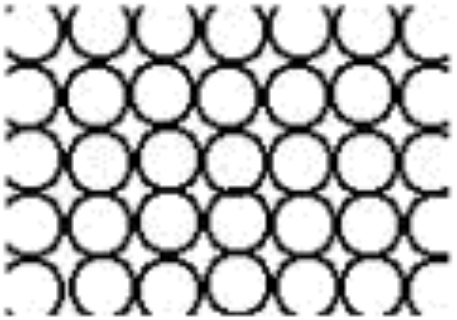
Mechanism of formation and its role

# Orientation of particles and the pore percentage.



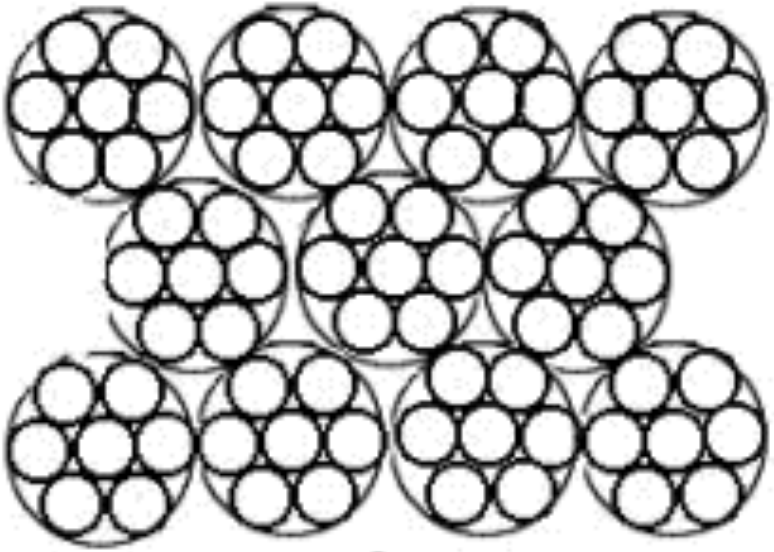
a

Pore 26 %



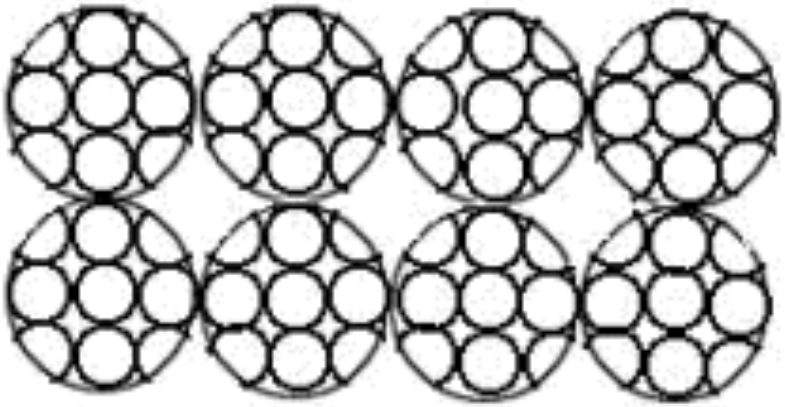
b

Pore 47.6 %



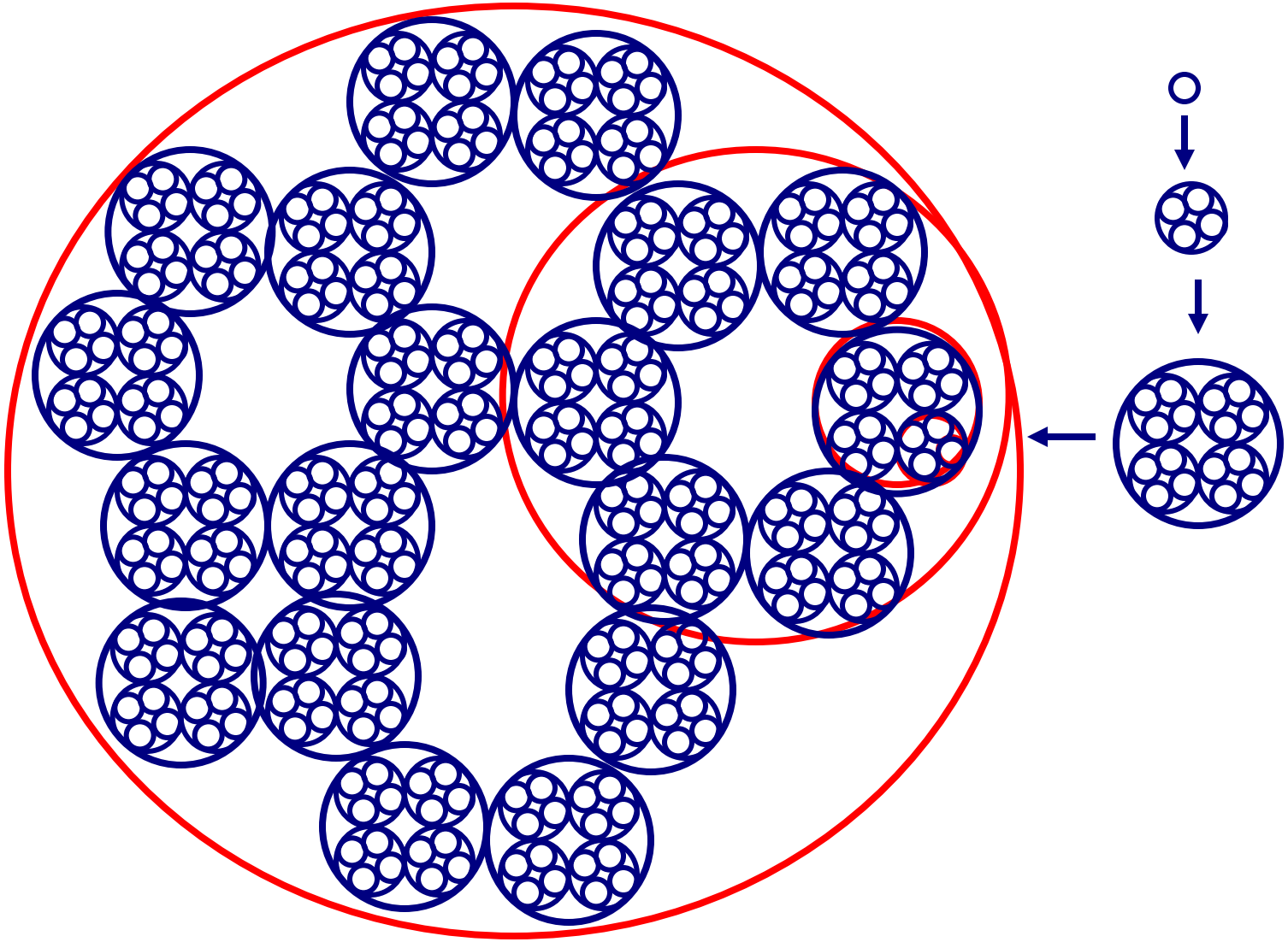
c

Pore 45.2 %

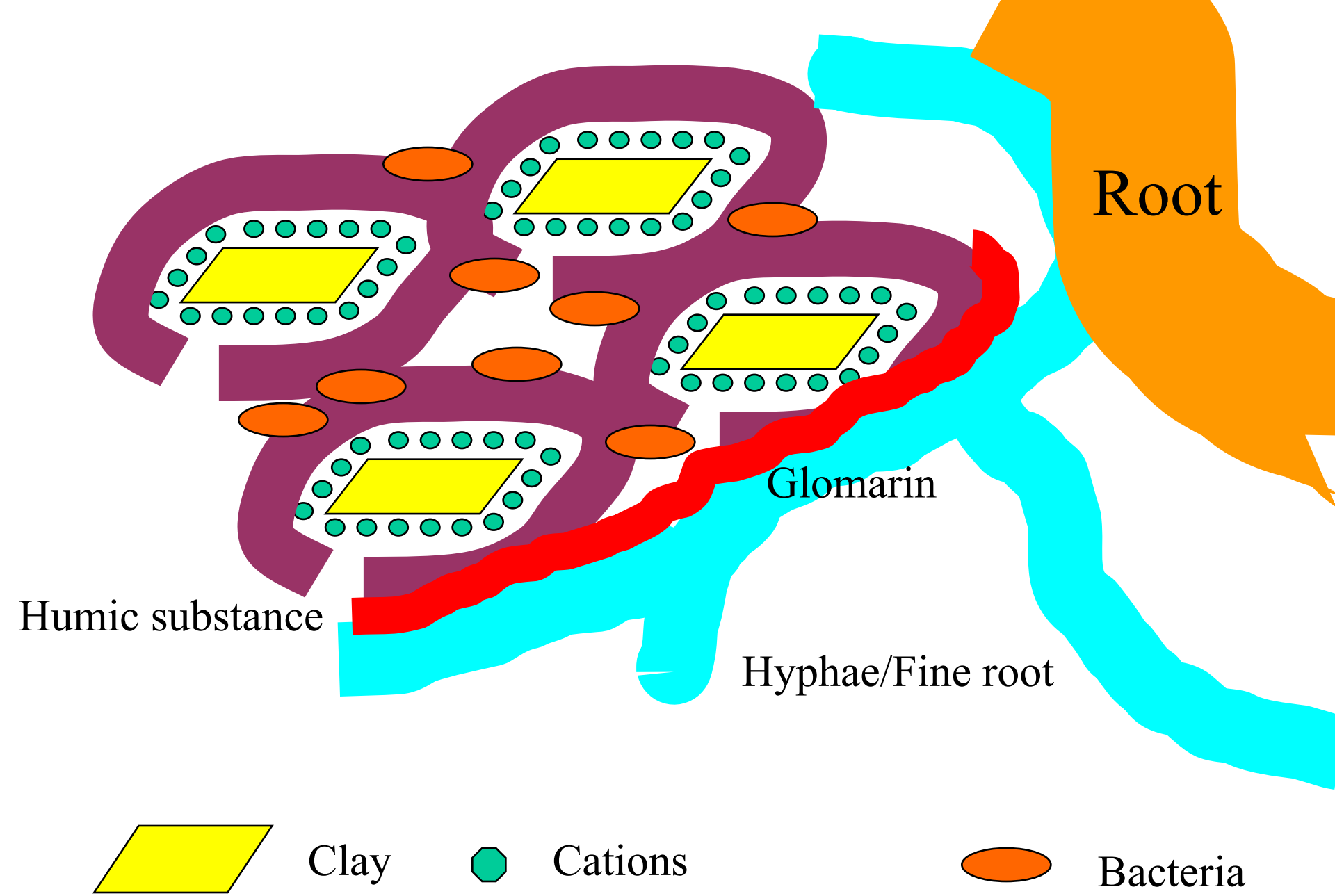


d

Pore 72.6 %

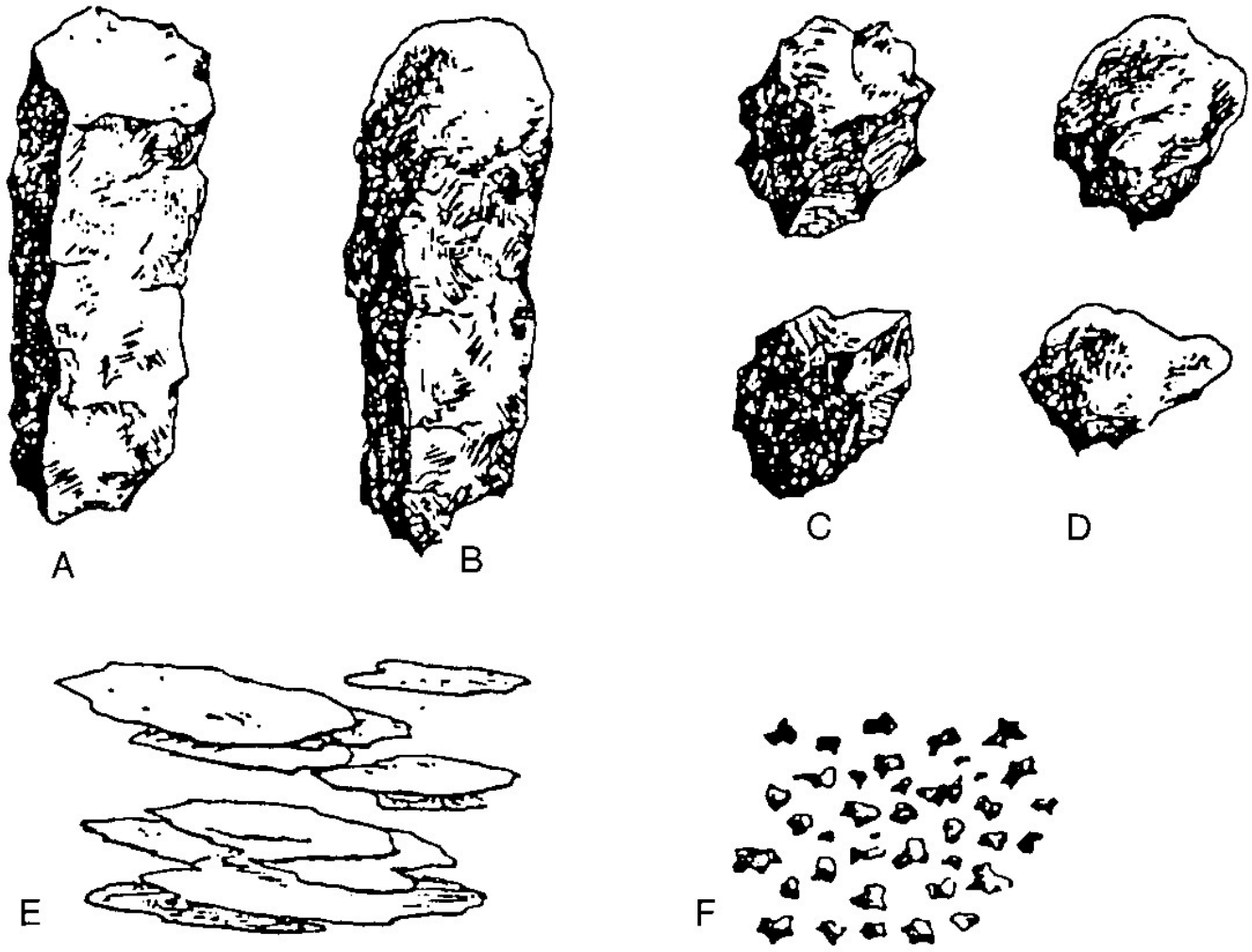


Hierarchical structure of soil aggrigate




Various binders for soil aggregates

# Soil structures




A: prismatic, B: columnar, C: angular blocky, D: sub-angular blocky, E: platy, F: granular

# Soil structures

Granular

Platy

Sub-angular blocky

Columnar

Soils with good soil structure are healthy soils.

# Causes of soil structure formation

- Repetition of drying and wetting
- Freezing
- Plant root activity
- Soil animal activity

# Soil water

# Expression of water holding potential (matric potential)

**Definition of the unit for the pressure: Pa (Pascal)**

$1\ \mathrm{Pa} = 1\ \mathrm{N/m^2} = 1\ \mathrm{kg\ m/sec^2\ /m^2}$

**Conversion with the height of water column:**

Pressure of 1 m high water column:

$100\ \mathrm{gw/cm^2} = 10^6\ \mathrm{gw/m^2} = 10^3\ \mathrm{kgw/m^2}$

$= 9.8 \times 10^3\ \mathrm{kg\ m/sec^2/m^2}$

$= 9.8\ \mathrm{kPa}$

# Maximum water holding capacity （Saturated water holding capacity）

- Soil water content when all the pore is filled with water.

**Gravity water　　φ= 0 kPa**

**It can not be expressed by pF**

**（because log 0 = - ∞）.**

# Field water holding capacity

- Soil water content 1-2 days after the heavy rain or irrigation, when the descending speed of water becomes very slow.

**Readily available water: φ= － 6 kPa**

**pF = 1.78**

**(Varies according to the types of soils)**

# Growth inhibition point

- Moisture in the range of healthy growth of crops.

**Readily available water :**

**φ= -49 ～ -98 kPa, pF = 2.7 ～3.0**

**Height of water column: 5 ～ 10 m**

# Initial wilting point

- Moisture content when plants start wilting.

**Hardly available water:**

**$\varphi = -600$ kPa, pF = 3.78**

# Permanent wilting point

- Water content at the point plants do not recover from wilting even if moisture is supplied at the saturated vapor pressure.

**Unavailable water:**

**φ= - 1,500 kPa,  pF = 4.18**

1,500 kPa = 10.2 × 1,500 cm = 15,300 cm = 153 m (Tension equivalent to 153m high water column).

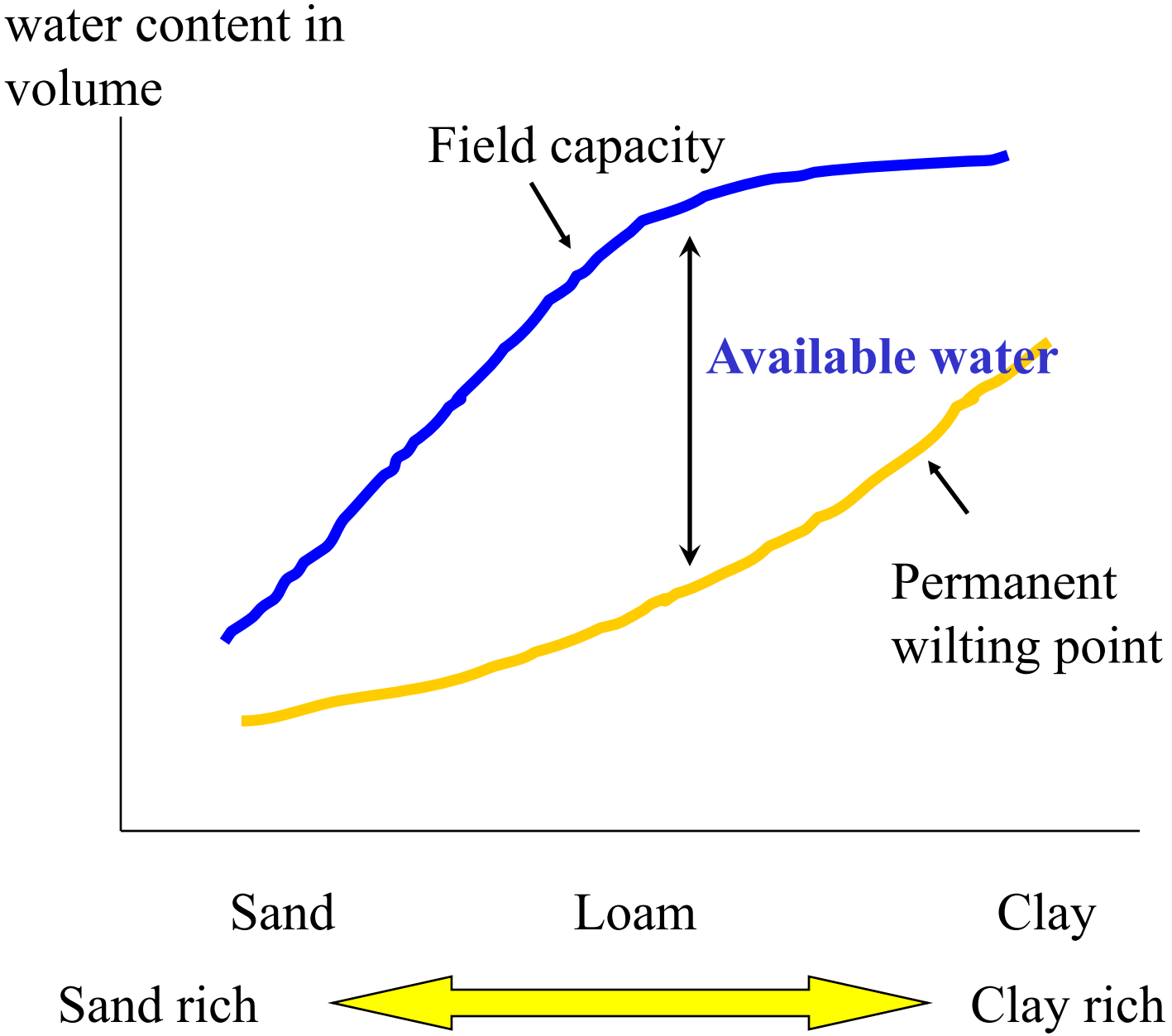
# Available water is the moisture between field capacity and permanent wilting point

- Matric potential: -6 ~ -1,500 kPa
- pF : 1.78 ~ 4.18
- Height of water column:

  60.2 cm ~ 15136 cm (= 152 m)
- Radius of capillary tube :

  0.0244 mm (fine sand) ~

  $9.67 \times 10^{-5}$ mm (ca. 0.1 μm: radius of fine clay)


water content in volume
Field capacity
Available water
Permanent wilting point
Sand
Loam
Clay
Sand rich
Clay rich

# Available water

Larger in loam, and less in sand and clay.

Available water can be increased also by soil organic matter and compost.