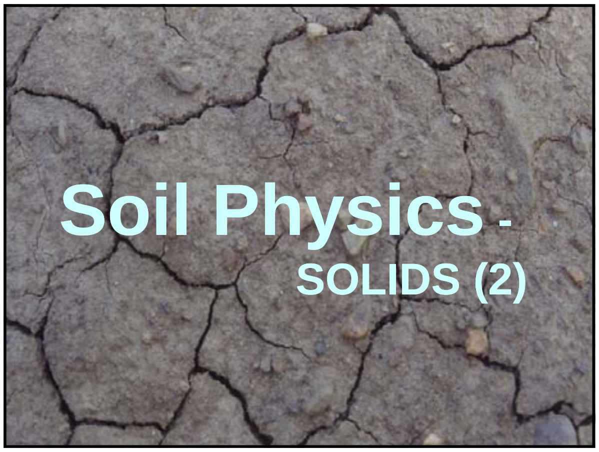
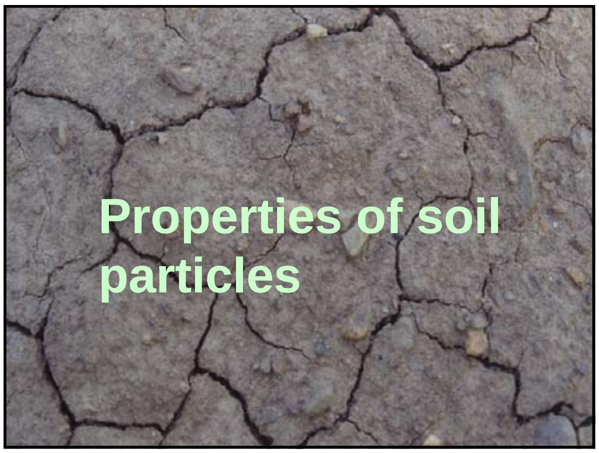


Lecture outline

- Properties of soil particles
- Phyllosilicate clay minerals
- Inter-particle forces



Sand (0.05 - 2 mm) - small specific surface area (e.g. 0.1 m^2/g), inert

Clay (<0.002 mm) - large specific surface area (e.g. 10-1,000 m^2/g), reactive, behave as colloids

Specific surface area = area / mass [m^2/g]

Soil colloids

- Phyllosilicate clay minerals
- Oxides and hydrous oxides of Fe and Al (gibbsite, hematite, goethite)
- Amorphous minerals (allophane, imogolite)
- Organic colloids

Influence of mineral soil particles on soil properties

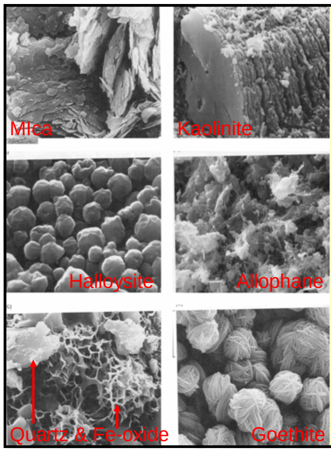
Property	Sand	Silt	Clay
Water-holding capacity	Low	Medium to high	High
Aeration	Good	Medium	Poor
Ability to store plant nutrients	Poor	Medium to high	High

Primary minerals in sand and silt size fraction

- Quartz (SiO_2)
- Feldspars ($MAlSi_3O_8$, M=K, Ca, Na)
- Mica (muscovite and biotite)
- Pyroxene ($MSiO_3$, M=Mg, Mn)
- Amphiboles $Ca_2Mg_5Si_8O_{22}(OH)_2$
- Olivine $(Mg, Fe)_2SiO_4$

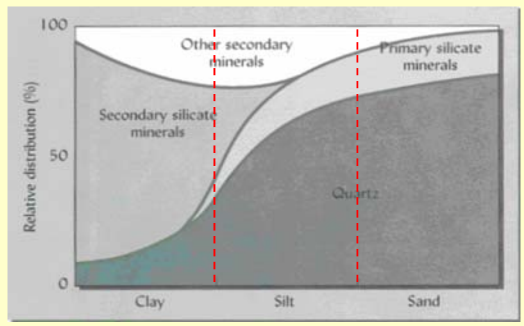
Secondary minerals in clay size fraction

- Silicate clay minerals (e.g. phyllosilicates)
- Carbonates (calcite $CaCO_3$)
- Sulfates (gypsum $CaSO_4 \cdot 2H_2O$)
- Oxides/hydrous oxides of Fe and Al (sesquioxides $R_2O_3 \cdot nH_2O$; R=Fe, Al)
  - gibbsite $Al(OH)_3$, goethite FeOOH, hematite Fe_2O_3
- Amorphous clay minerals (aluminosilicates)
  - alophane and imogolite



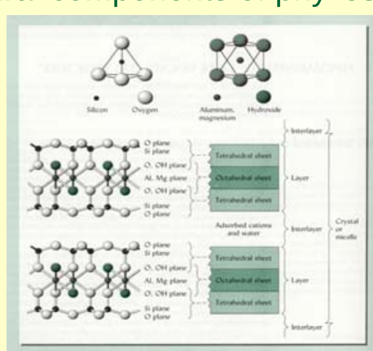
Phyllosilicates, sesquioxides, and amorphous clay mineral (allophane)

Relationship between particle size and kinds of minerals



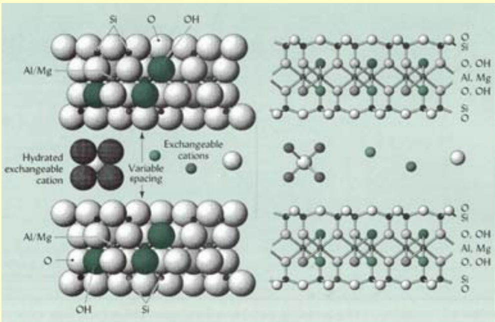
Phyllosilicate clay minerals

Structural components of phyllosilicates



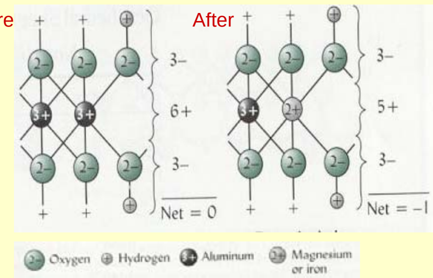
For more information go to:
http://soils1.cses.vt.edu/MJE/CSES3124/VR_exports/index.html

Montmorillonite (2:1)



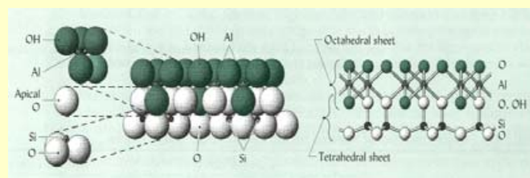
Isomorphic substitution – process by which one element fills a position usually filled by another of similar size and valence. It leads to formation of permanent charge on clay minerals.

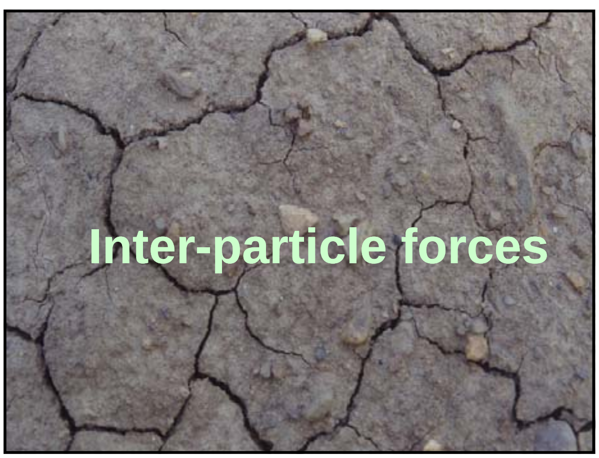
Before After



Deep cracks in a soil rich in montmorillonite

Kaolinite (1:1)

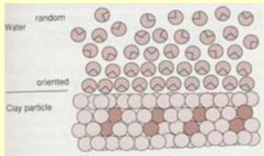




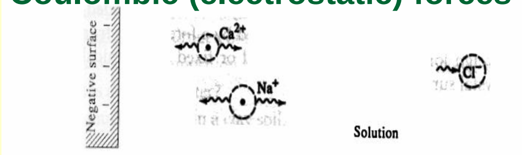
Inter-particle forces

- **van der Waals forces**
  - between individual atoms in 2 particles
  - weak, but additive when large molecules / particles get close to each other
  - operational over short distance
- **Hydrogen bonds**
  - H atom is connecting linkage
- **Coulombic (electrostatic) forces**
  - attraction between ions

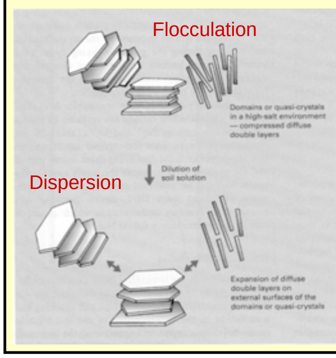
Hydrogen bond



Coulombic (electrostatic) forces

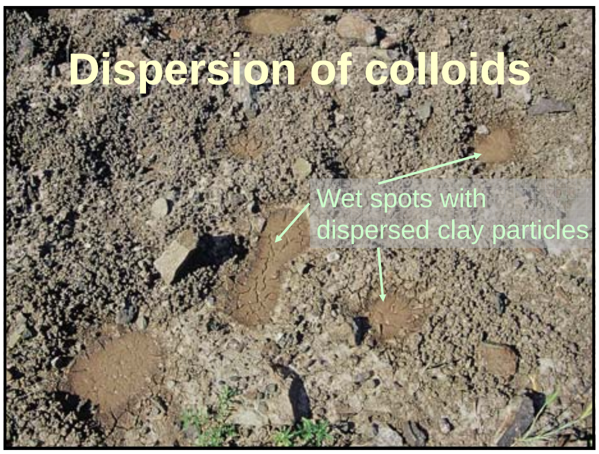


Dispersion and flocculation



Flocculation is a state when primary particles (i.e. clay particles) remain close together due to interactive forces (electrostatic, van der Waals, and/or hydrogen bonding) and form microscopic clumps or floccules.

Dispersion is opposite of flocculation.



Formation of soil aggregates

Aggregation = Flocculation + Cementation

Flocculation is a state when primary particles (i.e. clay particles) remain close together due to interactive forces (electrostatic, van der Waals, and/or hydrogen bonding) and form microscopic clumps or floccules

Cementation represents stabilization of floccules by action of a cementing agent (organic compounds, Fe/Al oxides, clay, carbonates)