Home work 1

Task: interpret the figures on the factors influencing permeability (intrinsic permeability & hydraulic conductivity)

What you can see in the figures?
What are the possible reasons or mechanism for those?

From the theoretical equation on K, such as

$$K = \frac{k\rho g}{\mu}$$

Taylor (1948) using Poiseuille's law

$$K = D_S \frac{\rho g}{\mu} \frac{e^3}{(1+e)} C$$

Kozey-Carman equation

$$K = \frac{1}{k_0 S^2} \frac{\rho g}{\mu} \frac{e^3}{(1+e)}$$

some factors influencing K, beside k can be found;

ρ μ, as the properties of the fluid
e, D_s as the properties of soils (porous media)

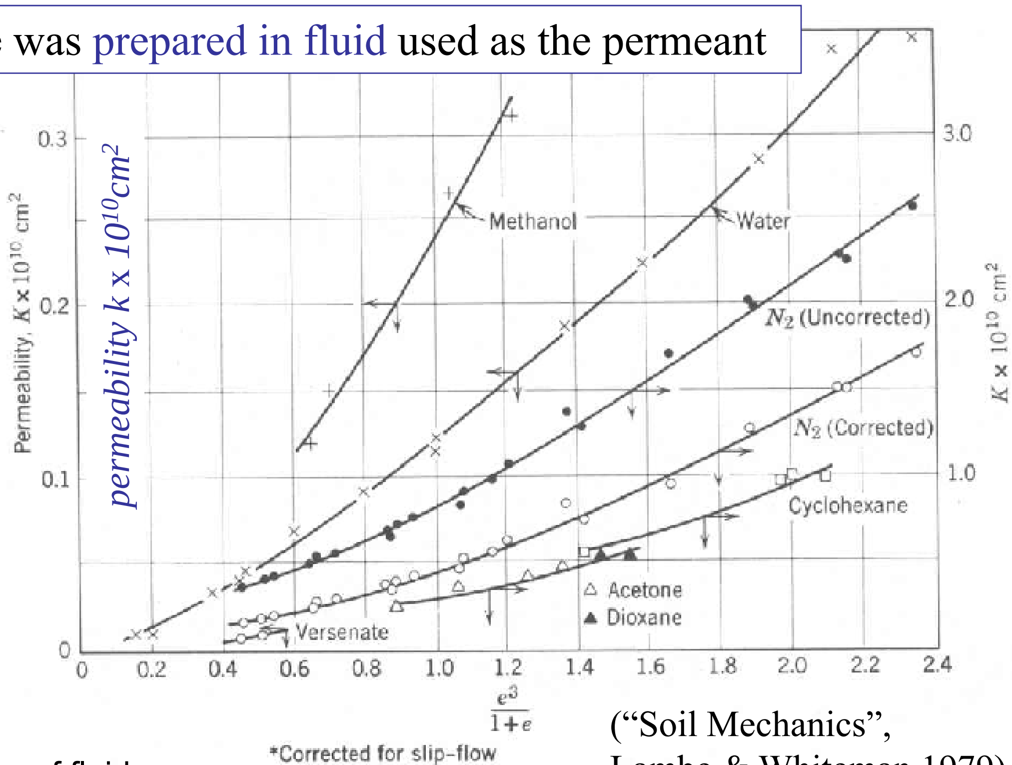
Factors in Kozey-Carman equation: k_0 depending on pore shape and ratio of length of actual flow path to soil bed thickness and S: specific surface area are related to the **compositions** and **fabrics** of soils. On top of them, air in the pore of the soil, in other word, **degree of saturation** also influence the permeability. (factors in red are all on soil, but some of them are influenced by the properties of fluid, polarity, electrovalence, beside ρ and μ.

Fig.1 Effects of *e* and permeant: intrinsic *k* of kaolinite

kaolin sample was prepared in fluid used as the permeant

The large difference in permeability at a given void ratio for the different fluid

the differences in soil **fabric** resulting from sample preparation in the different fluids.



very big influence of fluid

("Soil Mechanics", Lambe & Whiteman,1979)

Fig.2 Effects of *e* and permeant: intrinsic *k* of kaolinite

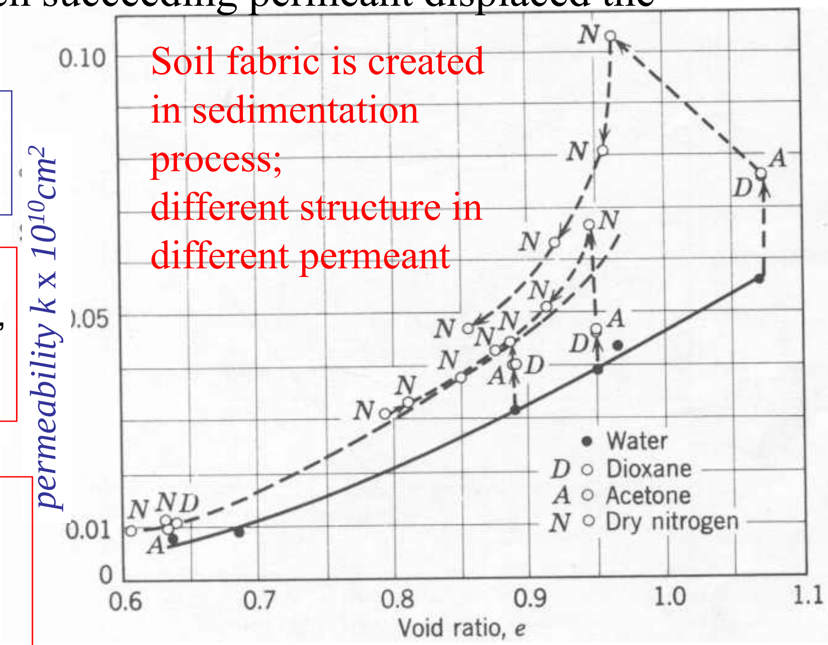
Water was used as the molding fluid and the initial permeant. After initial permeability test, each succeeding permeant displaced the previous one.

Difference in different permeant is less significant than the result shown in Fig.1.

Structure or **fabric** of soil is highly affected by molding fluid, but less affected by the permeant.

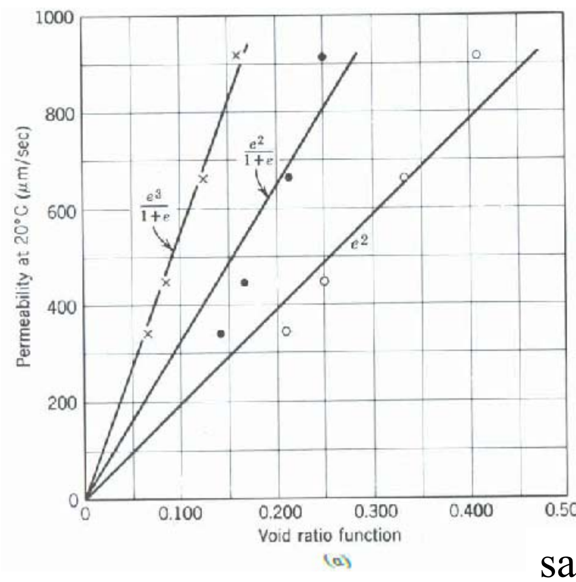
+

Mobility of the fluid adjacent to the soil particles depends on polarity of the pore fluid, which influences thickness of double diffusion layer.

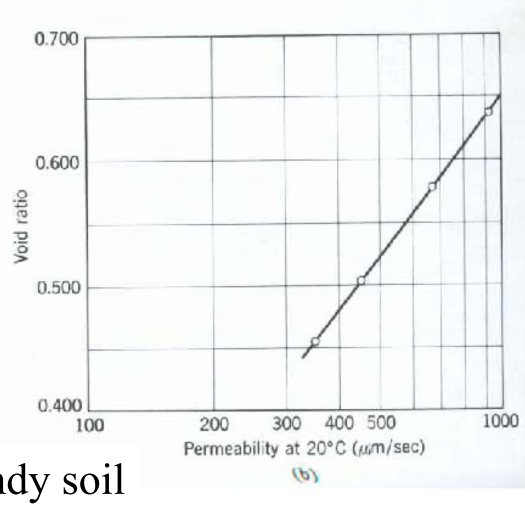


Viscosity and density are not the only permeant characteristics, as suggested by theoretical eqs., that influence the permeability of fine soils. Chemical characteristics of fluid affects the fabric of soil.

Figs.3 Relationship between void ratio- permeability



(“Soil Mechanics”, Lambe & Whiteman,1979)



sandy soil

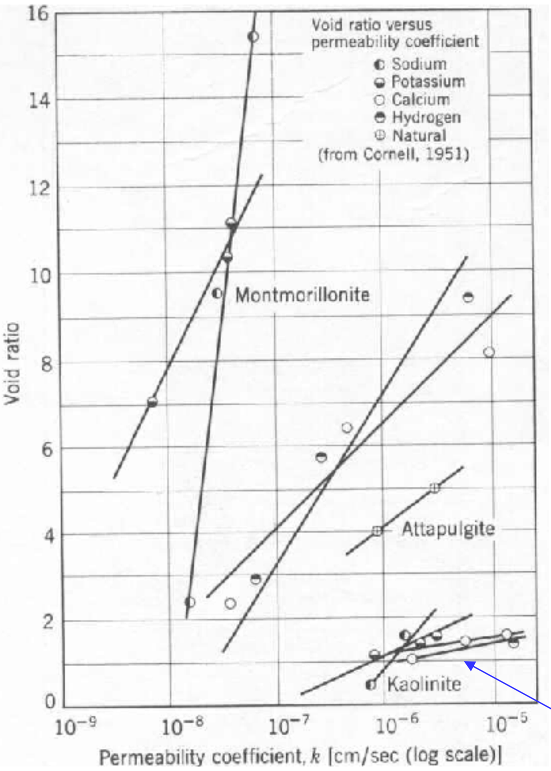
For this specific sand
linear relation can be obtained for $e^3/(1+e)$ - *K* and **e** –log*K*
But not the case for *e3/(1+e)* - *K* of Kaolin (Fig.1)

In general e –log*K* is more close to a straight line for wide range of soils

(See the figure on **P5** of sub-materials)

(“Soil Mechanics”, Lambe & Whiteman,1979)

Fig.4 Effects of soil composition



Influence of soil composition on K is of little importance with ***silt, sand gravel***, but of significant importance for ***clay***.

Sodium and Potassium ions give the lowest permeability.

N_a *montmorillonite* is one of least permeable soil minerals: *impermeabilizing additive*

why??

Lower (mono) valence cation create thick diffusion layer, that is less mobile fluid. The relative thickness of the diffusion layer is dependent on the specific surface area and level of negative charge, which can be represented by cation exchange capacity.

ion exchange capacity(イオン交換能):

Montmorillonite>> Attapulgite > Kaolinite

The lower the ion exchange capacity of soil, the lower the effect of exchangeable ion on permeability.

Figs.5 Effect of structure

(“Soil Mechanics”, Lambe & Whiteman,1979)

dispersant

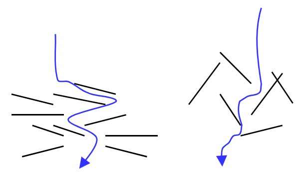
increase the repulsion between fine particles,

⇩

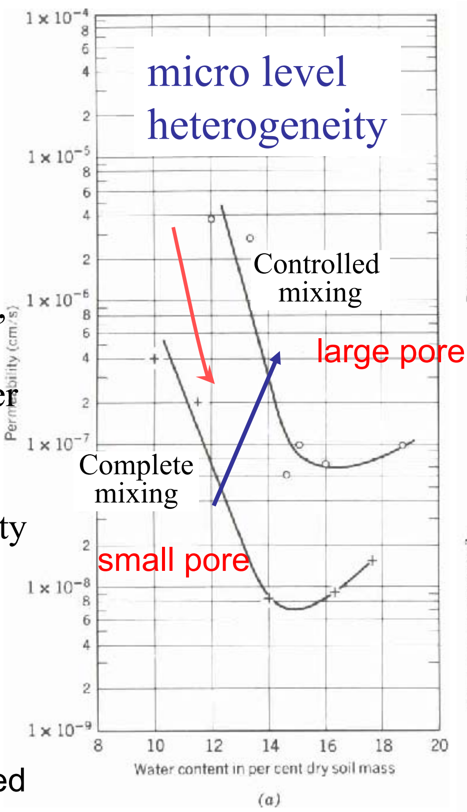
increasing double layer thickness

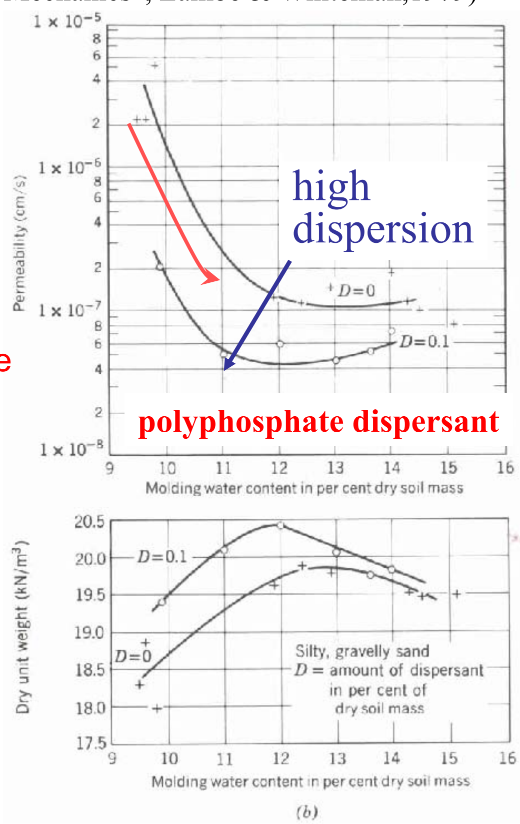
⇩

decreasing permeability



disperse flocculated



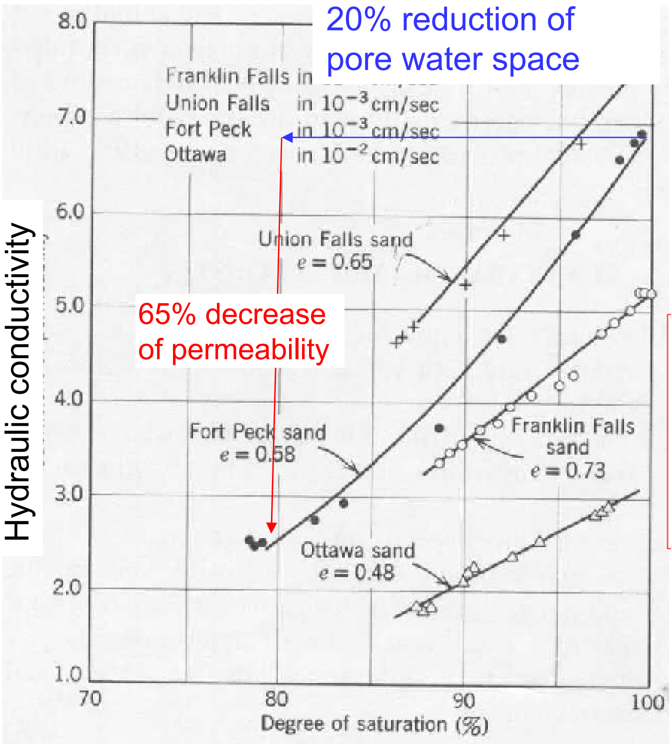


longer flow path in disperse structure than flocculated one

Large change of K for the low water cont.

large chunks of soils can be remained by strong suction => large pore size => large K values.

Fig. 6 Effect of degree of saturation S_r



The effect of S_r is very significant, much more than the effects of reduction of flow channels available for water flow due to air bubbles.

air bubbles tend to close the large pore, resulting the decrease of average pore size. On top of it surface tension prevent the movement of water.

("Soil Mechanics", Lambe & Whiteman,1979)