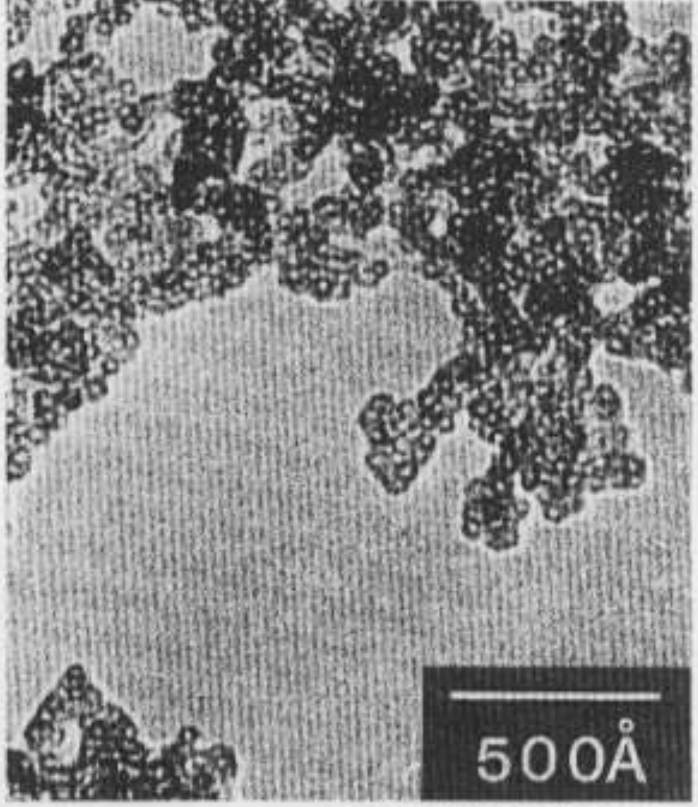


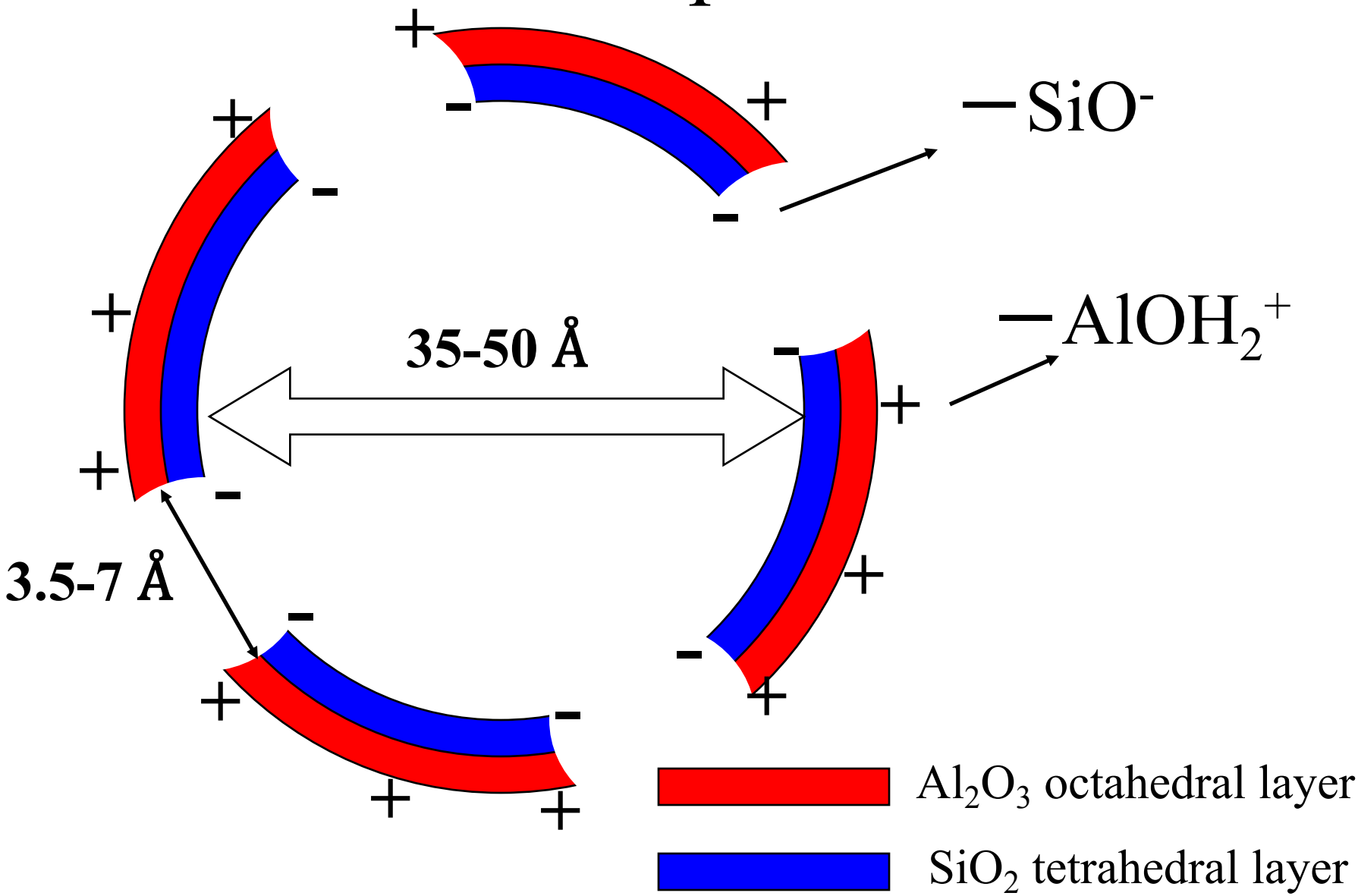
写真-1　アロフェンの高分解能電子顕微鏡写真.

pH 2 3 4 5 6 7 8 9 10 11

Allophane

(dispersed at both acidic and alkaline pH)

Structure of allophane



Unit: Ångstrom

- 1 Å = 10^{-10} m = 10^{-1} nm = 10^{-4} μm

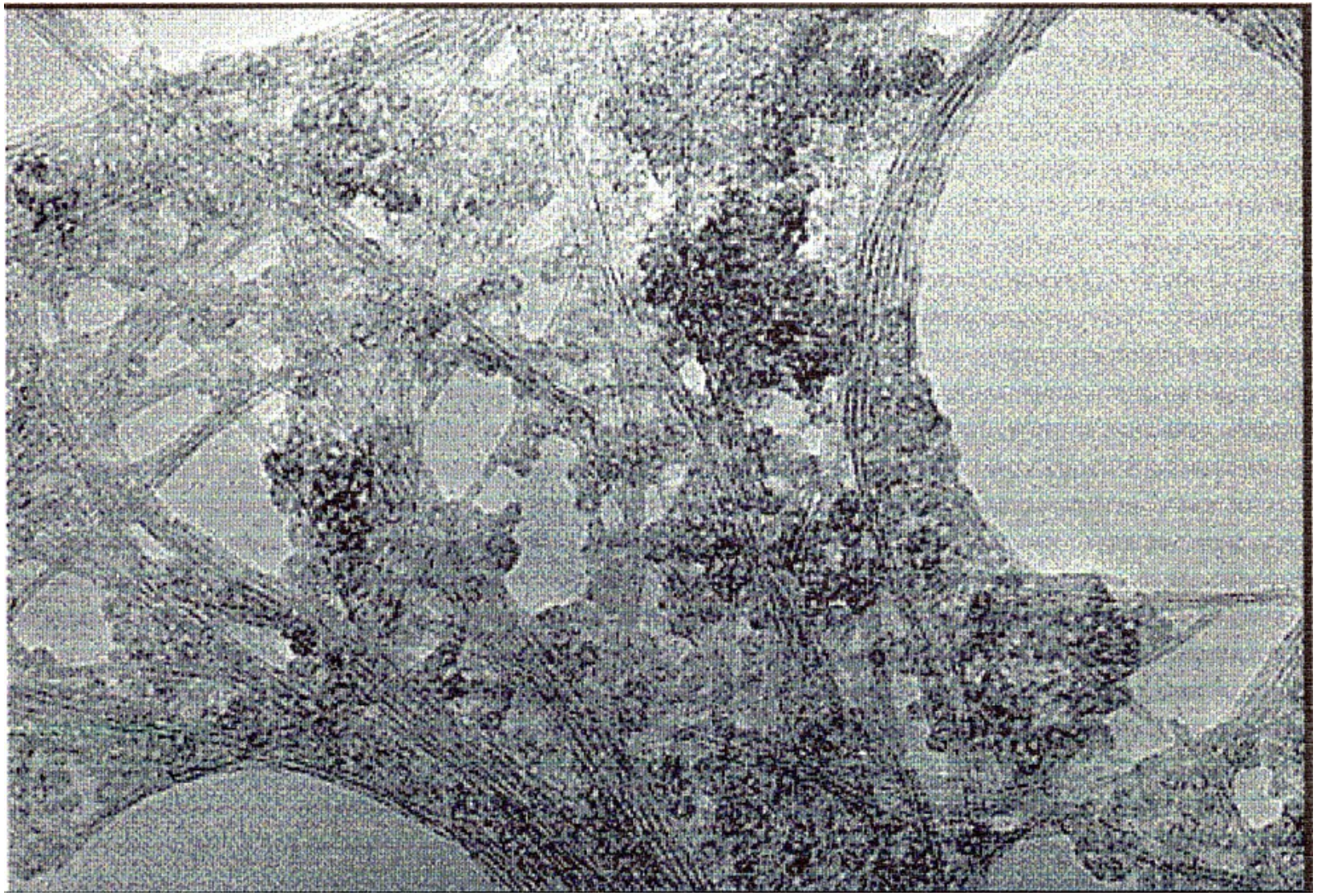
- Size of allophane particle:

  35 - 50 Å is 3.5-5.0 / 1000 of 1 μm .

  = 3.5 – 5.0 nm

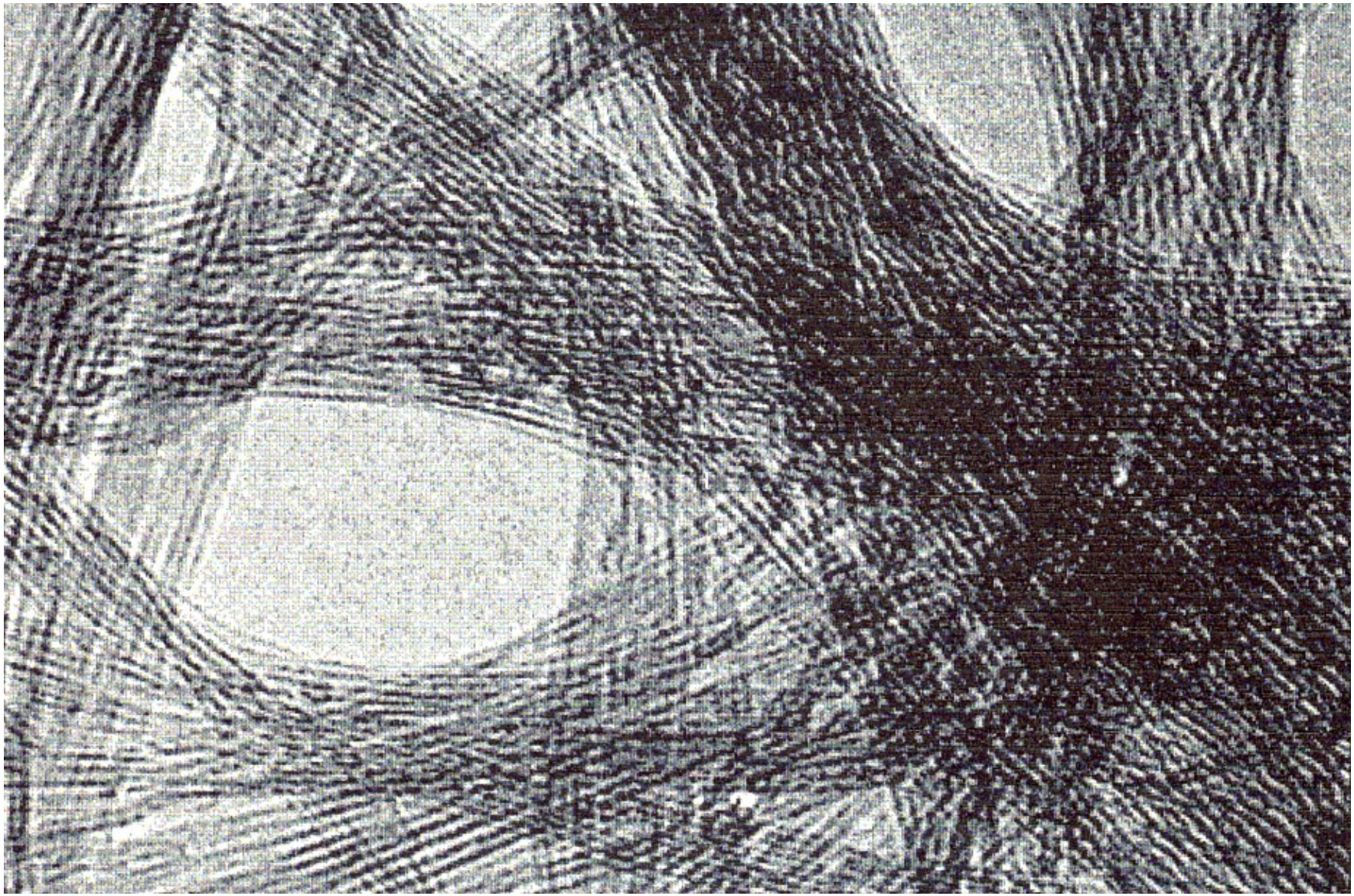
Functions of allophane

- Source of negative and positive charges.
- Adsorption of cations and anions.
- Fixation of phosphate.
- Absorption of moisture.
- Contribution to good physical property of soil.



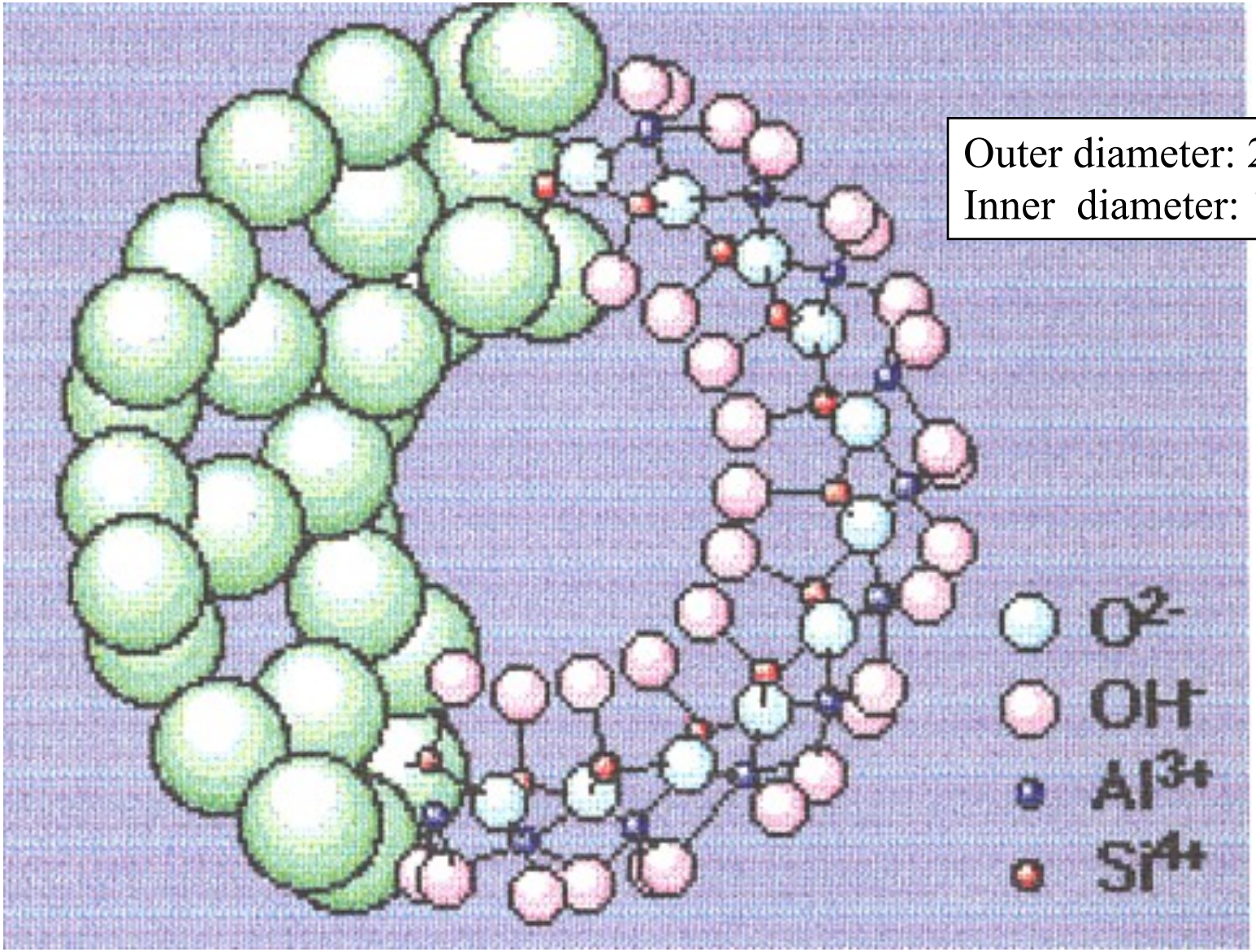
Allophane and Imogolite

Prof. Yoshinaga, Ehime Univ., Japan



Imogolite

Prof. Yoshinaga, Ehime Univ., Japan



Structural model of Imogolite

(Cracdwick et al. 1972)

Imogolite

Form

Tubular alumino-silicate

Outer diameter: 2.5 nm,

Inner diameter: 1.0 nm

Length: Tens ～ thousands nm

Chemical composition

$SiO_2 \cdot Al_2O_3 \cdot 2H_2O$

Origin

Volcanic glass, amorphous hydrated-oxides

Characteristics of 1:1 type clay minerals

Clay minerals	Form of particles	Specific surface area (m^2/g)	CEC ($cmol\ kg^{-1}$)
Kaolinite	Plate, thin plate	10 - 55	2 - 10
Halloysite (10 Å)	Hollow tubular, spherical	60 - 1100	5 - 40
Halloysite (7 Å)	Hollow tubular	60 - 1100	5 - 15

Characteristics of 2:1 and 2:1:1 type clay minerals

Clay minerals	Form of particles	Specific surface area (m^2/g)	CEC ($cmol\ kg^{-1}$)
2:1 type			
Smectite	Thin film	770	60 - 100
Vermiculite	Plate, thin plate	770	100 - 150
Illite	Plate, thin plate	10 - 55	10 - 15
2:1:1 type			
Chlorite	Plate, thin plate	10 - 55	2 - 10

Characteristics of quasicrystal and amorphous clay minerals

Clay minerals	Form of particles	Specific surface area (m^2/g)	CEC ($cmol\ kg^{-1}$)
quasicrystal			
Imogolite	Hollow tubular	1025	20 - 30
amorphous			
Allophane	Hollow spherical	1050	30 - 135

Negative charges in soil

1) Isomorphic substitution in 2:1 type clay minerals

2) Broken bond SiO^- charges of 1:1 clay minerals and allophane.

3) Acidic functional groups of humic substances: COO^-, phenolic O^-

Permanent negative charge

Isomorphic substitution in 2:1 type clay minerals.

Does not change with pH.

Behaves as strong acid.

pH dependent negative charge

1) Broken bond SiO^- in 1:1 clay minerals and allophane.

2) Acidic functional groups of humic substances: COO^-, phenolic O^-

Decreases with the decrease in pH.

Behaves as weak acid. Has pH buffering action.

Function of negative charges in soil.

Holding the cations NH_4^+, Ca^{2+}, Mg^{2+}, K^+, Na^+, etc.

Cation Exchange Capacity（CEC)

Positive charges in soil.

1) $AlOH^+$ in the surface of allophane and broken bond charge.

2) Nitrogen functional groups of humic substances.

R- NH_3^+, R- $N^+ H_2CH_3$, etc.

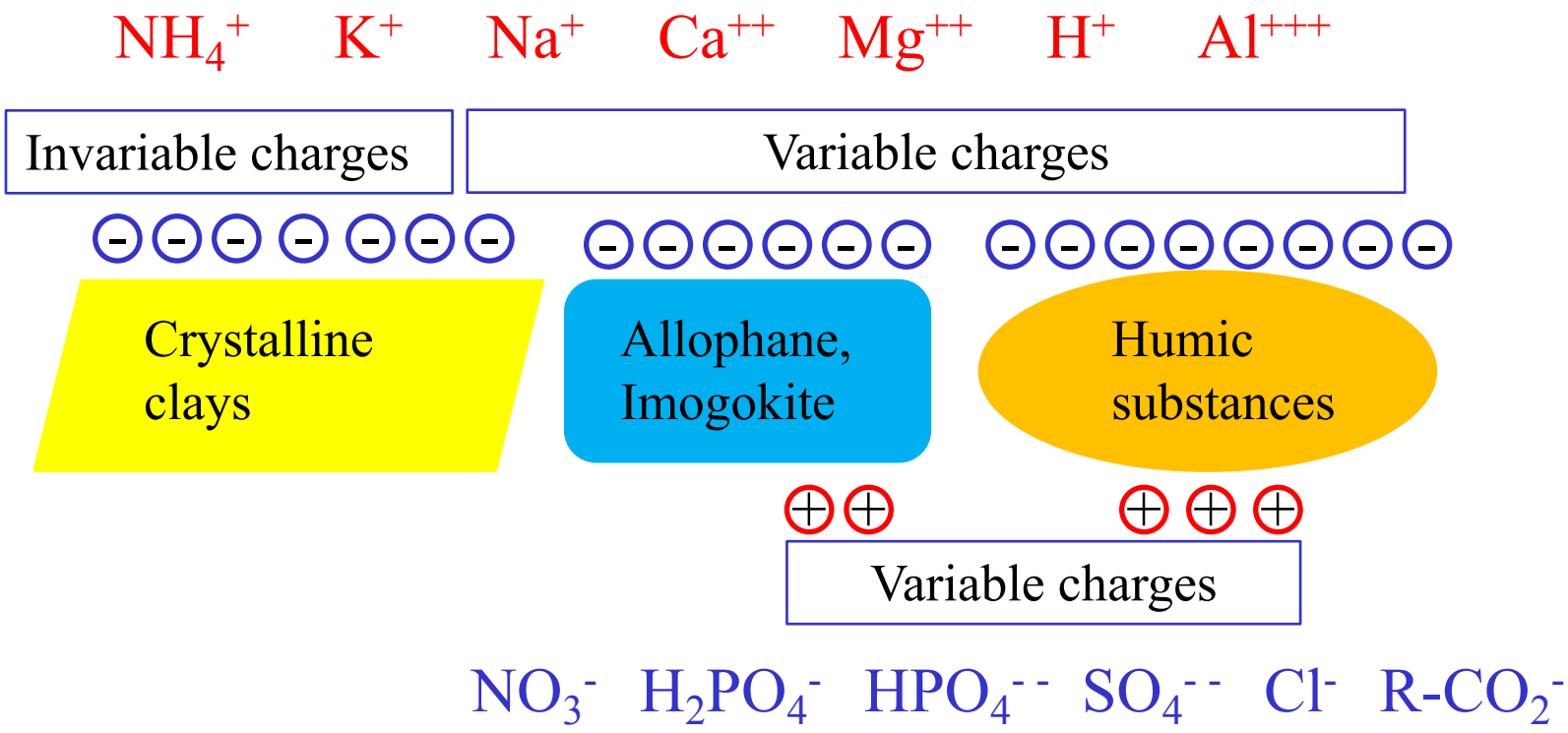
Increases with the decrease in pH.

Function of positive charges in soil.

Holding NO_3^-, SO_4^{2-}, PO_4^{3-},

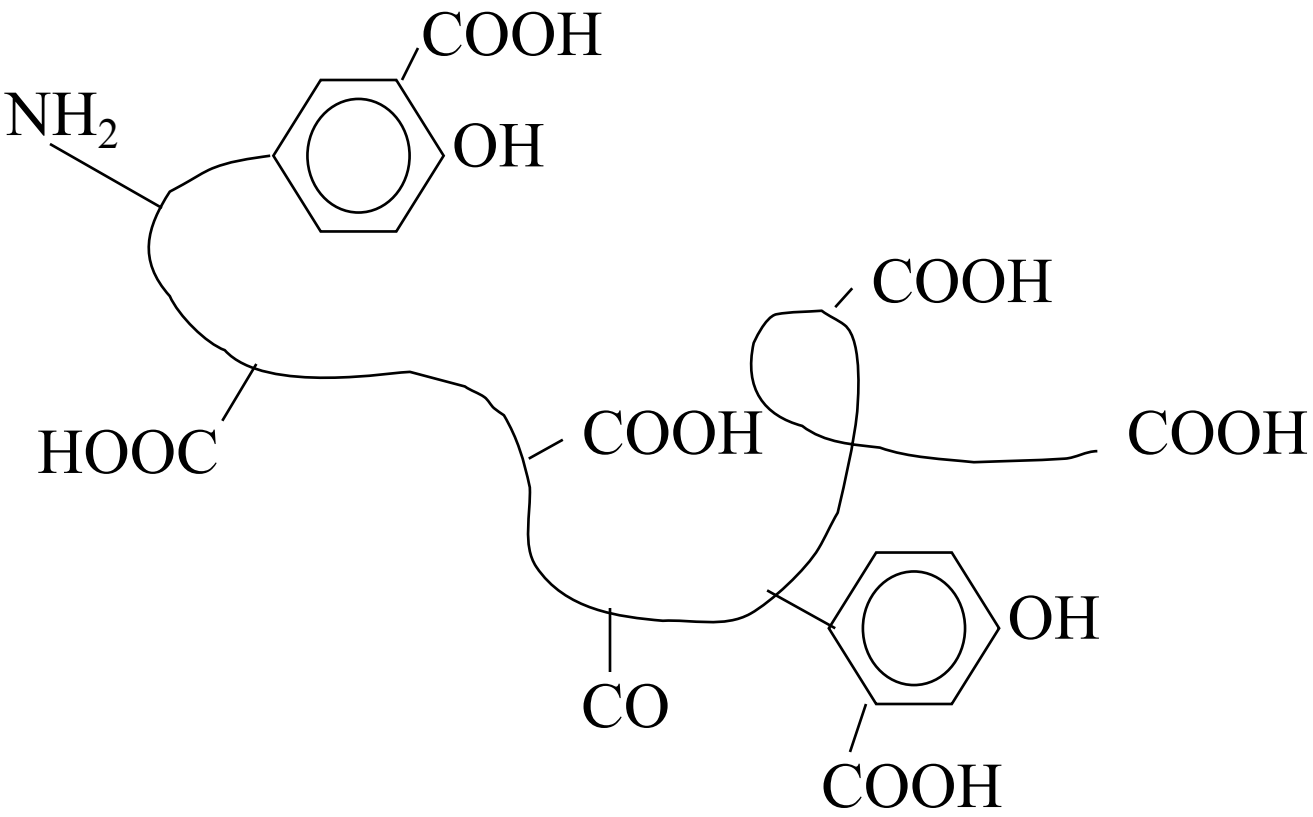
Organic anions, and humic substances.

Positive and negative charges in soil



Clay and humic substances load large amount of variable charges which attract ions in soil.

Simplified model of the structure of humic substances



Molecular weight: Tens of thousands – several million

Characteristics of organic colloids in soil (1)

- **Many charges per unit weight. ---- Becomes the dominant charge.**
- **Dissociation of carboxyl group. ---- Negative charge.**
- **Protonation of amino group. ---- Positive charge.**

Characteristics of organic colloids in soil (2)

- **Variable charge depending on pH.**
- **Keep negative charge even at low pH due to low isoelectric point.**
- **Easily decomposed and lost.**
- **Can be increased by organic matter application.**