Phyllosilicates

- 1:1 minerals
  - Kaolin group (layer charge ~ 0)
- 2:1 minerals (differ by layer charge)
  - Micas (layer charge = 1)
  - Vermiculites (layer charge = 0.6-0.9)
  - Smectites (layer charge = 0.2-0.6)
- 2:1:1 minerals
  - Chlorite (layer charge variable)

Unit formulae of phyllosilicates

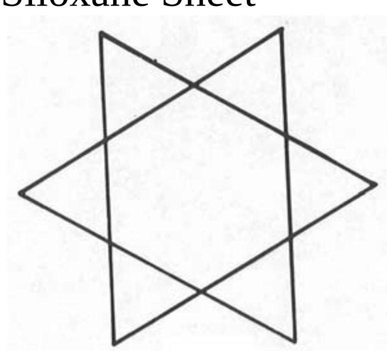
- ½ unit cell is used to simplify
  - A unit cell is the simplest repeating structure
  - For clay minerals, ½ cell contains 2 or 3 octahedral cations (Al, Fe or Mg) and 4 tetrahedral cations (usually Si)
- {interlayer cation}{octahedral occup.}{tetrahedral occup.}$O_{10}OH_2$
- $KAl_2(Si_3Al)O_{10}OH_2$ muscovite
- Layer charge is -1 and is balanced by interlayer cation, K^+
- $K_{0.85}Na_{0.09}(Al_{1.81}Fe^{II}_{0.14}Mg_{0.12})(Si_{3.09}Al_{0.91})O_{9.81}OH_2F_{0.19}$
- $K(Mg,Fe)_3(Si_3Al)O_{10}OH_2$ biotite

Note

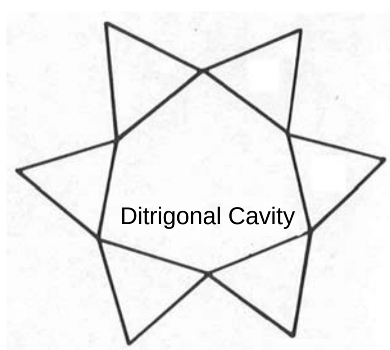
- An occupied octahedral cavity is a different size than an unoccupied octahedral cavity.
- Tetrahedral and octahedral sheets do not perfectly fit together.
- Cations have different sizes, and electronic (bonding) configurations.

Distortion

Siloxane Sheet



"Ideal"



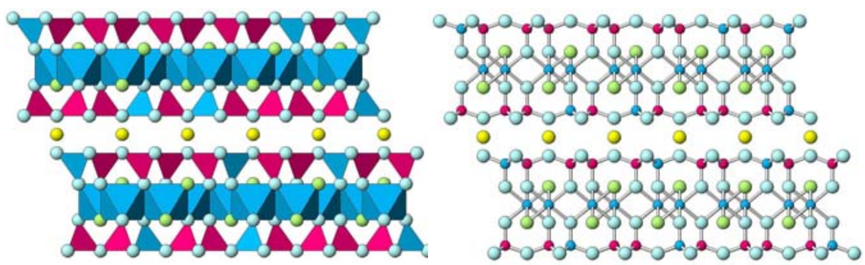
Actual

From Dixon and Weed

Micas

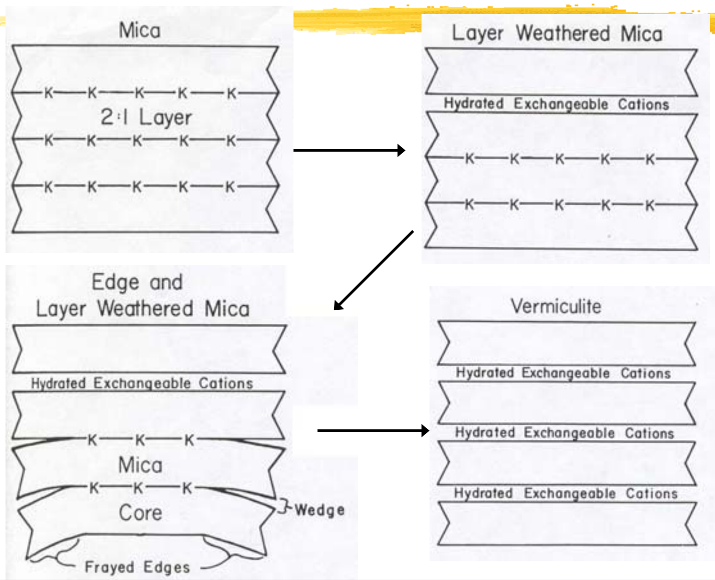
- Trioctahedral:Biotite, Phlogopite
- Dioctahedral:Muscovite
- Primary minerals
- Muscovite is more stable because it crystallizes at a lower temperature.
- Physical and chemical weathering creates secondary soil clay minerals.
- Weathering results in a reduction of the layer charge.

Mica

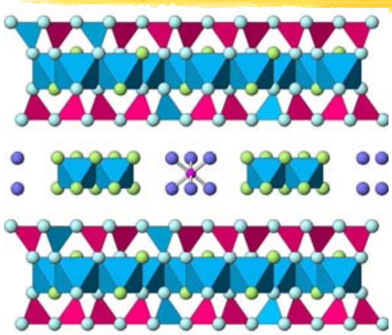


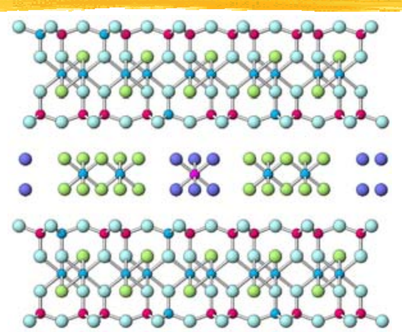
Muscovite:	$K(Si_3Al_1)(Al_2)O_{10}(OH)_2$
Biotite:	$K(Si_3Al_1)(Mg_{3-x}Fe_x)O_{10}(OH)_2$
Phlogopite:	$K(Si_3Al_1)(Mg_3)O_{10}(OH)_2$

Mica Weathering



Vermiculite



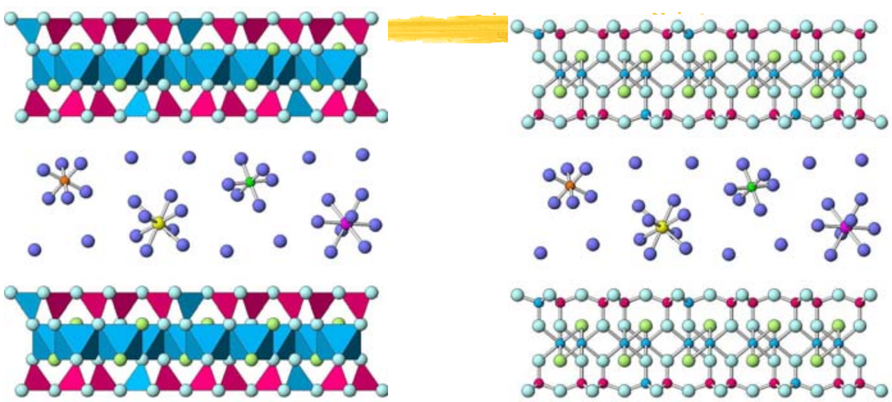


$M_{0.9}(Si_{4-x}Al_x)(Fe^{3+}Mg)_3O_{10}(OH)_2$

Smectites

- Trioctahedral:
  - Hectorite, Saponite
- Dioctahedral:
  - Montmorillonite, Beidellite, Nontronite
- Formed under conditions of high Si and "basic" cations (Ca^{2+} Mg^{2+}).
- Unstable under leaching environments—forms "pedogenic chlorite" and kaolinite.

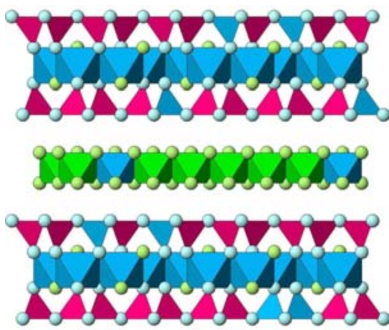
Smectite

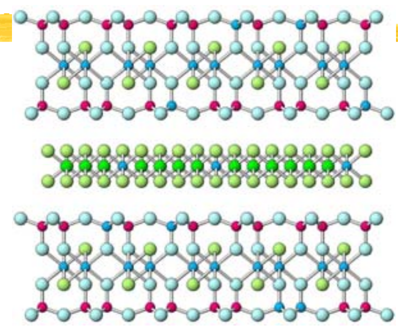


Montmorillonite:	$M_{0.25}(Si_4)(Al_{1.5}Mg_{0.5})O_{10}(OH)_2$
Beidellite:	$M_{0.25}(Si_{3.5}Al_{0.5})(Al_2)O_{10}(OH)_2$
Nontronite:	$M_{0.25}(Si_{3.5}Al_{0.5})(Fe^{3+}{}_2)O_{10}(OH)_2$

- Vermiculite—formed from micas
  - Release of K^+
  - Oxidation of Fe^{2+}
  - Increase in Si
- Chlorite—primary from metamorphics
  - Pedogenic chlorite = hydroxy-Al interlayered vermiculite or smectite (formed under acidic conditions of high Al availbility).
- Kaolinite—product of acidic weathering
  - High Al, low Si

Chlorite





$(Si_{4-x}Al_x)(R^{2+}, R^{3+})_3O_{10}(OH)_2 \bullet[(R^{2+}, R^{3+})_3(OH)_6]$

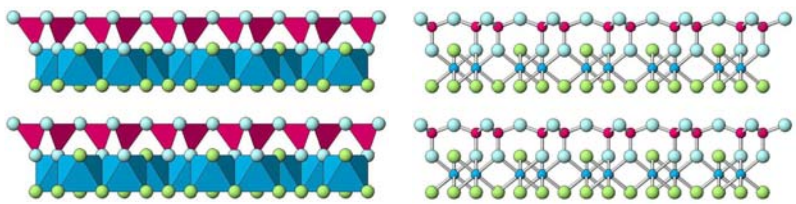
$R^{2+} = Mg^{2+}, Fe^{2+}, Mn^{2+}, Ni^{2+}$

$R^{3+} = Al^{3+}, Fe^{3+}, Cr^{3+}$

Kaolins

- Trioctahedral:
  - Chrysotile, Lizardite
- Dioctahedral:
  - Kaolinite, Halloysite

Kaolinite

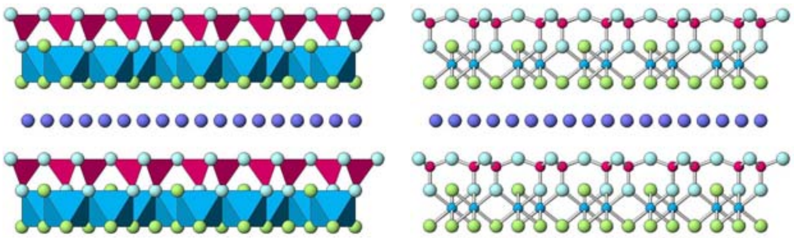


$Si_2Al_2O_5(OH)_4$

- Little or no substitution
- Charge from broken edges

$\Rightarrow$ pH dependant

Halloysite



$Si_2Al_2O_5(OH)_4 \cdot 2(H_2O)$

Definitions from the SSSA glossary

- **hydrous mica**: A better term might be illite.
- **illite**: (i) As a general term, refers to either a discrete non-expansible mica of detrital or authigenic origin or to the micaceous component of interstratified systems, as in illite-smectite. If used to refer to the species, it should meet the following requirements: a) The micaceous layers ideally are non-expansible; b) the octahedral sheet is dioctahedral and aluminous; c) the interlayer cation is primarily potassium; and (4) the composition deviates from that of muscovite in two main ways: 1) A phengitic component is present in which substitution of R2+ cations for octahedral Al is balanced by addition of tetrahedral Si beyond the ideal Si:Al ratio of 3:1 for muscovite.

definition of illite continued

- This substitution gives the octahedral sheet an overall negative charge of about 0.2 to 0.3 per formula unit. 2) Interlayer vacancies or water molecules amounting to about 0.2 to 0.4 atoms per formula unit are compensated by additional tetrahedral Si cations beyond those required by the phengitic component. Where reference is made to the *species* illite, a clear statement should be made to that effect in order to avoid confusion with the *general* usage. (ii) In soil taxonomy, the presence of a 1 nm x-ray diffraction peak and greater than or equal to 4% K2O is used to denote the presence of illite. [phengite is a high-Si muscovite]