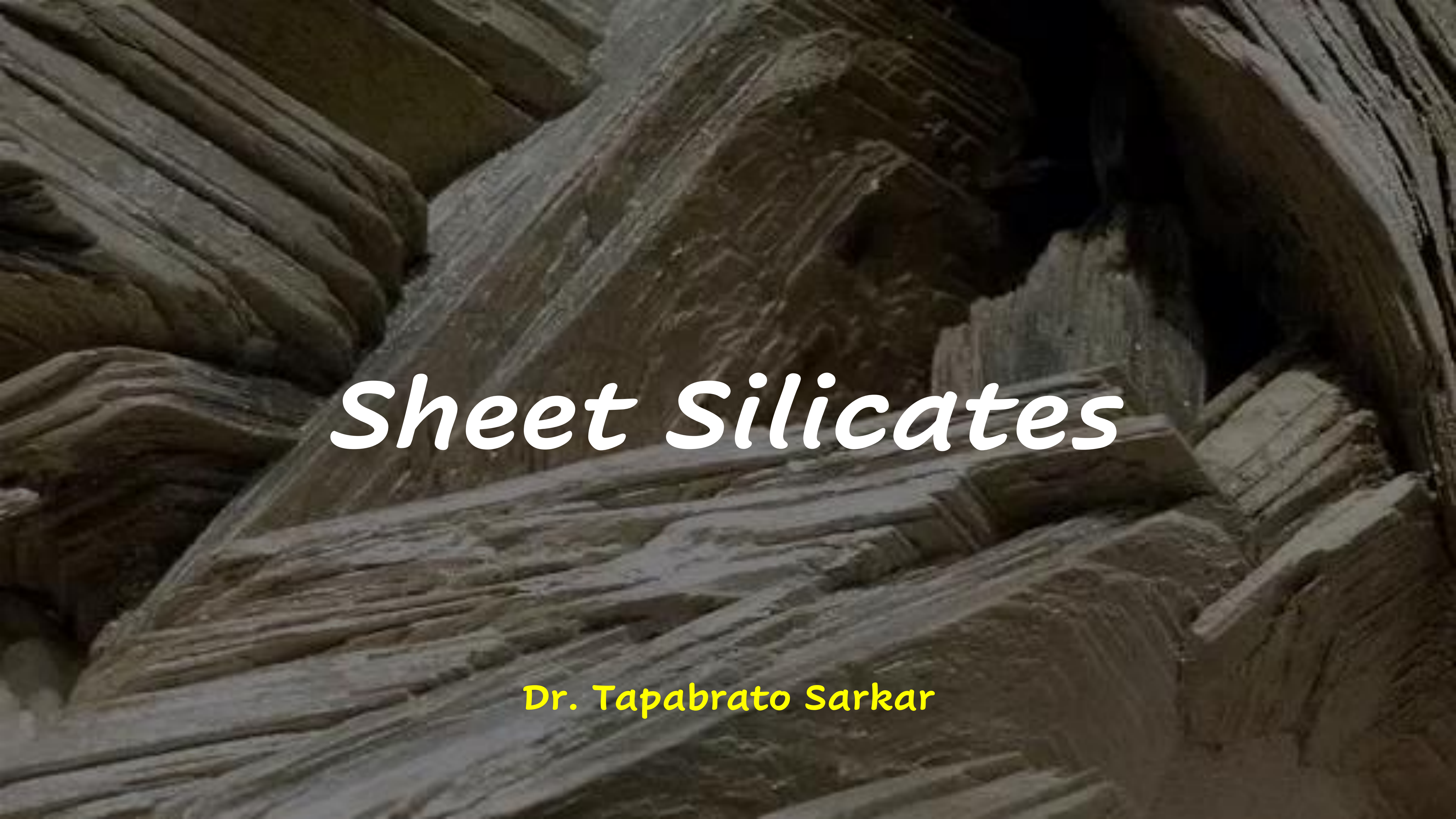


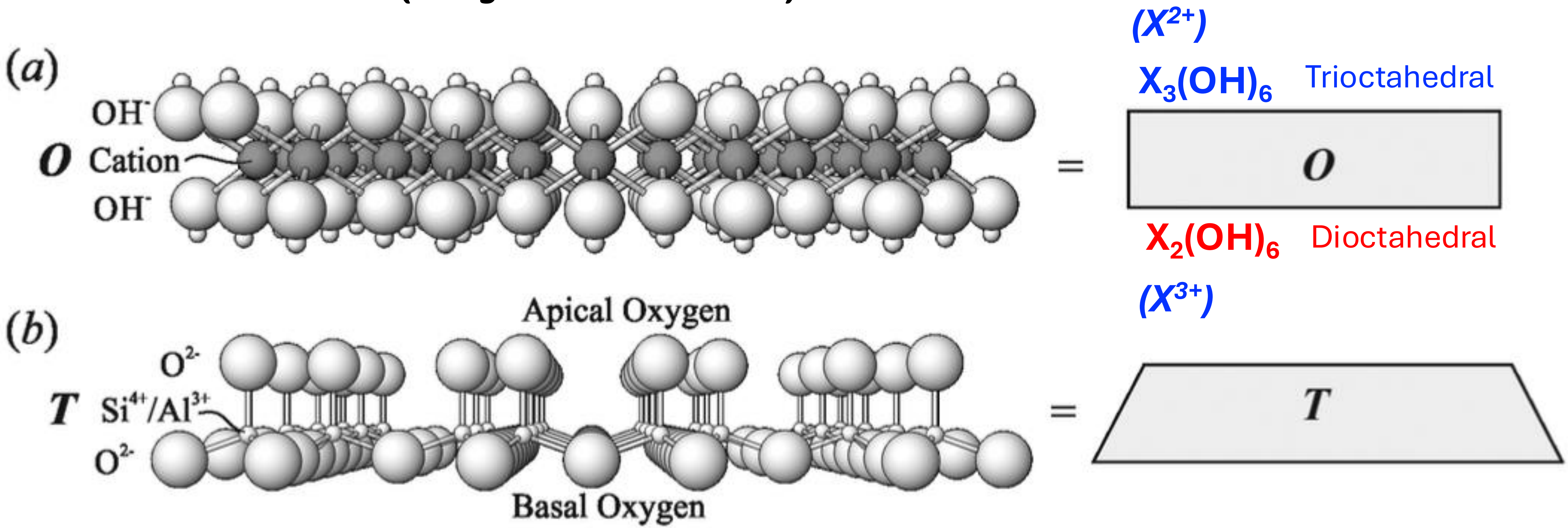
Sheet Silicates

Dr. Tapabrato Sarkar

Sheet Silicates (Phyllosilicates)

- Sheet silicates are abundant and important minerals, particularly in geological environments at or within roughly 20 km of the Earth's surface.
- They are commonly found in intermediate and felsic **igneous rocks** and in many **metamorphic rocks**, and are abundant in many sediments and **sedimentary rocks**, particularly if fine grained.
- All are hydrous, meaning that hydrogen is included in the structure, usually bonded to oxygen to form OH^-, not molecular water.
- Sheet silicates are also called phyllosilicates, a term derived from the Greek *phyllon*, which means leaf.
- Nearly all members of the group have a flaky or platy habit.

Sheet Silicates (Phyllosilicates)



- Constructed of sheets of two different types: O or octahedral sheets, and T tetrahedral sheets.
- Octahedral (O) sheets consist of two planes of OH^- anionic groups.
- Three (= tri) out of three octahedral sites are occupied → ***trioctahedral sheet***
- Two (= di) out of three octahedral sites are occupied, and one is vacant → ***dioctahedral sheet***
- Note that the “di” and “tri” refer to the occupancy of the octahedral sites, not the charge of the cations.

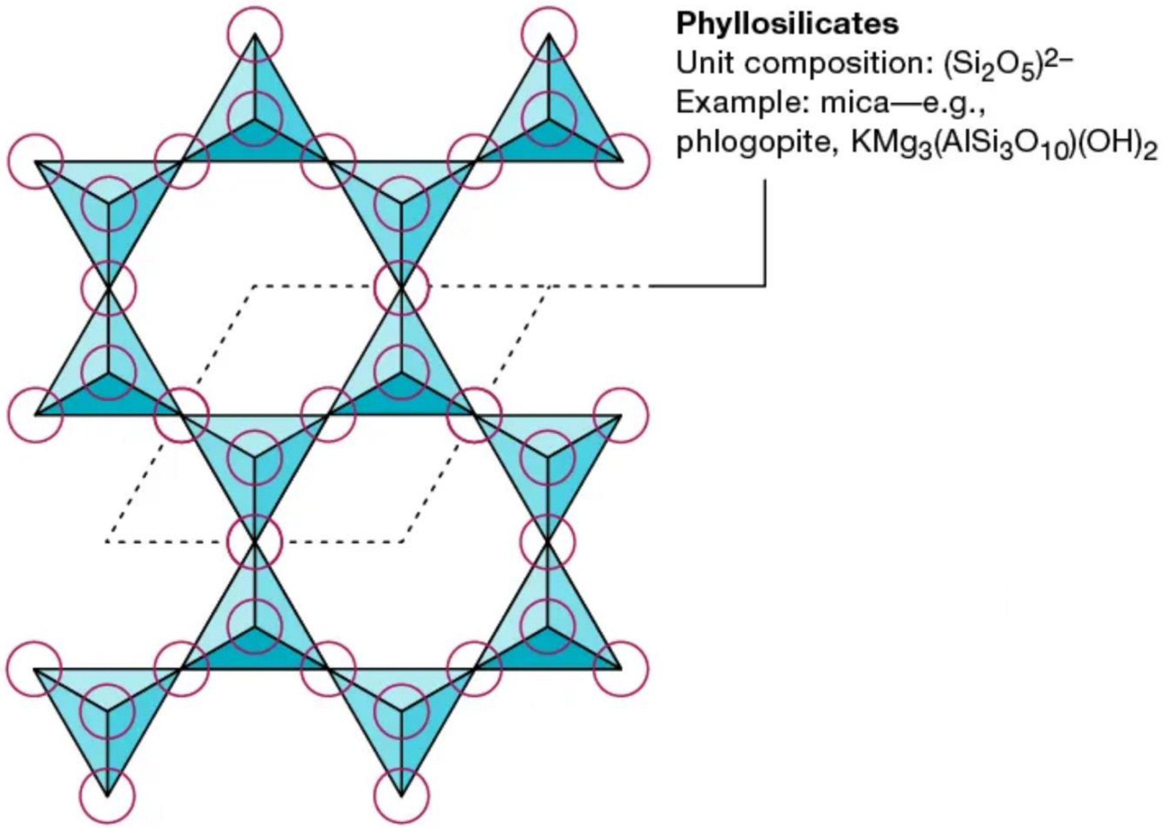
Sheet Silicates (Phyllosilicates)

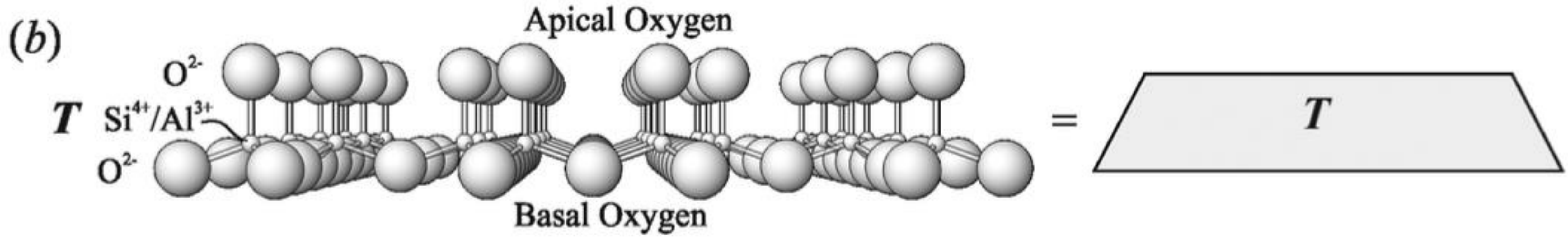
Tetrahedral (T) sheets consist of sheets of tetrahedrally coordinated cations.

Z_2O_5 **$(Si_2O_5)^{2-}$**

Z represents cations, usually Si^{4+}, Al^{3+}

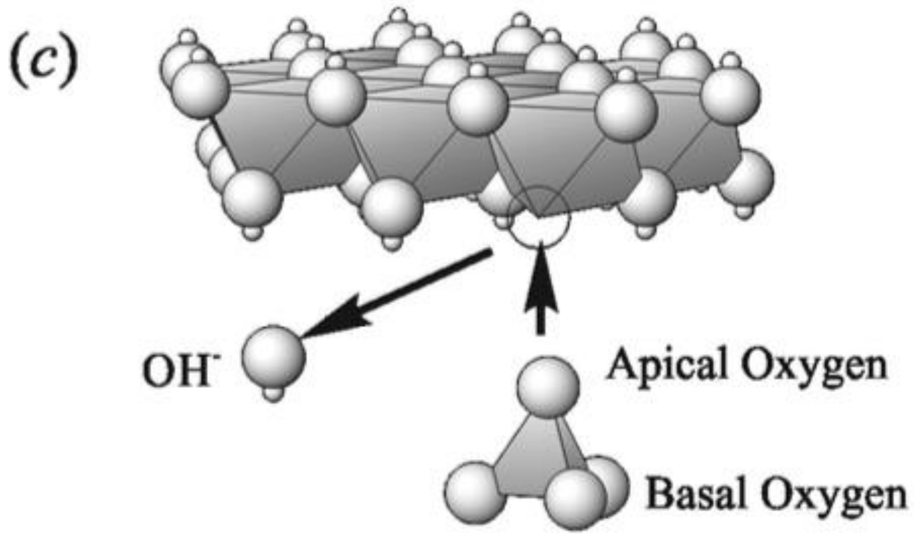
The three shared oxygen anions are known as the **basal oxygens** and the fourth, unshared, O^{2-} on each tetrahedra is known as the **apical oxygen**.





Sheet Silicates (Phyllosilicates)

- ✓ Tetrahedral sheets are always joined with an octahedral sheet.
- ✓ Octahedral and tetrahedral sheets are joined together to form layers.
- ✓ The layers are in turn stacked one atop another and bonded together to form the repeating unit structure of the mineral.



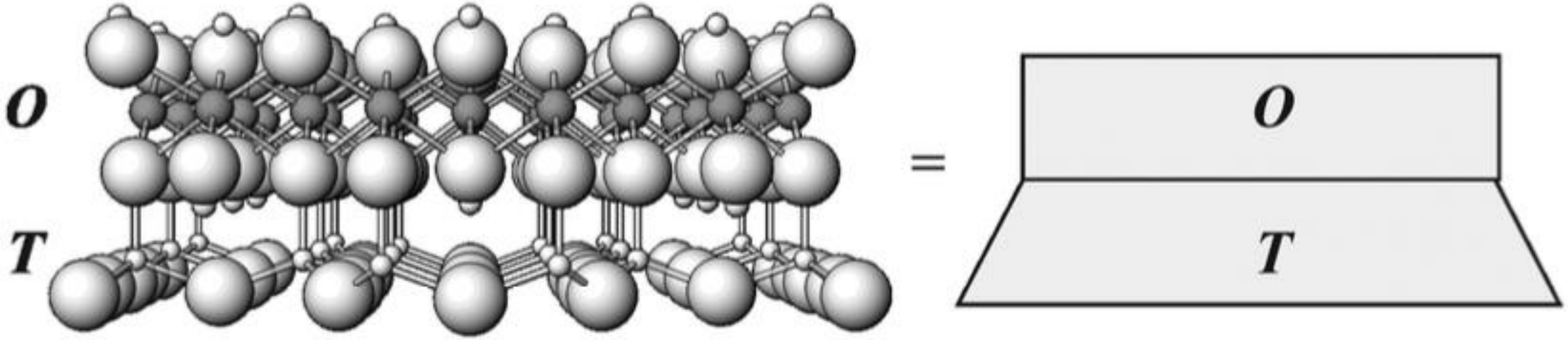
Combining a tetrahedral sheet with an octahedral sheet requires that two OH^- be removed from the octahedral sheet to make way for the apical oxygen on each tetrahedron.

Sheet Silicates: Structure

Common minerals:

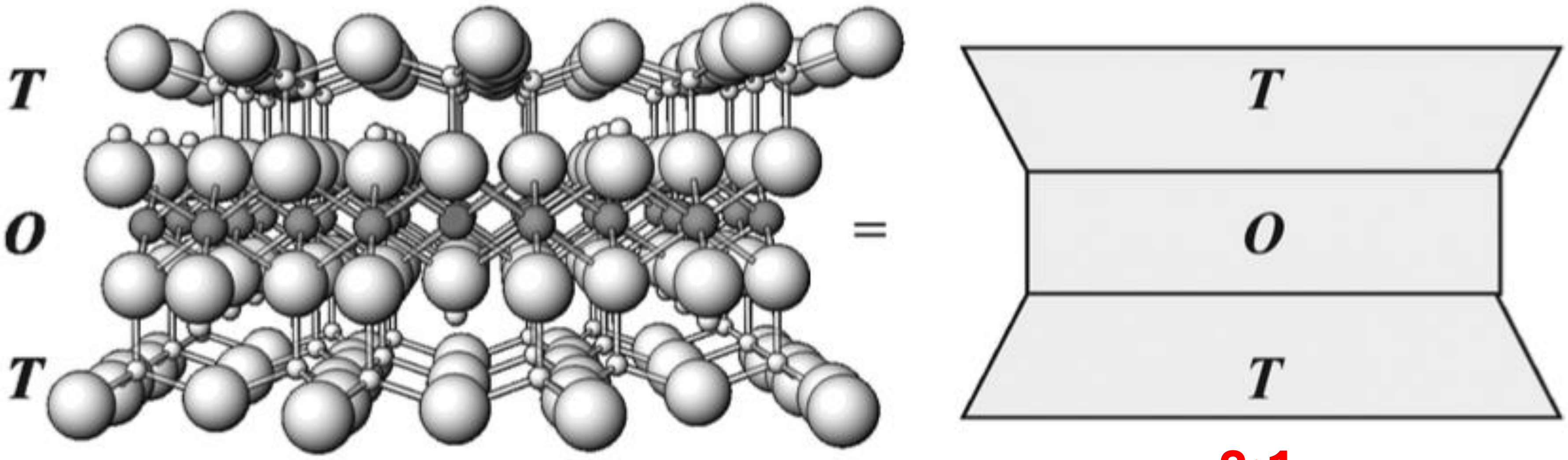
Muscovite
Biotite
Talc
Chlorite

(e)



1:1

(f)

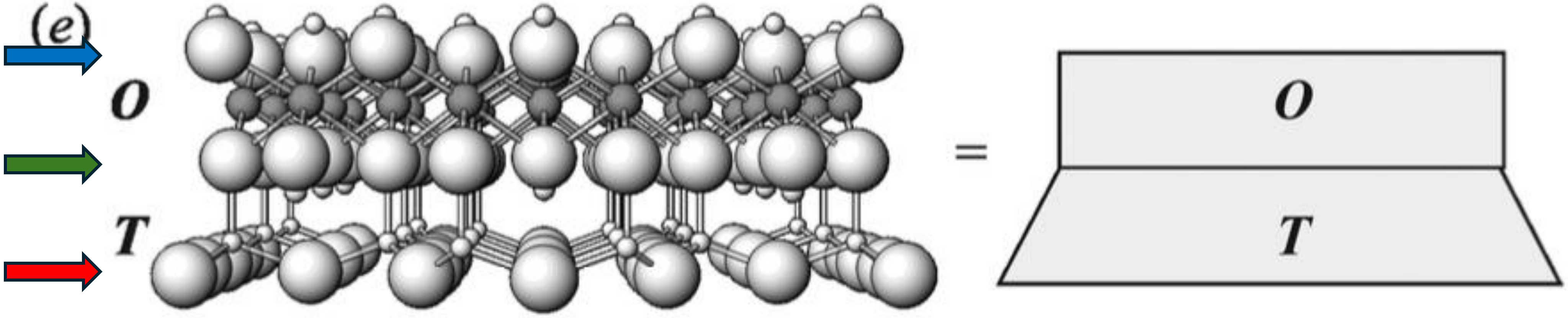


2:1

Sheet Silicates: Structure

- ✓ The combination of one tetrahedral and an octahedral sheet is called a TO or 1:1 layer and consists of three planes of anions.
- ✓ On one side are the basal oxygen anions of the tetrahedral sheet and on the other are OH^--anionic groups of the octahedral sheet.
- ✓ The middle plane contains both OH^- from the original octahedral sheet and the apical O^{2-} from the tetrahedral sheet.
- ✓ The combination of a T and an O sheet can be represented as follows to form a dioctahedral TO layer.

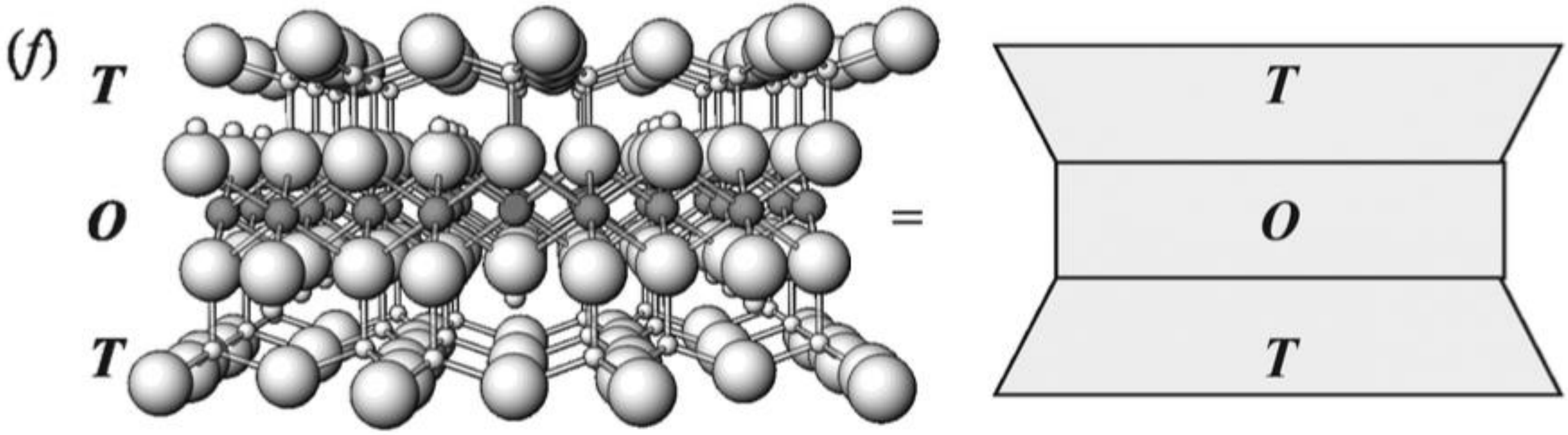
$$1T\ \text{sheet} + 1O\ \text{sheet} = TO\ \text{layer} + \text{hydroxyl}$$
$$Si_2O_5^{\ 2-} + Al_2(OH)_6 = Al_2Si_2O_5(OH)_4 + 2(OH)^-$$



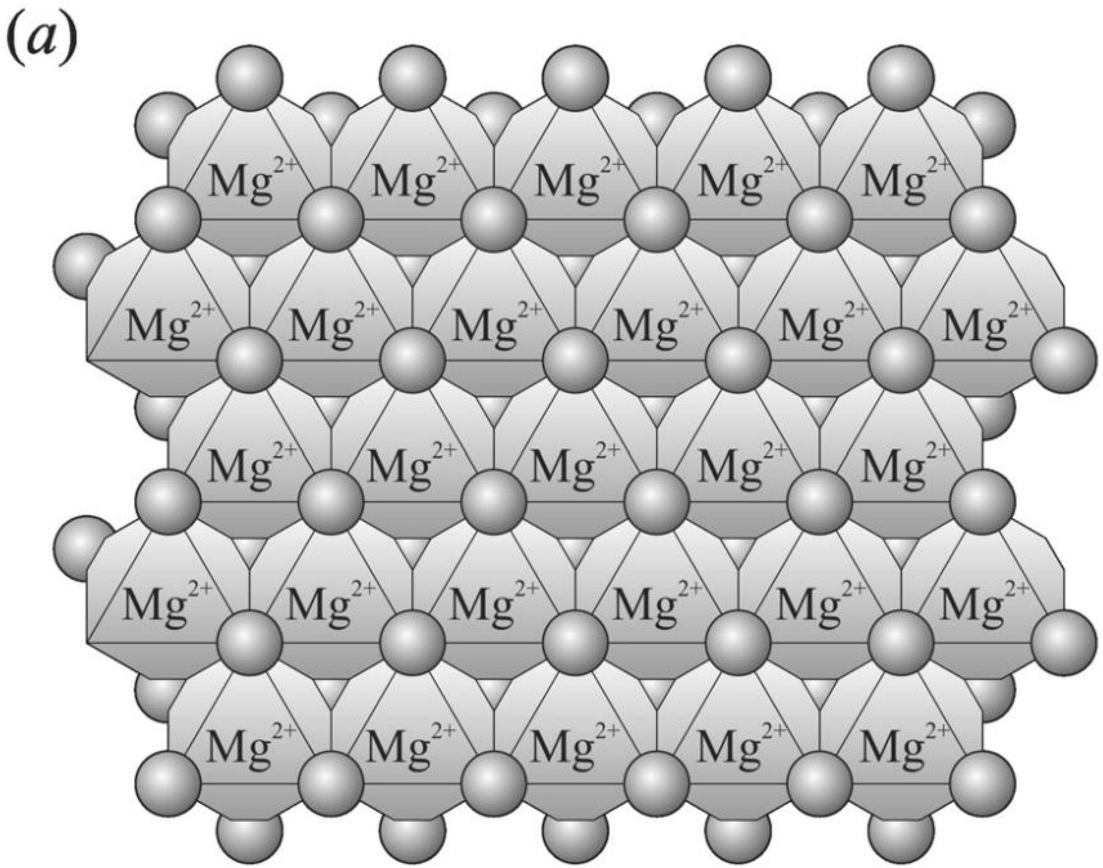
Sheet Silicates: Structure

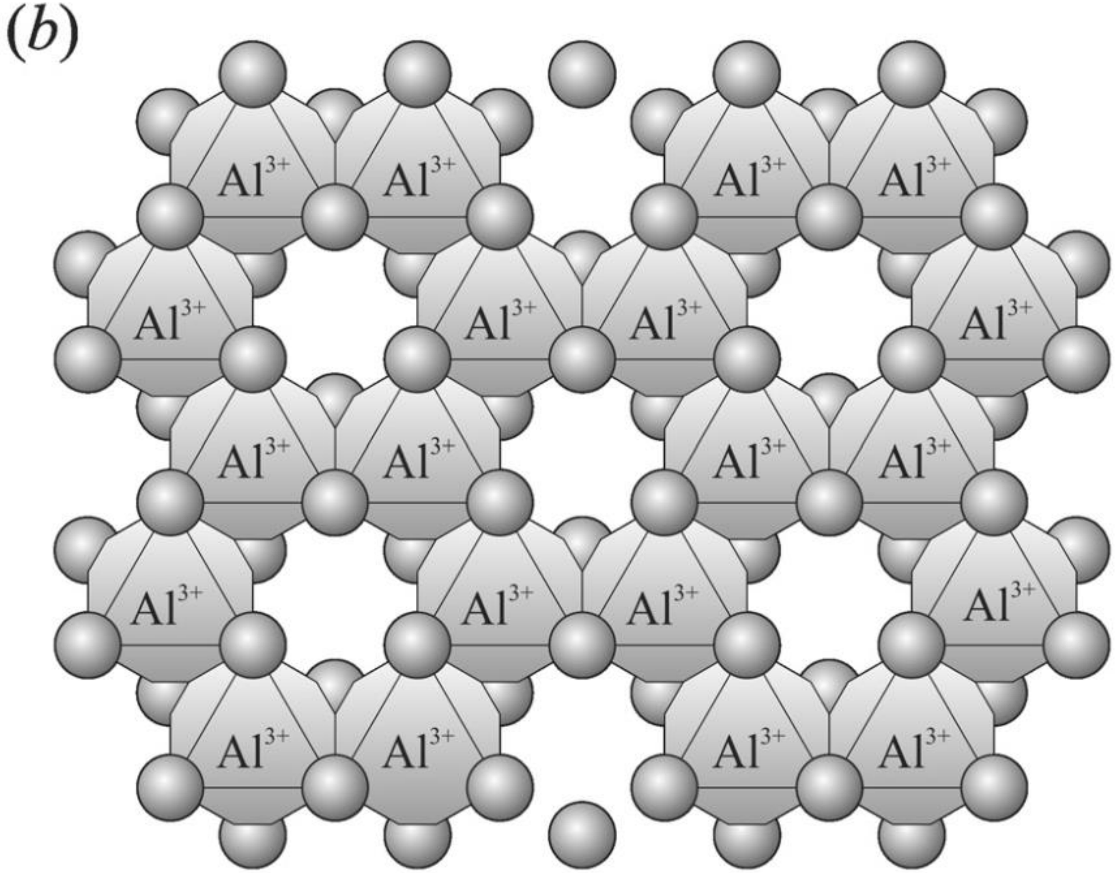
- ✓ A TOT or 2:1 layer is formed by joining a tetrahedral sheet to both sides of an octahedral sheet.
- ✓ These layers consist of four planes of anions. The outer two planes are the basal oxygen atoms of the tetrahedral sheets.
- ✓ The middle two planes contain both OH− from the original octahedral layer and O2− that are the apical oxygen anions on the tetrahedra.
- ✓ The combination of two T and one O layers to form a dioctahedral TOT layer can be represented:

$$2T \text{ sheets} + 1O \text{ sheet} = TOT \text{ layer} + \text{hydroxyl}$$
$$2(Si_2O_5^{2-}) + Al_2(OH)_6 = Al_2Si_4O_{10}(OH)_2 + 4(OH)^-.$$



Sheet Silicates: Structure





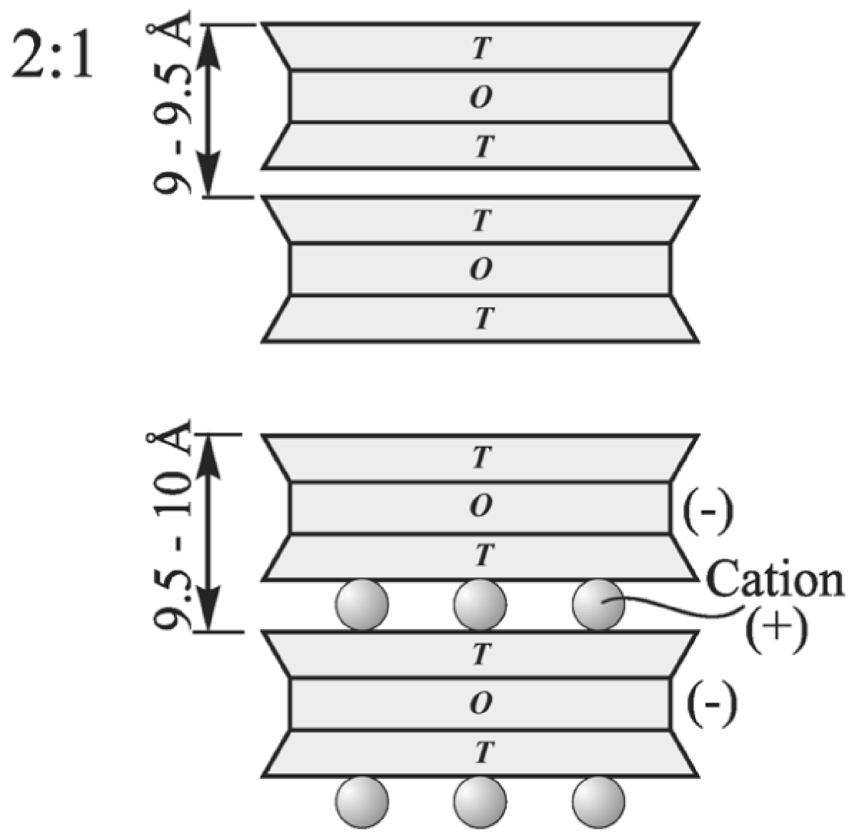
Trioctahedral

Divalent cations (usually Mg^{2+} or Fe^{2+}) occupy all (three out of three) octahedral sites.

Dioctahedral

Trivalent cations (usually Al^{3+}) occupy two-thirds of the potential octahedral sites.

Sheet Silicates: Structure



TOT
Pyrophyllite (d)
Talc (t)

$Al_2Si_4O_{10}(OH)_2$

$Mg_3Si_4O_{10}(OH)_2$

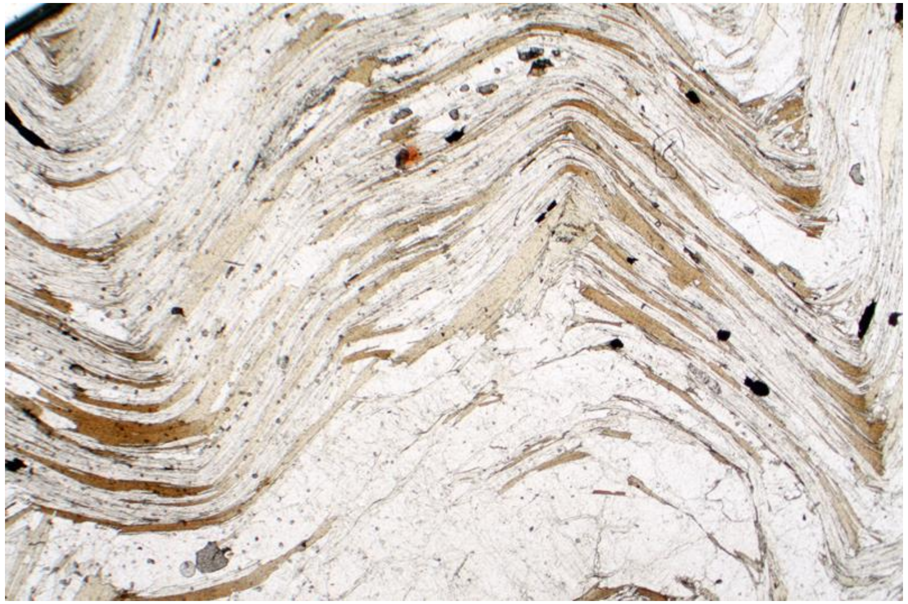
TOT + *c*
Muscovite (d)
Biotite (t)
Margarite (d)
Clintonite (t)

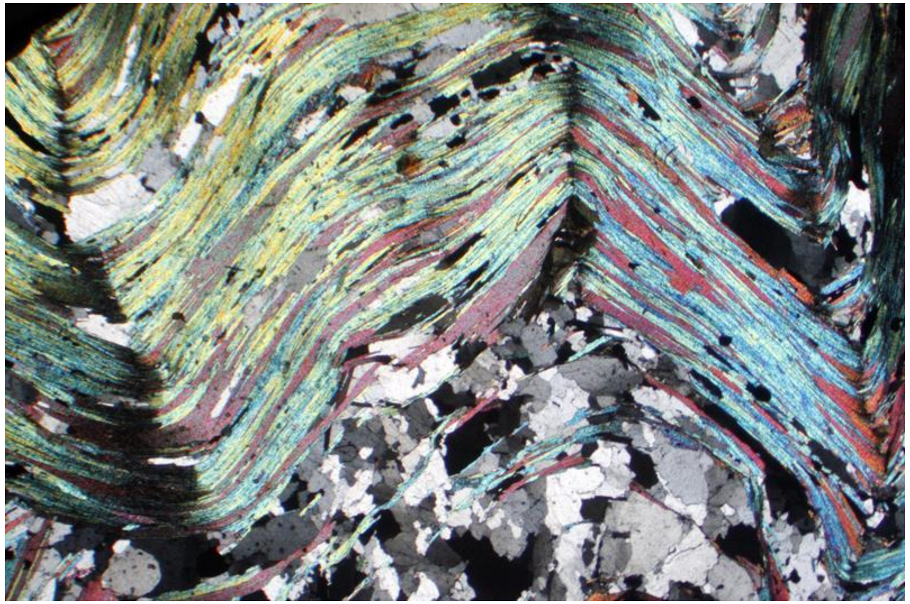
- ✓ Si4+ occupies all tetrahedral sites, so the TOT layers are electrically neutral
- ✓ Bonding between adjacent TOT layers depends on van der Waals bonds.
- ✓ The unit structure consists only of successive TOT layers.
- ✓ No additional cations are required to maintain charge balance.
- ✓ The weak interlayer bonding is responsible for the softness (H = 1) and waxy or greasy feel of both prophyllite and talc.

- ✓ In the micas, the ratio of Al^{3+} to Si^{4+} in tetrahedral sites is 1:3.
- ✓ **Dioctahedral** TOT layers **$Al_2(AlSi_3O_{10})(OH)_2{}^{1-}$ (Muscovite)**
- ✓ **Trioctahedral** TOT layers **$Mg_3(AlSi_3O_{10})(OH)_2{}^{1-}$ (Biotite)**
- ✓ The net negative charge of these TOT layers is balanced by inserting large monovalent cations such as K+ between the layers to form muscovite.

TOT layer + interlayer cation (*c*) = unit structure
$Al_2(AlSi_3O_{10})(OH)_{2^-} + K^+ =$
$KAl_2(AlSi_3O_{10})(OH)_2$ (muscovite)

Muscovite: Distinguishing features





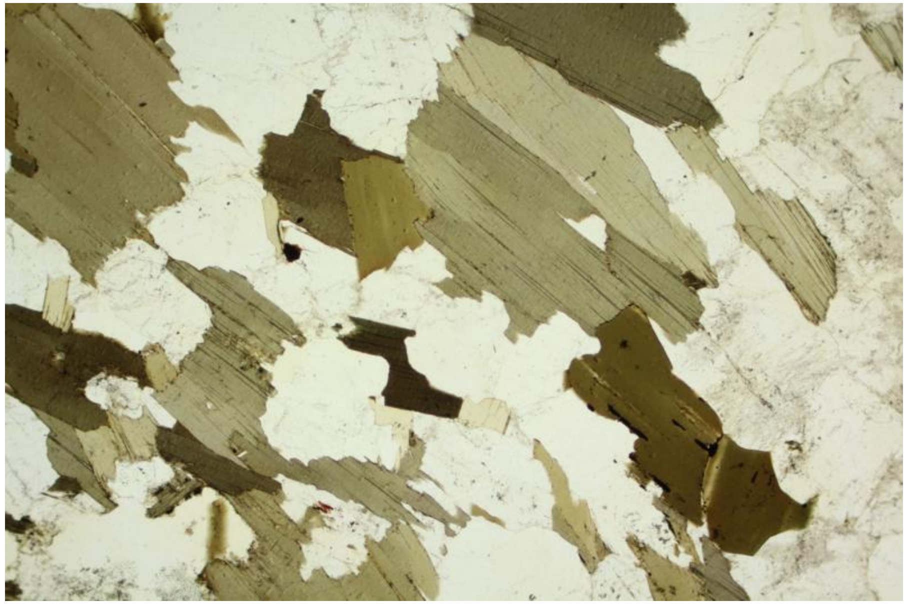
Distinguishing features in hand specimen:

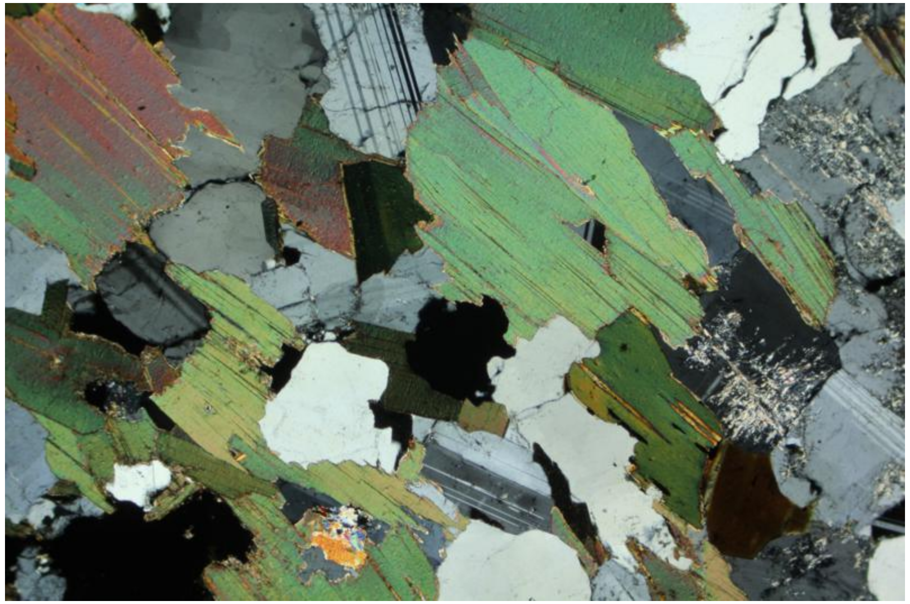
- Color: Colorless or light shades of green, red, or brown.
- Vitreous luster
- White streak
- Platy nature

Optical properties

- ✓ Color: Colorless
- ✓ Relief: Moderate.
- ✓ Birefringence: High
- ✓ Interference colors: Strong, III order colors.
- ✓ Cleavage: 1 set prominent
- ✓ Elongated or platy nature

Biotite: Distinguishing features





Distinguishing features in hand specimen:

- Color: Most commonly black or dark brown, sometimes greenish or reddish.
- Vitreous luster
- White or gray streak
- Platy nature

Optical properties

✓ Color: Typically brown, brownish green, or reddish brown and strongly pleochroic.

✓ Relief: Moderate.

✓ Birefringence: High

✓ Interference colors: Strong, III order colors. (colors are usually masked by the mineral color)

✓ Cleavage: 1 set prominent

✓ Elongated or platy nature

Thank You