



**FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES**

**SECONDARY MINERALS:** The secondary minerals are formed at the earth's surface by the weathering of the pre-existing primary minerals under variable conditions of temperature and pressure. Due to the action of weathering processes primary minerals are altered or decomposed. They are two types.

- a. Silicate minerals
- b. Non-silicate minerals

**Silicate minerals:** These are the minerals that contain silica along with other elements.

### **Basic structural units of Secondary minerals:**

**Silica Tetrahedron:** Geometrically it is possible to arrange only four oxygen atoms (with radius of  $1.32 \text{ \AA}$ ) around a central silicon cation (with radius of  $0.42 \text{ \AA}$ ), so that all are touching each other. To attain neutrality silicon would have to combine with two oxygen atoms only. But to attain geometrically stable structure silicon ion combines with four oxygen ions and the resultant silica tetrahedron ( $\text{SiO}_4^{4-}$ ) carries a net negative charge of four. This is called a silica Tetrahedron

In nature, the geometry and valence constraints are reconciled; first by linking together tetrahedra so that oxygen ions are shared between neighbouring silicon thus reducing the negative charge deficit; second by making use of the positive charges of other metal cations, to balance the negative charge. Both these occur to produce a neutral mineral. Like wise, the basic tetrahedra arrange themselves in an orderly manner, according to a fixed plan.

### **IMPORTANT SECONDARY MINERALS**

#### **Silicates**

-Clay minerals : Illite, Montmorillonite, Kaolinite

#### **Non Silicates**

-Oxides, Hydroxides of Al and Fe : Hematite, Goethite, Gibbsite

- Carbonates: Calcite, Dolomite

- Sulphates: Gypsum

- Phosphates: Apatite
- **Early stage of weathering:** Gypsum  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$  Calcite  $\text{CaCO}_3$  Dolomite  $\text{CaCO}_3 \cdot \text{MgCO}_3$

$\text{CO}_3 \cdot \text{MgCO}_3$

- **Intermediate stage of weathering:** Secondary clay minerals like

- Illite, Vermiculite, Montmorillonite

- **Advanced stage of weathering:**

- Silicate minerals like Kaolinite and Halloysite. Non silicate minerals like

- Gibbsite  $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ; Hematite -  $\text{Fe}_2\text{O}_3$ ; Goethite  $\text{FeOOH}$

- Rutile and Anatase  $\text{TiO}_2$ , Zircon  $\text{ZrSiO}_4$

- **Formulae of Different Rock Forming Minerals ;**

- **Phosphorus containing minerals**

- Fluorapatite  $\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2$ ; Apatite:  $\text{Ca}_{10}(\text{PO}_4)^{2+}$

- Variscite  $\text{AlPO}_4 \cdot 2\text{H}_2\text{O}$ ; Vivianite  $\text{Fe}_3(\text{PO}_4)_2$  Strengite  $\text{FePO}_4 \cdot 2\text{H}_2\text{O}$

- **Boron containing minerals**

- Tourmaline -  $\text{Na}(\text{Mg,Fe})_3\text{Al}_6(\text{BO}_3)_3\text{Si}_6\text{O}_{18}$

- **Iron containing minerals**

- Limonite -  $\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$  Vivianite  $\text{Fe}_3(\text{PO}_4)_2$  Ilmenite -  $\text{FeTiO}_3$ ;

- Siderite -  $\text{FeCO}_3$  Pyrite -  $\text{FeS}_2$ ; Hematite:  $\text{Fe}_2\text{O}_3$

- Chalcopyrite -  $\text{CuFeS}_2$ ; Magnetite -  $\text{Fe}_3\text{O}_4$

- **Zinc containing minerals :**

- Sphalerite -  $\text{ZnS}$ ; Smithsonite -  $\text{ZnCO}_3$

- **Mg containing minerals :** Epsom -  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ; Magnesite -  $\text{MgCO}_3$

- Dolomite -  $\text{CaCO}_3 \cdot \text{MgCO}_3$ ; Epsomite -  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$

- **Cu containing minerals:**

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- Chalcocite -  $\text{Cu}_2\text{S}$
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- Covellite -  $\text{CuS}$  Chalcopyrite -  $\text{CuFeS}_2$
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**Mn containing minerals:** Pyrolusite -  $\text{MnO}_2$ ; Manganite -  $\text{MnOOH}$  Rhodocrosite -  $\text{MnCO}_3$

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**Mo containing minerals :** Molybdenite :  $\text{MoS}_2$

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- Wulfenite :  $\text{PbMoO}_4$ ; Powellite  $\text{CaMoO}_4$