## ❖ MINERALOGICAL ORGANIZATION OF SILICATE CLAYS

Based on the number and arrangement of crystal units or layers, crystalline clays may be classified into 3 main groups:

**i) 1: 1 silicate clays**

In which each layer contains one tetrahedral and one octahedral sheet.

**ii) 2: 1 silicate clays**

In which each layer has one octahedral sheet sandwiched between tetrahedral sheets

**iii) 2: 1: 1 silicate clays**

A 2: 1 layer with a magnesium dominated tri octahedral sheet attached to it.

### ❖ CLAY MINERALS FOUND IN PAKISTANI SOILS

Illite >> kaolinite > montmorillonite > chlorite > vermiculite

### ❖ METHODS OF IDENTIFICATION OF CLAY MINERALS

1. X-Ray Diffraction Techniques (XRD)
2. Thermal Analysis Techniques or Differential Thermal Analysis (DTA)
3. Electron Microscope Analysis
4. Infrared Spectrometry/Spectroscopy
5. Magnetic methods
6. Chemical Analysis (CEC Hysteresis)

rays. The most significant amorphous silicate clay is allophone. It is mostly available in soil developed from volcanic ash.

### ii)–Organic Colloids:

These are not crystalline and these are composed basically of carbon, Hydrogen and Oxygen rather than silicon, aluminum, iron, magnesium and hydroxyl group. These may be as small as silicate clays. The organic colloids vary in size.

## Mineralogical composition of silicate clays:

On the basis of number and arrangement of tetrahedral and octahedral sheets contained in the crystal unit. Silicate clays are classified into 3 groups.

1) -1:1 type silicate mineral

2) -2:1 type silicate mineral

3) -2:1:1/2:2 type silicate mineral

## Important definition

**Sheet:** Building block of silicate mineral is known as sheet.

Types: i)-Tetrahedral sheet ii)-Octahedral sheet

**Tetrahedron:** A four sided building block in which one silicon atom is surrounded by four oxygen atoms is known as tetrahedron.

**Octahedron:** Octahedron is eight sided building block in which an aluminum or magnesium iron is surrounded by six hydroxy group or oxygen atom.

**Layer:** Different combinations of tetrahedronal and octahedral sheet are known as layer.

**Interlayer space:** The space b/w is consecutive layers within the crystal structure in the crystal structure is known as interlayer space.

**Inter layer:** A film of water and associated cations which is present b/w consecutive layers within the mineral structure is known as inter-layer.

## (1)-1:1 Type Silicate Mineral:

# 1) 1:1 Type of Silicate clay minerals:

Silicate mineral in which each layer is made up of one tetrahedral sheet and are octahedral sheet giving rise to the name 1:1 type silicate mineral.

Kaolinite ——members——→ halloysite, nacrite, dickite

The tetra and octahedral sheet within 1:1 type layer are held together tightly by oxygen atom which are mutually shared by silicon and aluminum or magnesium atom in their respective sheet.

- Effective surface of 1:1 type mineral is thus restricted to its outer surface.
- Cation exchange capacity of 1:1 type mineral is very small.
- Due to strong bonding forces b/w the structural layers in 1:1 type mineral are not readily broken into thin plates.
- 1:1 type exhibited very little plasticity, cohesion, sweeling and shrinkage.

## (2)-2:1 type silicate minerals:

The crystal unit (layer) of these minerals is characterized by an octahedral sheet sandwiched b/w two tetrahedral sheets.

**Example:** Smectite, vermiculite, fine grained, mica

2:1 type silicate minerals are further classified into 2 classes

i)–Expanding 2:1 type silicate mineral

ii)–Non expanding 2:1 type silicate mineral

## (i)–Expanding 2:1 Type Silicate Mineral:

The minerals which expand on wetting and contract on drying are known as expanding 2:1 type silicate minerals.

**Example:** Smectite ———→ members Montmorillonite,beidillite, [Main group] Nantronite, saponite

- The crystal structure of these minerals is comprised of 2:1 type layers which are loosely held by very weak oxygen to oxygen linkages. Exchangeable cations and water molecules can easily enter into the interlayer space causing the expansion of crystal structure on wetting
- Effective surface area of these minerals is comprised of external as well as internal surface area. For example, smectite mineral has surface area 700-800 $m^2/gm$ as compared to 5-20 $m^2/gm$ in case of kaolinite (1:1) type mineral.
- Smectite minerals also have high cations exchange capacity, high plasticity and marked swelling and shrinkage properties on alternate wetting and drying. Moreover, due to high effective surface smectite mineral have high

nutrient holding capacity and ultimately contribute significantly towards the chemical property of soil.

> Wide cracks commonly appear in soil dominant in smectite when they are dried after wetting. The dry aggregates are very hard, making such soils difficult to cultivate or tilth.

## ii]–Non expanding 2:1 Type Silicate Mineral:

2:1 type minerals in which potassium ions are strongly attracted in b/w the crystal layers making the crystal structure Non-expanding.

**Example**: Mica

Soil properties such as hydration, cation exchange capacity, plasticity, swelling and shrinkage are much less intense in mica as compared to smectite but it more than Kaolinite. Specific/effective surface area of these mineral vary from 70-100$m^2$/g.

## (3)-2:1:1/2:2 Type Silicate Mineral:

In 2:2 type silicate minerals a magnesium dominated octahedral sheet. Sheet is a sandwiched in b/w adjacent 2:1 types layers.

These minerals are Non-expanding because a hydroxylated surface of an intervening Mg dominated octahedral sheet is hydrogen bonded to the oxygen atom of the 2 adjacent tetrahedral sheets. Binding the layers very tightly together. The colloidal properties of 2:1 type mineral are much similar to non-expanding 2:1 type silicate minerals.

**Example:** Chlorite

## Properties of Silicate Minerals

| | Smectite | Vermiculite | Mica (Non-epanded) | Chlorite (Non-epanded) | Kaolinite (Fixed) |
|---|---|---|---|---|---|
| Size(μm) | 0.01-1.0 | 0.1-5.0 | 0.2-2.0 | 0.1-2.0 | 0.5-5 |
| External surface area ($m^2/g$) | 70-120 | 50-100 | 70-100 | 70-100 | 10-30 |
| Internal surface Area($m^2/g$) | 550-650 | 500-600 | 0 | 0 | 0 |
| Net –ve charge CEC(cmol/kg) | 80-120 | 100-180 | 15-40 | 15-40 | 2-5 |

- Kaolinite, chlorite and mica are non-expanding silicate minerals so these are good for construction
- Non-expanding minerals increases the life of any infrastructure