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FACULTY OF MEDICAL SCIENCES

Secondary silicate clay minerals

Inorganic soil colloids or clay minerals or secondary silicate minerals, which are mostly new ly formed crystals from the soluble products of the primar y minerals. Some clay minerals are formed by slight alteration of some primary minerals i.e., illite from Muscovite or Biotite.

Secondary minerals

- Layer silicate clays
- Fe and Al oxide clays
- Allophone and associated amorphous clays

Formation

1. A slight physical and chemical alteration of certain primary minerals
2. A decomposition of primary minerals with subsequent recrystallization of certain of their products.

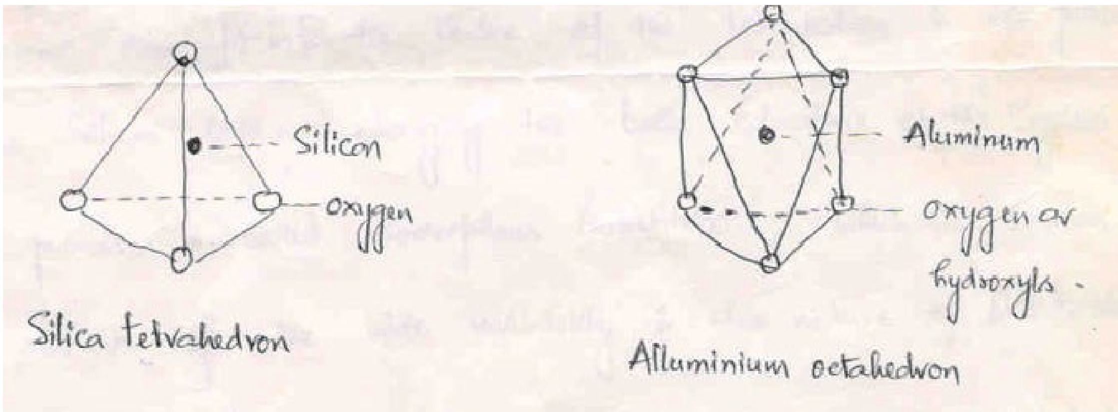
Layer Silicate Clays : These are crystalline, layer like structures. The layers comprise primarily horizontally oriented sheets of Si, Al, Mg and/or Fe atoms, surrounded and held together by oxygen and hydroxyl groups e.g. kaolinite, montmorillonite and illite etc.

The basic building block for the silica dominated sheet is a unit composed of one silicon atom surrounded by four oxygen atoms. It is called "silica tetrahedron" because of its four sided configuration. An interlocking array of a series of these silica tetrahedra tied together horizontally by shared oxygen anions gives a "Tetr ahedral sheet".

The basic building block for the aluminum and /or Magnesium (some times iron) dominated sheet is a unit composed of an aluminum ion surrounded by six oxygen atoms or hydroxyl groups gives an eight sided building block termed "Octahedron".

Numerous octahedra linked together horizontally comprise the "Octahedral sheet".

In aluminum dominated sheet, two Al^{3+} ions satisfy the negative charge from surrounding oxygen and hydroxyl ions and so this sheet is known as "di -octahedral sheet". In Magnesium dominated sheet, three Mg^{2+} ions satisfy the negative charge and so this sheet is



known as tri-octahedral sheet.

The tetrahedral and octahedral sheets are bound together with in crystals by shared oxygen atoms in to different layers. The specific nature and combination of sheets is these layers vary from one type of clay to another and largely control the physical and chemical properties of each clay mineral.

Classification of silicate clay m inerals (Layer s ilicates)

Based on the number and arrang ement (sequence) of tetrahedral and octahedral sheets in each crystal unit of silicate clays, they are classified.

1:1 type : Kaolinite, Halloysite

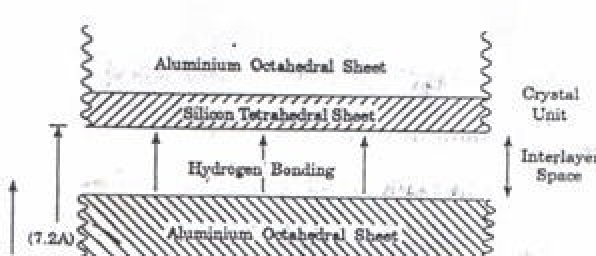
2:1 type : Montmorillonite, illite, vermiculite (limited expansion, 2:1 type)

, Talc 2:2 type : Chlorite

Layer silicate minerals are also classified based on layer charge per unit cell of structure, the type of inter layer bond and interlayer cations, type of cations in octahedral sheet etc.

Kaolinite

It is 1:1 type clay mineral made up of one silica tetrahedral sheet combined



with one aluminum octahedral sheet. The tetrahedral and octahedral sheets in a layer of kaolinite crystal are held together tightly by oxygen atoms, which are mutually shared by silicon and aluminum cations in their respective sheets. The crystal units in turn are held together by "**hydrogen bonding**", which results in "fixed" structure, giving no scope for cations or water to enter between the structural layers. Other minerals of this group are halloysite, anauxite, dickite.

Montmorillon ite

This is a 2:1 type mineral comes under smectite group. Other minerals of this group are beidellite, nontronite, saponite etc. It is an expanding type of clay mineral. **Fig Layer Structure of montmorillonite**

ach layer is made up of an octahedral sheet sandwiched between two tetrahedral sheets. Two units are linked together by weak oxygen bonding, which results in ready and variable space between layers, for occupation by water and exchangeable cations. Isomorphous substitution occurred in both tetra and octahedral sheets (Si by Al) (Al by Mg), giving rise to net negative charge (high CEC)

Illite : It is a 2:1 non-expanding type clay mineral. It is also called as hydrous mica.

In a giv nted as that of montmorillonite. In tetrahedral sheet 20en layer, the tetrahedral and octahedral sheets are orie% silicon is substituted by aluminum. The resultant

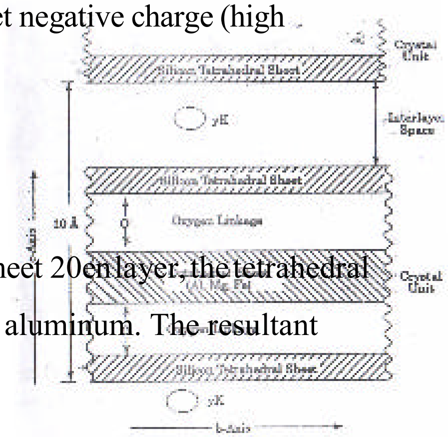


Fig. 3.7 Schematic sketch of crystal structure of illite

negative charge is satisfied largely by potassium and keeps the lattice structure nonexpanding. The properties of illite, li e in between those of Kaolinite and montmorillonite.

Distinguishing Properties of Important Clay Minerals.

S.No.	Property	Kaolinite	Montmorillonite	Illite
1.	Type	1:1	2:1 expanding	2:1 nonexpanding
2	Size (μm)	0.5-5.0	0.01 to 1.0	0.2 to 2.0
3	Shape	Hexagonal crystals	Flakes	Flakes
4	Surface area Internal surface area (m^2/g) External surface area (m^2/g)	 -- 10-30	 550-650 70-120	 -- 70-100
5	Inter layer spacing (nm)	0.7 (7.2A^o)	1.0-2.0 (9.6 to 18.0A^o)	1.0 (10A^o)
6	Isomorphous substitution	**-No-** (pH dependant charge)	Octahedral sheet (0.6)	Tetrahedral sheet (1.0)
7	CEC (cmol (p+) kg^{-1})	2 to 5	80 to 120	15-40
8	Inter layer bonding	Hydrogen bonding	0-0 bonding	0-0 bonding
9	Cohesion, plasticity swelling and shrinkage	Low	High	Medium

Chlorite

It is a 2:2 or 2:1:1 type of clay mineral. Chlorites is basically iron – magnesium silicates with some aluminum present. It has 2:1 layers, like others, alternate with a magnesium dominated trioctahedral sheet giving a 2:1:1 ratio. Magnesium also dominates the octahedral sheet in 2:1 layer. Thus the crystal unit contains two silica tetrahedral sheets and two magnesium dominated trioctahedral sheets.

It is a nonexpansive type, with size and negative charge similar to that of illite. Chlorites are mostly found mixed with montmorillonite and vermiculite