WEATHERING OF SOIL MINERALS AND CHANGE IN MINERAL COMPOSITION

Weathering is the principal process that acts upon the earth's primary minerals to form the smaller and finer particles that we call "soil."

There are two types of weathering:

- **physical weathering and**
- **chemical weathering.**

Differences in weathering patterns are the reason why there is a great range in soil particle size.

Boulders are much less weathered than gravel.

In return, gravel is much less weathered than clay particles.

Clay particles may even weather into other materials, such as:

iron and aluminum oxides,

which are generally resistant to further weathering.

In the tropics, chemical weathering is very important. Since the climate is typically warm and moist year-round, it provides a suitable environment for continuous chemical weathering to occur.

Over time, with sufficient amounts of rainfall and warm temperatures, mineral particles weather into smaller and smaller soil particles.

As a result, tropical soils tend to be highly weathered soils (at advanced weathering stage).

Physical Weathering

Physical weathering is a process that breaks up and disintegrates parent rock, or primary minerals, within the earth.

In the tropics, physical weathering is caused by:

- the wetting and drying of rocks;
- erosion;
- actions of plants and animals; or
- the falling, smashing, or breaking of rock materials into smaller pieces.

Chemical Weathering

Once parent rock has broken down into smaller pieces, another process acts upon the rock.

This process is chemical weathering.

Chemical weathering involves the change, or transformation, of primary minerals into secondary minerals.

Secondary minerals serve as the basic building blocks of the small particles with the soil.

As a result, new materials may be synthesized, residual material may accumulate from materials (such as oxides) which cannot be furthered weathered, or materials can be lost as the result of leaching.

Primary, secondary minerals, aluminum and iron oxides, and amorphous materials	
Primary Minerals of Basalt Rock	• Plagioclase Feldspar • Olivine • Augite Others: magnetite, apatite, ilmenite
Secondary Minerals	• Smectite, such as montmorillonite (less weathered) • Kaolin, such as halloysite (more weathered)
Iron Oxides	• Hematite • Goethite • Magnetite • Maghemite • Lepidocrosite • Ferrihydride
Aluminum Oxide	• Gibbsite
Amorphous Materials	• Allophane • Imogolite

TYPES OF SOIL COLLOIDS

There are four major types of colloids present in soil

1. Layer silicate clays

2. Iron and aluminum oxide clays (sesquioxide clays)

3. Allophane and associated amorphous clays

4. Humus.

Inorganic colloids:

- Layer silicate clays,
- Iron and aluminum oxide clays,
- Allophane and
- Associated amorphous clays

Organic colloid:

- Humus

1. LAYER SILICATE CLAYS

These are most important silicate clays and are known as **phyllosilicates** (Phyllon - leaf) because of **their leaf-like or plate like structure.**

They are comprised of **two kinds of horizontal sheets.** One dominated by **silicon and other by aluminum** and/or magnesium.

2. IRON AND ALUMINUM OXIDE CLAYS (SESQUIOXIDE CLAYS):

Under conditions of extensive leaching by:

- **rainfall and**
- **long time intensive weathering of minerals**

in humid warm climates, most of the silica and much of the alumina in primary minerals are dissolved and slowly leached away.

The remnant materials, which have lower solubility, are sesquioxides.

Sesquioxides (metal oxides) are mixtures of:

- **aluminum hydroxide, $Al(OH)_3$, and**
- **iron oxide, Fe_2O_3, or**
- **iron hydroxide, $Fe(OH)_3$.**

Examples of iron and aluminum oxides common in soils are

- gibbsite ($Al_2O_3.3H_2O$) and
- geothite ($Fe_2O_3.H_2O$).

Less is known about these clays than about the layer silicates.

These clays:

- do not swell,
- not sticky and
- have high phosphorus adsorption capacity.

3. ALLOPHANE AND OTHER AMORPHOUS MATERIALS:

These silicate clays are mixtures of silica and alumina.

They are amorphous in nature.

Typically, these clays occur where large amount of weathered products existed.

These clays are common in soils forming from volcanic ash (e.g., Allophane).

ALLOPHANE

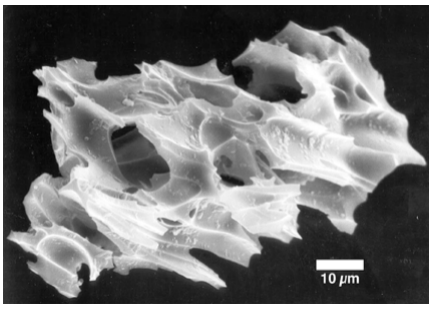
1. **Volcanic ash** is chemically/mineralogically distinct from most other soil parent materials.

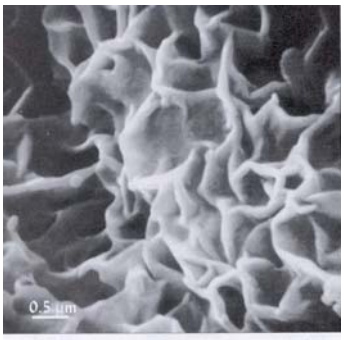
2. Composed largely of **glassy materials** containing varying amounts of Al and Si.

3. It **lacks a well-defined crystal structure** (i.e., amorphous) and is **quite soluble**.

Allophane is a common **early-stage residual weathering product** of volcanic glass and has **poorly-ordered structures.**

Allophane forms **inside glass fragments where Si concentration and pH are high** and has a characteristic spherule (tiny sphere) shape.





4. HUMUS (ORGANIC COLLOID):

Humus is amorphous, dark brown to black, nearly insoluble in water, but mostly soluble in dilute alkali (NaOH or KOH) solutions.

It is a temporary intermediate product left after considerable decomposition of plant and animal remains.

They are temporary intermediate because the organic substances remain continue to decompose slowly.

The humus is often referred to as an organic colloid and consists of various chains and loops of linked carbon atoms.

The humus colloids are not crystalline.

They are composed basically of:

carbon, hydrogen, and oxygen

rather than of

silicon, aluminum, iron, oxygen, and hydroxyl groups.

The organic colloidal particles vary in size, but they may be at least as small as the silicate clay particles.