

الله أكبر

## Lecture # 7



## Weathering and Erosion

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# Weathering

**Weathering** is the process that produces changes in the surfaces of rocks exposed to the atmosphere. The rocks break and undergo decay under the influence of the atmospheric agencies like wind, sun, frost, water and organisms **and produce soil.**

**Erosion** involves the transportation and removal of weathered materials from the place of their formation.

# Weathering

**Weathering** is of two types:

- 1. Physical weathering or disintegration**
- 2. Chemical weathering or decomposition**

**Physical Weathering:**

**By this process, angular fragments of rocks are broken off from the high mountain ranges. These fragments of rock roll down the hill slope and accumulate at the bottom. The various types are:**

- 1.1 Thermal stress**
- 1.2 Frost weathering**
- 1.3 Pressure release**
- 1.4 Hydraulic action**
- 1.5 Salt-crystal growth**
- 1.6 Biological Weathering**

# 1. Physical Weathering

**1.1 Heating and cooling or Thermal stress:** The heating and cooling of rock masses occur due to daily and seasonal temperature changes. The heat causes them to expand and cooling causes them to contract. The repeated expansion and contraction tend to develop cracks in the rocks.

In desert areas, the coarse grained rocks, like granite, disintegrate soon into their constituent crystals, and become desert sands as a result of temperature variation.

**1.2 Frost Action:** The alternate freezing and thawing of water in the cracks of rocks tend to disintegrate them because water on freezing expands and therefore, exert pressure on the walls of the cracks.

# 1. Physical Weathering

**1.3 Pressure Release:** In pressure release, also known as unloading, overlying materials (not necessarily rocks) are removed (by erosion, or other processes), which causes underlying rocks to expand and fracture parallel to the surface. Often the overlying material is heavy, and the underlying rocks experience high pressure under them, for example, a moving glacier. Pressure release may also cause exfoliation to occur



Pressure Release of granite.

# 1. Physical Weathering

## 1.4 Hydraulic action:

**This is when water (generally from powerful waves) rushes into cracks in the rock face rapidly. This traps a layer of air at the bottom of the crack, compressing it and weakening the rock. When the wave retreats, the trapped air is suddenly released with explosive force. The explosive release of highly pressurized air cracks away fragments at the rock face and widens the crack itself.**

## 1.5 Salt-crystal growth

**Salt crystallization, otherwise known as haloclasty, causes disintegration of rocks when saline solutions seep into cracks and joints in the rocks and evaporate, leaving salt crystals behind.**

**These salt crystals expand as they are heated up, exerting pressure on the confining rock.**

**Salt crystallization may also take place when solutions decompose rocks (for example, limestone and chalk) to form salt solutions of sodium sulfate or sodium carbonate, of which the moisture evaporates to form their respective salt crystals.**

# Weathering

- c) **Plants.** Plants disintegrate rocks when it grow in the cracks of the rocks.
- d) **Organisms.** such as worms, ants etc also contribute to the disintegration of rocks.







A rock in Abisko, Sweden fractured along existing joints possibly by frost weathering or thermal stress



Salt Crystallization



Comparison of un-weathered (left) and weathered (right) limestone.



Salt weathering of building stone on the island of Gozo, Malta

# Chemical Weathering

Chemical Weathering or decomposition is the process in which rocks are broken down by chemical decay of minerals. The main agents of chemical weathering as follows:

**Water.** The chemical weathering of rocks is done mainly by rain water.

The process involved are:

**Oxidation:** The oxygen, in the presence of water, readily unites with the iron present in the minerals such as pyroxenes, amphiboles and olivine and convert it to iron oxide (hemite) or to hydroxides (limonite). The oxidation of pyrite leads to the formation of limonite and weak solution of sulphuric acid. This acid is a powerful chemical agent which attacks the rocks and develop solution pits. The iron oxides and hydroxides are the very common products of oxidation which impart the red and yellow colors to soils.

# Chemical Weathering

**Hydration.** Hydration is the process in which water molecules combine chemically with the minerals to produce new compounds. The formation of gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) from anhydrite ( $\text{CaSO}_4$ ) is a good example of hydration. Carbonation frequently occurs together with hydration. Thus orthoclase feldspar, a mineral which is abundant in granite, is decomposed and converted into kaolin by hydration and carbonation.

**Carbonation.** When minerals containing calcium, magnesium and sodium or potassium ions react with water containing carbon dioxide, carbonates and bicarbonates are formed which are taken into solution. This process of decomposition is called carbonation.



A freshly broken rock shows differential chemical weathering (probably mostly oxidation) progressing inward.

# Chemical Weathering

**Solution.** The process of solution and carbonation goes on together. The lime stones, dolomite, rock salt and gypsum are particularly susceptible to solution when they are attacked by water containing carbon dioxide.

**Vegetation.** Decay of organic matter releases certain organic acids which increase the solvent power of water. For example, the solubility of silica, alumina and iron is much greater in the presence of organic acids. Some plants tend to extract certain chemical elements from rocks and thus they contribute to their decomposition.

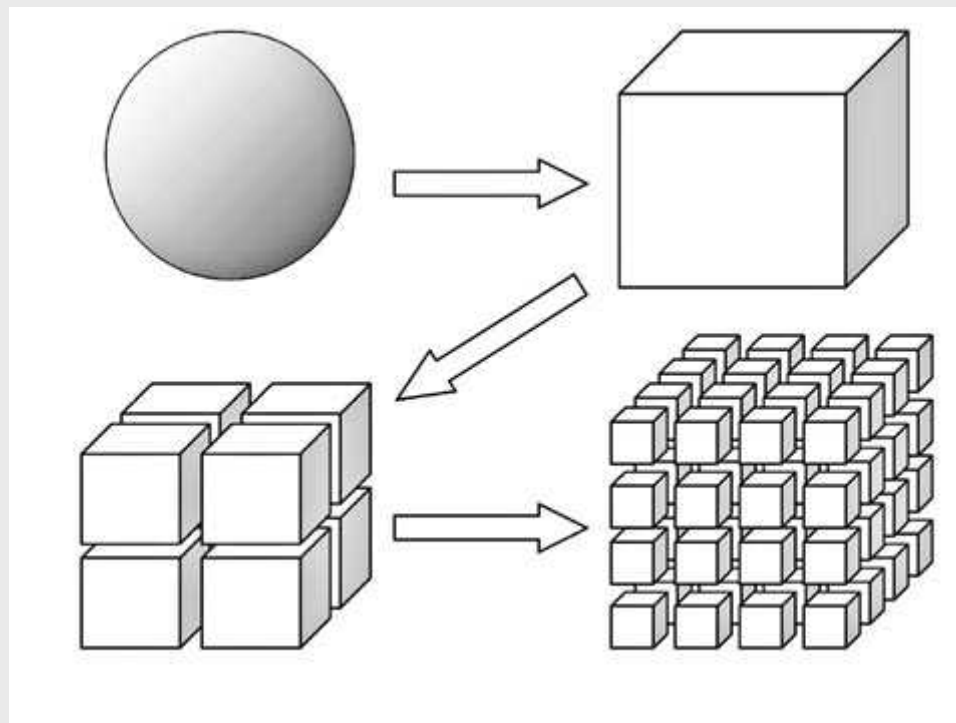
# Exfoliation

**Exfoliation.** The process in which rocks, exposed to weathering chip off in thin sheets or layers concentric with the surface, thereby producing a round mass. It is sometimes formed when the pressure on a rock from overlying rock is released. The rock then expands and cracks. The exfoliation is also caused by alternate heating and cooling of rocks by weather conditions.



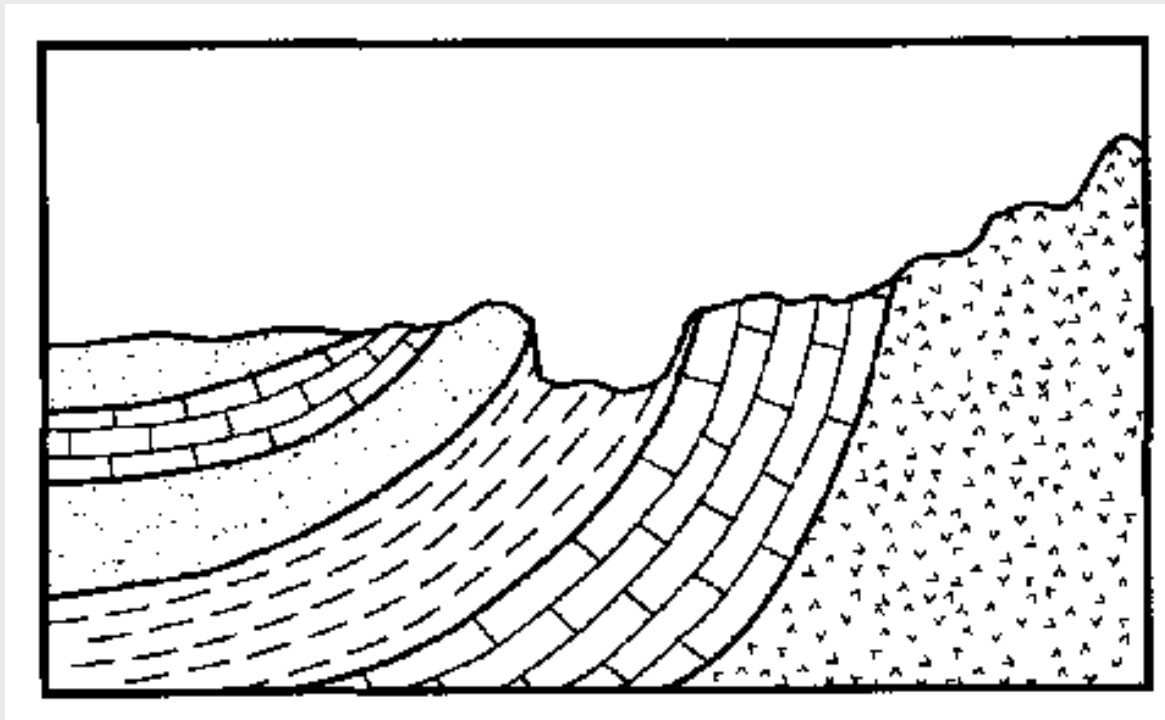
# Rate of weathering

Rates of weathering will be influence by surface area exposed. More surface exposed, the faster the weathering will occur



# Mineral Composition

Some minerals are more resistant than others. For example Quartz is resistant to chemical and physical weathering.



# Erosion

**Erosion is the process of weathering and transport of solids (sediment, soil, rock and other particles) in the natural environment or their source and deposits them elsewhere. It usually occurs due to transport by wind, water, or ice; by down-slope creep of soil and other material under the force of gravity; or by living organisms, such as burrowing animals, in the case of bio-erosion.**

**Erosion is distinguished from weathering, which is the process of chemical or physical breakdown of the minerals in the rocks, although the two processes may occur concurrently.**



**Cliff erosion in Pacifica, California**



# Erosion

## 1. Causes:

- Areas with high-intensity precipitation,
- More frequent rainfall,
- More wind, or more storms.
- Sediment with high sand or silt contents and
- Areas with steep slopes erode more easily,
- Areas with highly fractured or weathered rock.
- Porosity and permeability of the sediment or rock affect the speed with which the water can percolate into the ground.
- Sediments containing more clay tend to erode less than those with sand or silt.

## 2. Effects of Erosion:

- Approximately 40% of the world's agricultural land is seriously degraded.
- Threat to bio-diversity.
- Loss of top soil.

# Erosion

## Erosion Processes:

### 1. Gravity:

**Mass wasting**, also known as **slope movement** or **mass movement**, is the geomorphic process by which soil, regolith, and rock move down slope under the force of gravity.

### 2. Water.

**Splash erosion** is the detachment and airborne movement of small soil particles caused by the impact of raindrops on soil.

**Sheet erosion** is the detachment of soil particles by raindrop impact and their removal down slope by water flowing overland as a sheet instead of in definite channels or rills.

**Bank erosion** is the wearing away of the banks of a stream or river. This is distinguished from changes on the bed of the watercourse, which is referred to as *scour*.

**Gully erosion**, also called *ephemeral gully erosion*, occurs when water flows in narrow channels during or immediately after heavy rains or melting snow.

**Shoreline erosion**, which occurs on both exposed and sheltered coasts, primarily occurs through the action of currents and waves but sea level (tidal) change can also play a role.

# Erosion

## Ice:

**Ice erosion** can take one of two forms. It can be caused by the movement of ice, typically as glaciers, in a process called *glacial erosion*. It can also be due to freeze-thaw processes in which water inside pores and fractures in rock may expand cause further cracking.

## Wind

In arid climates, the main source of erosion is wind. The general wind circulation moves small particulates such as dust across wide oceans thousands of kilometers downwind of their point of origin, which is known as deflation. Erosion can be the result of material movement by the wind. There are two main effects.

-First, wind causes small particles to be lifted and therefore moved to another region. This is called deflation

- Second, these suspended particles may impact on solid objects causing erosion by abrasion (ecological succession).

## Thermal

Thermal erosion is the result of melting and weakening permafrost due to moving water. It can occur both along rivers and at the coast. Rapid river channel migration observed in the Lena River of Siberia is due to thermal erosion, as these portions of the banks are composed of permafrost-cemented non-cohesive materials.<sup>1</sup>

# Effects of Erosion

## **Climate Change:**

The warmer atmospheric temperatures observed over the past decades are expected to lead to a more vigorous hydrological cycle, including more extreme rainfall events.

## **Tectonic effects:**

The removal by erosion of large amounts of rock from a particular region, and its deposition elsewhere, can result in a lightening of the load on the lower crust and mantle.

This can cause tectonic or isostatic uplift in the region. Research undertaken since the early 1990s suggests that the spatial distribution of erosion at the surface of an orogen can exert a key influence on its growth and its final internal structure.



Erosion due to wave pounding at Venus Bay, South Australia.



A rock formation in the Altiplano, Bolivia sculpted by wind erosion.



Wind-eroded alcove near Moab, Utah.



A Linxia City, China, farmer is gradually losing his land, as the edge of the loess plateau is eroded away <sup>21</sup>