

Weathering: The Breakdown of Rocks

Weathering is the physical disintegration or chemical alteration of rocks at or near the Earth's surface.

Types of Weathering

1. Mechanical (physical) weathering is the physical disintegration and reduction in the size of the rocks without changing their chemical composition.

- Examples: exfoliation, frost wedging, salt wedging, temperature changes, and abrasion

II. Chemical weathering decomposes, dissolves, alters, or weakens the rock through chemical processes to form residual materials.

- Examples: carbonation, hydration, hydrolysis, oxidation, and solution

III. Biological weathering is the disintegration or decay of rocks and minerals caused by chemical or physical agents of organisms.

- Examples: organic activity from lichen and algae, rock disintegration by plant or root growth, burrowing and tunneling organisms, and acid secretion

I. Mechanical Weathering

Mechanical weathering is the physical disintegration and reduction in the size of the rocks without changing their chemical composition.

- Exfoliation
- Frost Wedging
- Salt Wedging
- Temperature Changes
- Abrasion

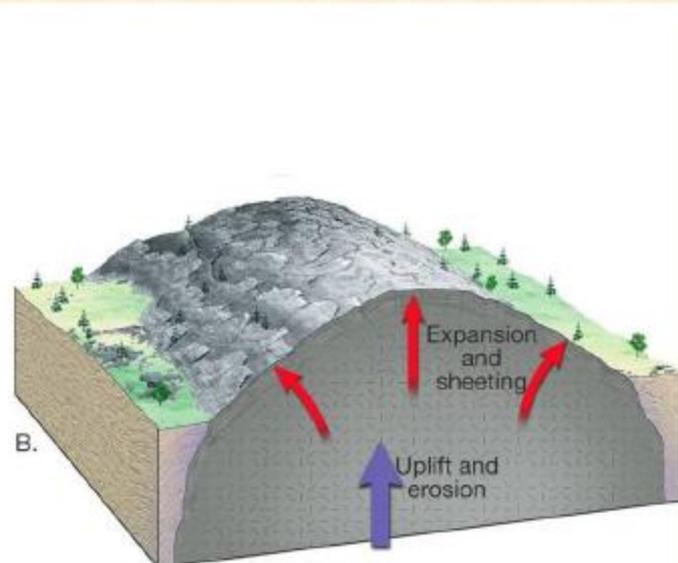
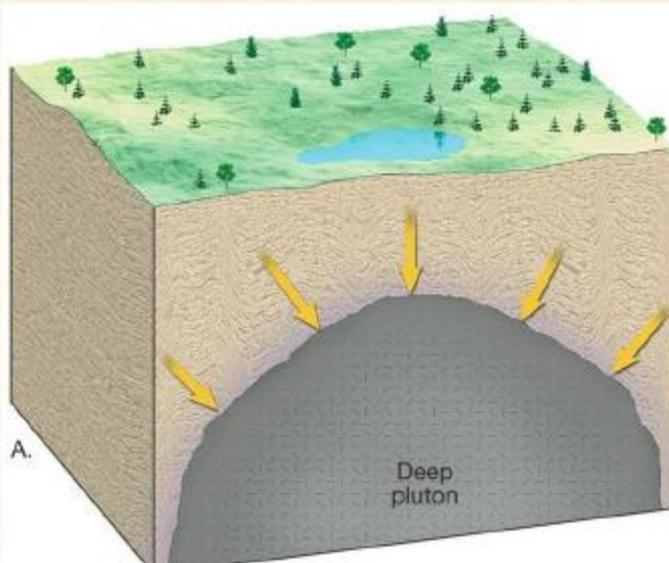
Mechanical weathering processes disintegrate metamorphic rocks in South Carolina's Piedmont Region.



Photo courtesy of SCGS

Mechanical Weathering: Exfoliation

- **Exfoliation** is a mechanical weathering process in which pressure in a rock is released (**unloading**) along parallel alignments (**sheet joints**) near the surface of the bedrock and layers or slabs of the rock along these alignments break off from the bedrock and move downhill by gravity.
- Exfoliation primarily occurs on **intrusive igneous** or **metamorphosed** rocks that are exposed at the Earth's surface.



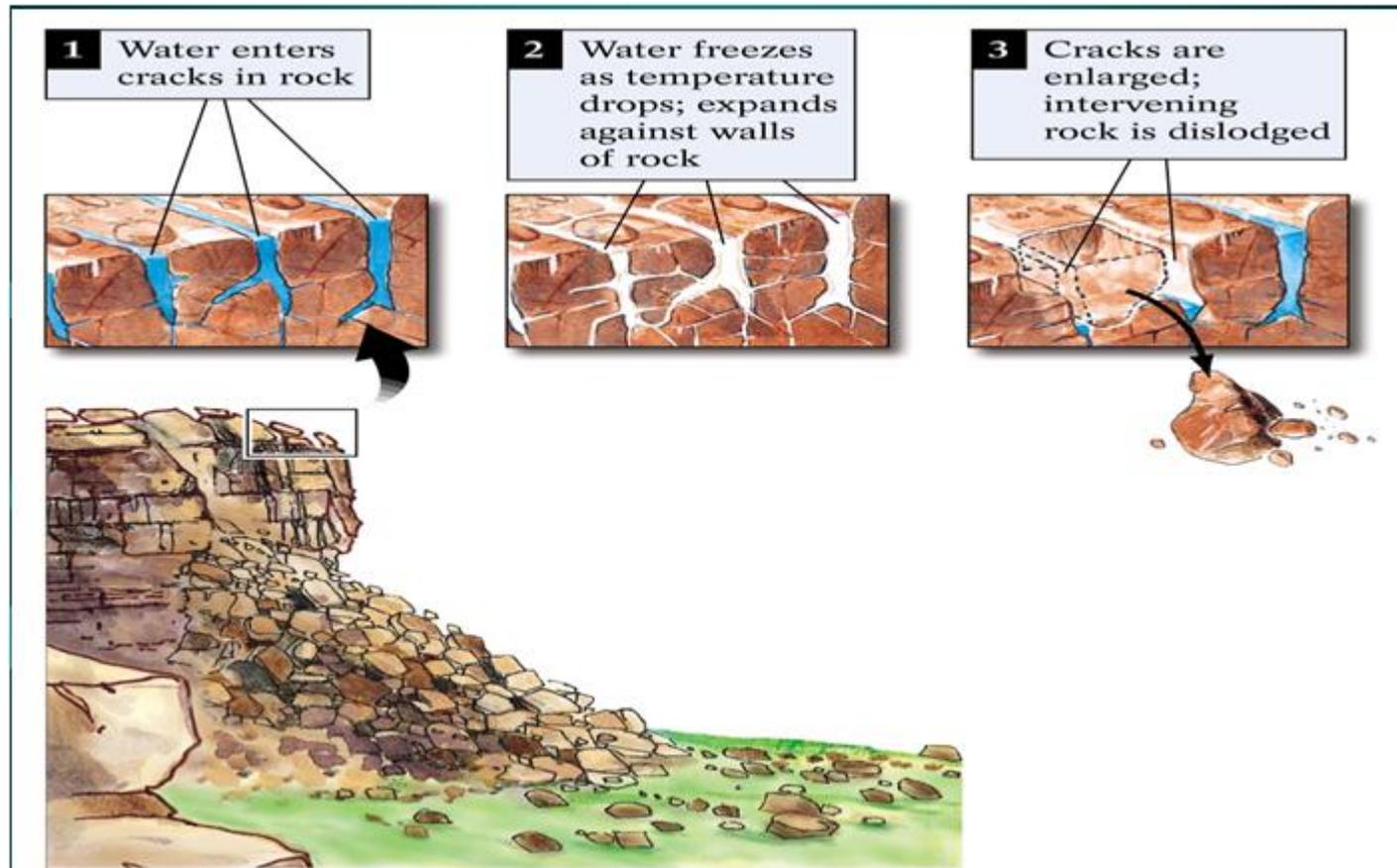
Mechanical Weathering: Exfoliation

- Exfoliation can occur both very slowly or very rapidly as a form of mass wasting.
- Large rocks characterized by exfoliation are commonly referred to as **exfoliation domes**.



Mechanical Weathering: Frost Wedging

- **Frost wedging** is a mechanical weathering process caused by the freeze-thaw action of water that is trapped between cracks in the rock.



Mechanical Weathering: Frost Wedging

- This process gradually weakens, fractures, and breaks the rock through **repetitive freeze-thaw weathering cycles**.
- Frost wedging generally produces angular blocks and **talus**



Temperature Changes

- This process is more common in desert climates because they experience extreme fluctuations in daily temperature changes.
- Temperature changes are often not the dominant form of weathering, but instead temperature changes tend to accelerate other forms of weathering already occurring.

Mechanical Weathering: Salt Wedging

- **Salt wedging** occurs when salts crystallize out of solution as water evaporates. As the salt crystals grow, they apply pressure to the surrounding rock weakening it, until it eventually cracks and breaks down, enabling the salt crystal to continue growing.
- Salt wedging is most common in **drier climates, high evaporative climates**, such as deserts.

These salt crystals were found growing between rock fractures in California's Death Valley.



Mechanical Weathering: Abrasion

- **Abrasion** occurs when rocks collide against each other while they are transported by water, glacial ice, wind, or gravitational force.
- The constant collision or gravitational falling of the rocks causes them to slowly break apart into progressively smaller particles.
- **Flowing water** is the primary medium of abrasion and it produces the 'rounded' shape of fluvial/coastal sediments.

Abrasion processes in creek beds produce rounded boulders and cobbles. Over time, abrasion processes will eventually break these rocks into progressively smaller particle sizes, such as gravel, sand, silt, and clay.



Photo Source: SCGS

Mechanical Weathering: Abrasion

- During abrasion, rocks may also weather the bedrock surface they are coming into contact with as well as breaking into smaller particles and eventually individual grains.
- Bedrock weathering through abrasion may produce a smooth surface.



Types of Chemical Weathering

Chemical weathering decomposes, dissolves, alters, or weakens the rock through chemical processes to form residual materials.

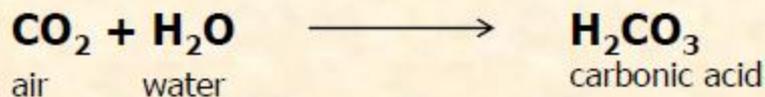
Stalactite and stalagmite joining together in Onondaga Cave State Park, Missouri.

- Carbonation
- Hydrolysis
- Hydration
- Oxidation
- Solution



Chemical Weathering: Carbonation

- Carbonation is a process by which carbon dioxide and rainwater or moisture in the surrounding environment chemically react to produce carbonic acid, a weak acid, that reacts with carbonate minerals in the rock.
- This process simultaneously weakens the rock and removes the chemically weathered materials.



Influenced by:

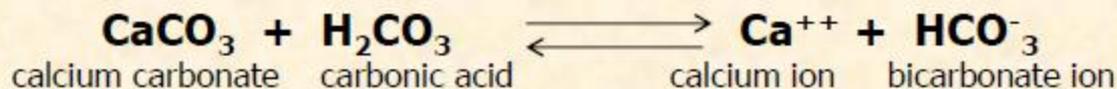
Temperature

Pressure

Partial pressure of CO₂

pH

Ion concentration



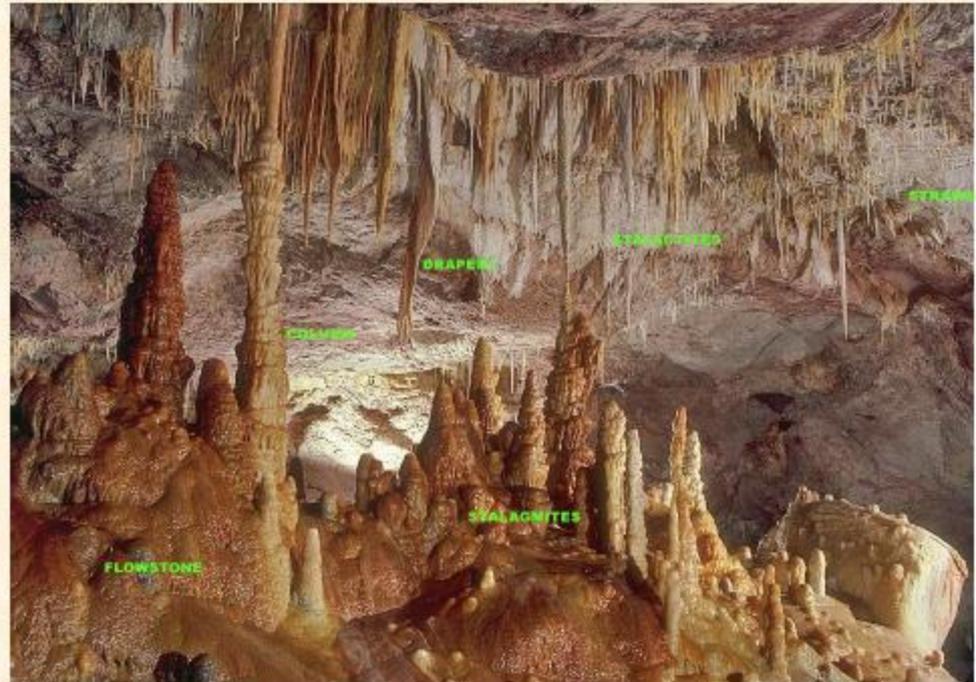
Chemical Weathering: Carbonation

- Carbonation primarily occurs in wet, moist climates and affects rocks both on and beneath the surface.
- Carbonation occurs with limestone or dolomite rocks and usually produces very fine, clayey particles.

Limestone weathered by carbonation processes

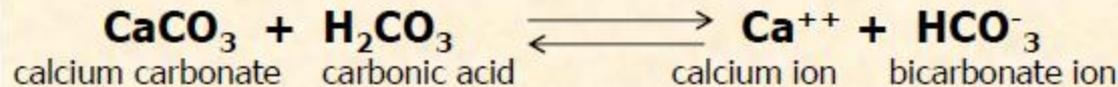
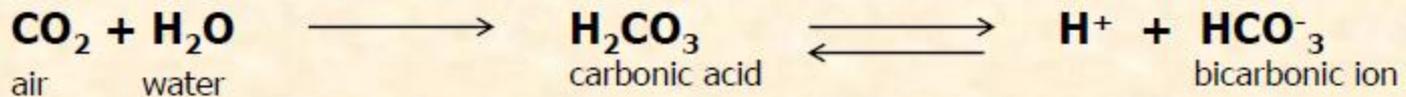


Photo source: Wikipedia GNU Free Documentation License



Chemical Weathering: Hydrolysis

- Hydrolysis is a chemical reaction between H^+ and OH^- ions in water and the **minerals** in the rock. The H^+ ions in the water react with the minerals to produce weak acids.
- The reaction creates new compounds which tend to be softer and weaker than the original parent rock material.
- Hydrolysis can also cause certain minerals to expand, which also facilitates mechanical weathering processes.



Chemical Weathering: Hydrolysis

- Hydrolysis commonly affects igneous rocks because they are composed of silicate minerals, such as quartz and feldspar, which readily combine with water.
- Hydrolysis may also be accompanied by **hydration** and **oxidation** weathering processes.
- The hydrolysis of feldspars produces kaolinite, which is a **clay**.

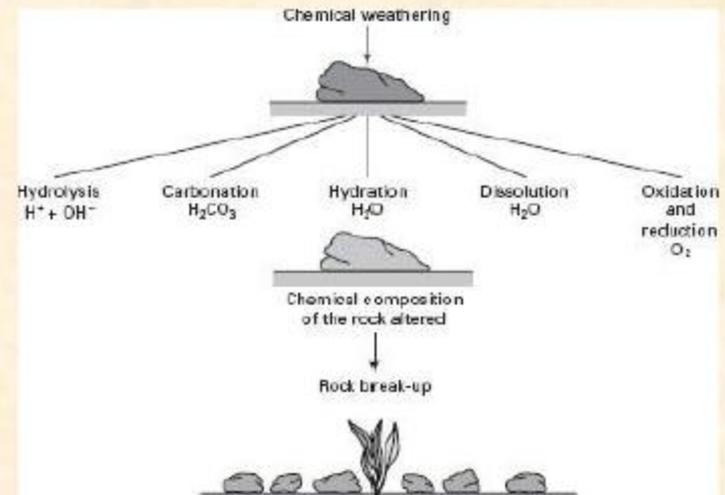
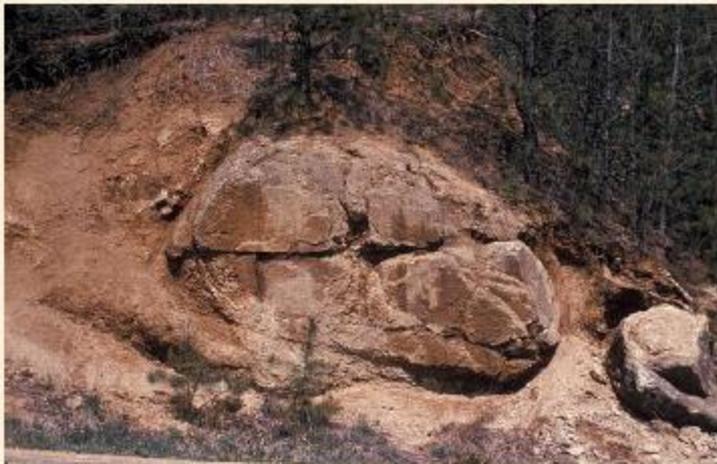


Photo Source: Dr. Hugh Mills, Tennessee Technical University



Chemical Weathering: Hydration

- Hydration is a process where mineral structure in the rock forms a weak bond with **H₂O**
- Mineral grains **expand**, increased **stress** promotes the **disintegration** of the rock.
- Often **color changes** in the weathered rock surface.



Chemical Weathering: Oxidation

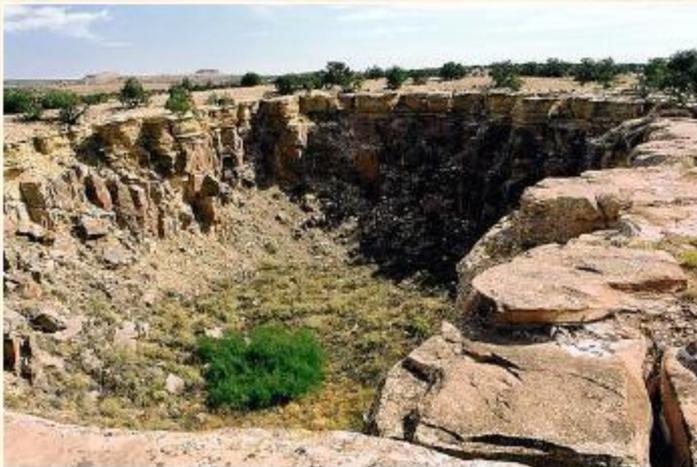
- Oxidation occurs when an ion in a mineral structure loses an electron to an oxygen ion.
- Common in iron bearing, rock forming minerals. Ferrous iron (Fe^{++}) oxidizes to ferric iron (Fe^{+++})
- Oxidation accelerates rock decay, rendering it more vulnerable to other forms of weathering.



Chemical Weathering: Solution

- Solution occurs when minerals in rock dissolve directly into water.
- Solution most commonly occurs on rocks containing **carbonates**, also affects rocks with large amount of halite, or rock salt.
- Solution of large areas of bedrock may cause sinkholes to form, where large areas of the ground subside or collapse forming a depression.

Subsurface dissolution of halite has caused overlying rocks to collapse and form crater-like features.



This is an example of a limestone solution karst feature found in Florida's Everglades National Park.



Biological Weathering

Biological weathering is the disintegration or decay of rocks and minerals caused by chemical or physical agents of organisms.

- Organic activity from lichen and algae
- Rock disintegration by plant growth
- Burrowing and tunneling organisms
- Secretion of acids

Biological Weathering

Biological weathering is the disintegration or decay of rocks and minerals caused by chemical or physical agents of organisms.

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- Secretion of acids

- This bio-chemical weathering process leaches minerals from the rock causing it to weaken and breakdown.



This is an example of biological weathering that is caused by mosses and lichen growing on the face of a rock.



- The decaying of plant materials can also produce **acidic compounds** which dissolve the exposed rock.
- Organism growth across the surface may also exerts a small amount of **abrasion** and pressure that gradually cause the **mechanical weathering** of the rock.

- Plant roots penetrate into cracks and crevices of rocks and cause the rock to split or break into smaller particles through mechanical weathering.
- Process enhanced in rocks that may already have a pre-existing weaknesses such as fractures, faults, or joints.



This is an example of a tree that is growing between a crevasse in a rock. The tree is splitting the rock along parallel planes of alignment that are already weakened by foliation processes, a form of mechanical weathering.