

Physical Weathering and Mass Wasting

Processes - continually removing materials from higher elevations and moving them to lower elevations including:

1. **Weathering** - the disintegration (physical alteration) and decomposition (chemical alteration) of rock at or near Earth's surface.
2. **Mass Wasting** - the transfer of rock material downslope under the influence of gravity.
3. **Erosion** - the incorporation and transportation of material by mobile agents such as water, wind, or ice.

Weathering

Weathering occurs when rock is mechanically fragmented (disintegrated) and chemically altered (decomposed).

1) **Mechanical weathering** - physical forces break rock into small pieces without changing rock's mineral composition.

Generally proportional to elevation.

Higher elevation → greater physical weathering.

2) **Chemical weathering** - transformation of the rock into one or more new compounds.

Why Rocks Weather

Weather in response to a changing environment. Most minerals or rocks at or near the earth's surface are in an environment which is dramatically different from the one they are formed at.

Weathering - the process of rock and mineral alteration to more stable forms under the variable conditions of moisture, temperature, and biological activity which prevail at the earth's surface.

Mechanical Weathering

Involves the breaking of rock into smaller and smaller pieces, each retaining the characteristics of the original rock.

The end result is many small pieces from a single large one.

Note: This breakage increases the surface area of the original rock available for chemical attack.

Four natural ways to mechanically deform rock:

1) **Frost Wedging:**

Results from alternating cycles of freezing and thawing.

Water expands ~10% as it freezes; exerts a tremendous outward force as it expands.

In nature, water works its way into cracks or voids in rocks, freezes, and breaks the rock into angular fragments. This process is called **frost wedging**.

Most pronounced in mountainous regions in mid-latitudes where daily freezing-thaw cycles exist.

In these regions, sections of rock break loose and accumulate in big piles called **talus slopes** that form at the base of steep rock outcrops

2) Unloading:

When large igneous bodies (e.g. granite) are exposed to erosion, concentric slabs begin to break loose.

This process is called **sheeting** - it occurs because of the great reduction in pressure when the overlying rock is stripped away.

After the unloading, the outer layer expands more rapidly than the rock below and are separated from the rock body.

Layers that result are >1m thick.

Fractures develop parallel to topography and gives body a domed shape.

These large structures are - **exfoliation domes**.

3) Thermal Expansion:

the daily cycle of temperature change is thought to weaken rocks.

Heating causes expansion, and cooling causes contraction.

This is a minor weathering process which has more importance in the desert where there are more major chemical variations.

4) Organic Activity

Plant roots grow into fractures, and wedge rocks apart.

Burrowing animals move fresh material to the surface.

Mass Wasting

Mass Wasting

the downslope movement of rock, regolith, and soil under the direct influence of gravity. It differs from erosional processes in that it does not require a transporting medium. It typically follows weathering.

Once weathering weakens and breaks rocks apart, mass wasting transfers the debris downslope, where a stream usually carries it away. The sediment is ultimately transferred to the sea.

It is combined effects of mass wasting and running water that produce stream valleys (the most conspicuous landforms at the earth's surface).

If it were only the streams that created the valleys, most of them would be much narrower; however, most river valleys are wider than they are deep is a strong indication that mass wasting processes is significant in supplying material to streams.

Gravity is major controlling force of mass wasting.

Other factors are important in aiding the downslope movement of material, including:

1) Water - when the pores in sediments become filled with water, the cohesion among the particles is destroyed, allowing them to slide past one another with relative ease.

Thus, saturation reduces the internal resistance of minerals, which are easily set in motion by the force of gravity.

Water is a lubricant. When clay is wetted, it becomes very slick. Water also adds considerable weight to a mass of material. The added weight in itself may be enough to cause the material to slide or flow downslope.

Oversteepening of slopes is another cause of mass movements. Loose, undisturbed particles assume a stable slope called the **angle of repose**, the steepest angle at which material remains stable. It is typically 25-40°. If the angle is increased, the rock debris will adjust by downslope movement.

Classification of Mass Wasting Processes

Classification is based on: 1) the type of material involved; 2) the kind of motion displayed, and 3) the velocity of the movement.

Type of Material

Simple differentiation of bedrock vs. unconsolidated material.

If bedrock breaks loose call it **rock**;

If soil or regolith use terms as such as **debris, mud, or earth**.

Type of Motion

The way a material moves can be important.

The types of movement include a **fall, slide, or a flow**.

A fall involves the free-fall of detached individual pieces of any size.

Common movement on steep slopes. Can be the result of freeze-thaw cycles or root wedging. Primary mechanism for the building and maintenance of talus slopes.

A slide occurs when material remains fairly coherent and moves along a well-defined surface. This can be a joint, fault, or bedding plane that is approximately parallel to the slope.

A **slump** involves the movement along a curved surface of rupture.

A flow occurs when material moves downslope as a viscous fluid. Most flows are saturated with water and typically move as lobes or tongues.

Rate of Movement

The most rapid type of mass movement is termed a **rock avalanche**.

Material is believed to "float on air" as they move downslope. Material moves as a buoyant flexible sheet across the surface. Most mass movements are imperceptibly slow. e.g. creep is measured in mm - cm/year.

SLUMP

refers to the downward sliding of a mass of rock or unconsolidated material moving along a curved surface.

Usually the slumped material does not travel far or fast.

This is a common form of mass wasting, especially with thick accumulations of cohesive material such as clay.

The surface of rupture is characteristically spoon-shaped.

As the movement occurs, a crescent-shaped scarp (cliff) is created at the head and the block's upper surface is sometimes tilted backwards. It typically consists of multiple blocks.

Slumps commonly occur because a slope has been oversteepened.

Slumps may also occur when a slope is overloaded, causing internal stress on the material below.

This type of slump often occurs where weak, clay-rich material underlies layers of stronger, resistant rock such as sandstone.

ROCKSLIDES

occur when blocks of bedrock break loose and slide down a slope. Termed **debris slide** if it is unconsolidated.

These events are some of the fastest and most destructive of the events.

Usually occur where rock strata are inclined, or joints and fractures exist parallel to the slope.

Sometimes they are triggered when rain or melting snow lubricates the underlying surface and reduces the friction.

Common in Spring when heavy rains and melting snow are most prevalent.

Earthquakes are another mechanism to trigger rockslides.

MUDFLOW

a relatively rapid type of mass wasting that involves a flowage of debris containing a large amount of water.

They are characteristic of semiarid mountain regions where there is little vegetation to anchor the material, and because of their high water content and the predominance of fine particles, tends to follow canyons and gullies.

The end product is a flowing tongue of well-mixed mud, soil, rock and water.

The rate of flow depends on slope and water content.

Pose a serious hazard to development in dry mountainous areas such as Southern California where construction on hill slopes and the removal of vegetation by brush fires has increased their frequency.

Builds up fan like structures called alluvial fans in the valleys at the base of canyons.

Termed **lahars** on the slopes of volcanoes-formed when ash and debris become saturated and unstable, and generally follow existing stream valleys

EARTHFLOW

Most often form on hillsides in humid areas during times of heavy precipitation and snowmelt.

When water saturates the soil and regolith on a hillside, the material may break away leaving a scar on the slope and forming a tongue - or teardrop-shaped mass that flows downslope.

The materials most commonly involved are rich in clay and silt and contain only small proportions of sand and gravel.

Vary in size from meters to kilometers.

Because they are viscous they generally move at relatively slow rates.

They are characterized by slow and persistent movement and may remain active for periods ranging from days to years. Velocities range from 1mm - meters/day.

In addition to occurring as isolated hillside phenomena, they take place in association with large slumps where they may be seen as tongues at the base of slumps.

CREEP

A type of mass wasting that involves the gradual downhill movement of soil and regolith.

Primary cause for creep is the alternate expansion and contraction of surface material caused by freezing/thawing or wetting/ drying. Freezing and wetting lifts particles at right angles to slope, and thawing and drying allows particles to fall back to slightly lower level.

Each cycle therefore moves the material a short distance downhill. Very slow process which cannot be observed in action.

Solifluction

A form of mass wasting that is common in regions underlain by permafrost.

Permafrost refers to the permanently frozen ground that occurs in association with the earth's harsh tundra and ice cap climates.

Solifluction may be regarded as a form of creep in which water-saturated material gradually moves downslope.

Solifluction occurs in a zone above the permafrost called the **active layer**, which thaws in the summer and refreezes in the winter. During the summer, water is unable to percolate into the impervious zone below; as a result the active layer begins to flow.