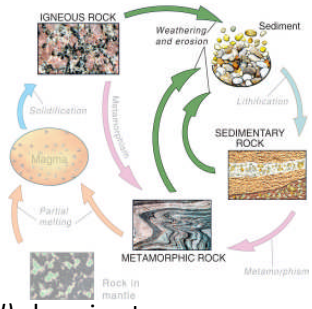
Chapter Outlines

NOTE: This is intended to help students 'organize' their understanding of each topic. It is <u>not</u> a comprehensive study guide for quizzes or midterms, i.e. <u>study your text!</u>



The Rock Cycle

Weathering, Soil, Mass Wasting

I. Earth's external processes include:

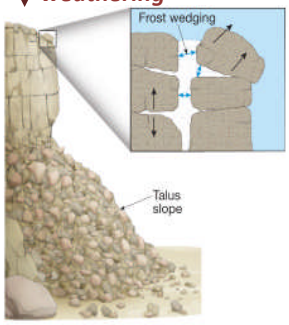
A. **Weathering**— the process of Earth material *(formerly deeply buried rock/mineral)* changing to become more stable in its new surface environment…or simply, the breakdown over time of rock at Earth's surface to form sediment. It is the result of interactions of air, water, and temperature on exposed rock surfaces.

1. Generally, the further a mineral is from its environment *(conditions)* of origin, the more unstable it is and therefore more susceptible to weathering
2. Weathering results in Earth materials becoming small enough to be eroded, transported, and to settle in low areas to eventually become sedimentary rock
3. Driving forces for weathering include:
   a. Tectonic forces…pushing deeply buried rock up forming mountains and thereby exposing them to Earth's surface environment
   b. The Sun… indirectly responsible for wind, rain, glaciers, various climates, and vegetation

B. **Mass wasting**—the mass transfer of rock material downslope under the influence of gravity

C. **Erosion**—the movement of particles followed by the transportation of material by a mobile agent, usually water, wind, or ice *(glaciers)*

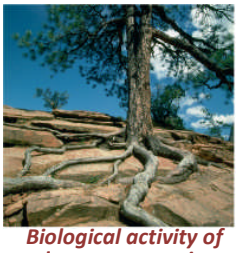
Example of mechanical weathering



II. **Weathering** - Two kinds of weathering:

1. **Mechanical weathering** – breaking of rocks into smaller pieces
   Processes include: frost wedging, unloading, biological activity, salt crystal growth
2. **Chemical weathering** - chemical changes in rocks/minerals as Earth materials react at the surface with Earth's surface environment, principally carbon dioxide, oxygen, and water. It involves decomposition of minerals, and often formation of new minerals. The most important reactions occur by oxidation or hydrolysis *(both CO_2 and oxygen are highly reactive components of the atmosphere):*
   a. **Solution weathering** *(affects calcite/limestone)*
      i. Acidity is key, CO2 in the atmosphere makes all rain acidic
      iii. $CaCO_3$ *(calcite/limestone)* dissolves to ions
      iii. Generalized reaction: $H_2CO_3 + CaCO_3 \rightarrow$ the ions Ca^{++} and HCO_3^-
   b. **Oxidation** *(includes rust)*
      i. Oxygen from the atmosphere combines with iron to form iron oxide.
      ii. Generalized reaction: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$
   c. **Hydrolysis** *(affects silicate minerals)*
      i. Reaction between water *(acidic from CO_2 in the atmosphere or ground)* and minerals
      ii. Feldspars *(and other silicate minerals)* dissolve to clay and other products
      iii. Sample reaction: $2KAlSi_3O_8 + 2H_2CO_3 + 9H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 4H_4SiO_4 + 2K^+ + 2HCO_3^-$

Result of chemical weathering



Biological activity of plant roots causing mechanical weathering

3. Mechanical and chemical weathering usually occur together, with their effects being interrelated
   Example: Granite weathers to clay, quartz sand, and dissolved ions. *(Mineral stability usually follows Bowen's reaction series, but in reverse)*
4. Rates of weathering
   a. Surface area; more surface area = faster weathering
   b. Climate; warmer and wetter = faster weathering
   c. Parent materials; Bowen's Reaction Series gives the general trend, but in reverse
   d. Presence of plants and animals; more plants = faster weathering
   e. Topography; steeper gradient = faster weathering due to quick removal of weathered material
   f. Composition – variations cause differential weathering and occasional dramatic landscapes

Mechanical weathering only breaks material into smaller fragments

III. When rock weathers in-place and is not transported away, a **soil profile** will form.

A. It normally consists of *(these classifications often vary!):*

O - horizon – the organic material at and near the surface

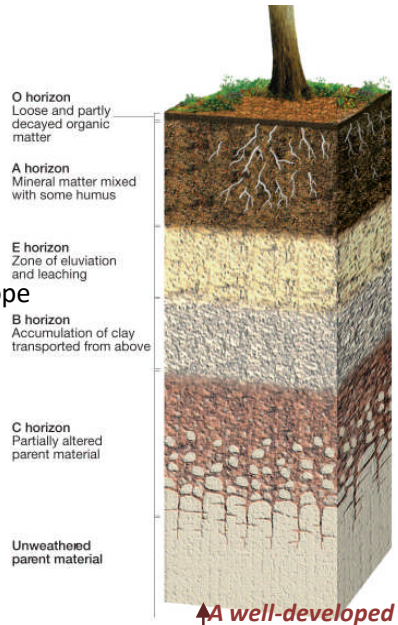
A - horizon – surface soil

E - horizon – leaching downward from the A to the B.

B - horizon – Subsoil: this layer accumulates iron, clay, aluminum and organic compounds

C - horizon – fragments of bedrock partially decomposed **unweathered** parent material

Photo of an O, A & E soil profile

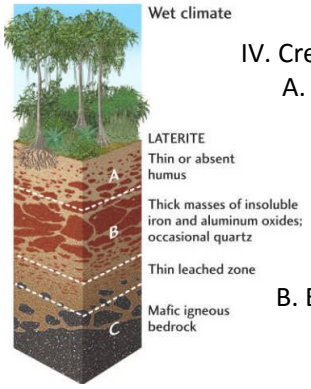


A well-developed soil profile

B. Factors affecting soil type are: climate, parent material, time, and slope

C. Soil erosion

1. Part of the recycling of Earth materials
2. Natural rates of erosion depend on: soil characteristics, climate, slope, and type of vegetation
3. Soil erosion and sedimentation can cause
   a. Reservoirs to fill with sediment
   b. Concentration of contamination by pesticides and fertilizers



Example of a laterite

IV. Creation of **ore deposits** by weathering

A. Process called ***secondary enrichment***

1. Metals are concentrated into economic deposits
2. Two mechanisms *(the resulting soil sequence is often called a '**laterite**')*
   a. Weathered material is removed from the decomposing rock, leaving the desired elements behind
   b. Desired elements are carried *(leached)* to lower zones and deposited

B. Examples

1. Bauxite, the principal ore of aluminum
2. Many copper and silver deposits

The top dark brown layer is an example of secondary enrichment

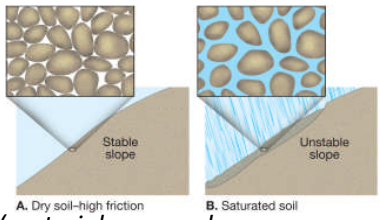
V. **Mass wasting**

A. The downslope movement of rock, regolith, and soil under the direct influence of **gravity** *(the controlling factor)*. Weathering weakens rock and produces a layer of rock debris called regolith. Mass wasting provides a *short distance* transit system for regolith. Streams are the *long distance* transit system for regolith

A devastating debris flow

B. Important triggering factors:

1. Saturation of the material with water destroys particle cohesion and water adds weight
2. Slopes become unstable if they exceed their **angle of repose**.
3. Removal of anchoring vegetation
4. Ground vibrations from earthquakes



Addition of water 'mobilizes' soil particles

D. Types of mass wasting processes. Generally, each type is defined by:

a. The material involved: debris, mud, earth, or rock

b. The movement of the material: **fall** *(free-fall of pieces),* **slide** *(material moves along a well- defined surface),* or **flow** *(material moves as a viscous fluid)*

c. The rate of the movement: slow *(regolith/creep can move < 1cm/year),* to fast *(thundering avalanches of over 125 mph)*

2. Forms of mass wasting

Slump – rapid movement along a curved surface

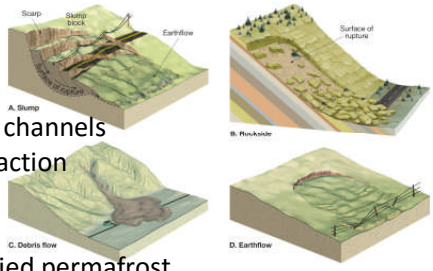
Rockslide – rapid movement of bedrock blocks down a slope

Debris flow – rapid flow of debris with water, often confined to channels

Earthflow – rapid flow of water-saturated soil. Similar to liquefaction

Creep – very slow movement of soil and regolith downhill
- causes fences and utility poles to tilt

Solifluction – slow movement of saturated surface soil over buried permafrost



Examples of mass wasting

Surface layer 'creeps' downslope