

**UNIT: WEATHERING, EROSION, DEPOSITION NOTEPACKET**

- A. **Weathering** - the breakdown of rocks and minerals into smaller particles called sediments
1. Weathering represents a rocks response to changing environmental conditions
  2. Weathering will occur whenever a rock is exposed to the atmosphere, hydrosphere, or biosphere - (the rock itself is part of the lithosphere)
- B. There are 2 primary types of weathering:
1. **Physical/Mechanical Weathering** - the breakdown of rocks and minerals into smaller particles sizes without a change in chemical composition - it results in a reduction of particle size, only
    - a. **frost/ice wedging** - water expands when it freezes and splits rocks like a wedge
    - b. **root wedging** - roots grow and expand into crevices, exerting pressure as they do
    - c. **exfoliation** - when the weight of overlying material is removed the rocks outer surface peels off
    - d. **abrasion** - rock particles that are carried along by water, wind or ice bump and rub against one another and wear each other down
  2. **Chemical Weathering** - the breakdown of rocks and minerals into smaller particle sizes by chemical action with a distinct change in the chemical composition of the sediment - results in a change of chemical composition as well as a reduction of particle size - the sediments are different chemically from the unweathered, parent rock
    - a. **oxidation** - elements in rocks and minerals combine with oxygen and break down
    - b. **hydration** - elements in rocks and minerals combine with water and break down - water dissolves many Earth materials
    - c. **carbonation** - carbon dioxide dissolves in water to form carbonic acid
    - d. **other acids** - oxides of sulfur dissolve in water to produce sulfuric acid  
oxides of nitrogen dissolve in water to produce nitric acid
    - e. **biosphere** - lichens and mosses secrete acids that dissolve rocks and minerals

Facts about chemical weathering;

1. it is more severe than physical/mechanical weathering
2. carbon dioxide, oxides of sulfur and oxides of nitrogen are all added to the

atmosphere by the activities of man

3. air pollution leads to acid rain and enhances chemical weathering rates

C. There are 4 factors that influence the **type** and **rate** of weathering:

1. **Exposure (surface area)** - as the exposure of rocks and minerals to the atmosphere, hydrosphere, or biosphere increases, the rates of weathering increase
2. **Particle size** - as particle size increases, weathering rates decrease
  - a. this is because smaller particles have more surface area (outside) exposed to the elements than does an equal amount of larger particles
3. **Chemical composition**
  - a. granite is vulnerable to exfoliation
  - b. halite is vulnerable to hydrolysis
  - c. calcite is vulnerable to carbonic (and other) acids
  - d. quartz is resistant to physical and chemical weathering
  - e. iron bearing minerals are vulnerable to oxidation
4. **Climate** - the most important factor in weathering
  - a. cold, moist climates (like NYS) promote physical weathering - frost action
  - b. warm, moist climates promote chemical weathering
  - c. generally, the more moist a climate is, the greater the rates of both physical and chemical weathering

NOTE : Rocks that are resistant to weathering commonly produce landscape features like ridges and cliffs

- a. sandstone, quartzite, and many conglomerates are resistant rock types
- b. in dry climates, marble and limestone are resistant rock types

Rocks that are NOT resistant to weathering commonly produce landscape features with rounded shapes and valleys

- a. shales have little resistance to weathering
- b. limestone and marble weather quickly in moist environments

D. The products of weathering

1. **Solid sediments** - any particle large enough to be seen with the naked eye
  - a. boulders, cobbles, pebbles, sand, and silt
2. **Colloids/Clay** - small particles that remain in suspension when placed in water
  - a. the particles don't sink to the bottom, nor rise to the top - they stay where they are put - if the water is flowing, they move right along with the water molecules

3. **Ions** - any electrically charged particle
  - a. they are smaller than colloids - some are atom size or smaller
  - b. sodium ions and chlorine ions carried to the oceans by rivers and streams are what makes sea water salty
  - c. ions dissolved in ground water cause it to be "hard"

E. The most important product of weathering is soils - there are 2 major types

1. **Transported soil** - soils formed in one place and later moved to another place
  - a. many soils in North America formed in Canada and transported south by glaciers
  - b. worldwide, transported soils are the most common type
  - c. the chemical composition of a transported soil does NOT match the composition of the bedrock it sits upon
2. **Residual soil** - soils which form in place from the weathering of local bedrock
  - a. form in areas where running water, glacial ice, and wind are not readily available to move them
  - b. their chemical composition DOES match the composition of the bedrock it sits upon

### Soil Terminology

1. **Soil profile** - a cross-sectional view through the uppermost part of the lithosphere
2. Soil horizon - a horizontal sub-unit of a soil profile - a layer
  - a. a mature soil profile has 3 horizons:
    - 1) **A- horizon or topsoil** - a combination of all 3 weathering products + organic materials added by the biosphere
      - a) topsoil is dark in color due to organic component
      - b) contains humus - decayed plant and animal matter
      - c) has a high percentage of sand
    - 2) **B-horizon or subsoil**
      - a) a little lighter in color than topsoil - less organics
      - b) a high clay content
      - c) contains many dissolved minerals and elements
    - 3) **C- horizon or regolith**
      - a) made of slightly weathered rock fragments - gravel
      - b) sits upon the unweathered bedrock

## Soil Facts:

1. The biosphere contributes to soils in 2 ways:
  - a. it contributes organic matter to the topsoil
  - b. it aids in the weathering of rocks and minerals
    - 1) root wedging and lichens/mosses from the plant kingdom
    - 2) ants, earthworms, rabbits, woodchucks and other animals dig holes in the soil which allow air and water to reach the bedrock and weather it
2. Residual soils indicate that a long, undisturbed period of weathering has occurred in the area - such soils form very slowly

## F. **Erosion** - the process whereby sediments are transported

1. weathering produces the sediments, erosion moves them around
2. sediments displaced from their source is evidence that erosion has occurred
3. all erosion is done by an erosional system which consists of 3 parts:
  - a. **Transporting/Erosional agent** - something to move the sediment around
    - 1) running water - the most important, worldwide
    - 2) glacial ice
    - 3) wind
    - 4) gravity
    - 5) man
  - b. **Driving Force** - something to make the erosional agent move
    - 1) it's usually gravity - this makes water flow downhill, and in part, makes glacial move
  - c. The sediments to be transported

## G. Identifying the Erosional agent by examination of the sediments transported

### **Wind** as the transporting agent

- a. moves only the smallest particle sizes
  - b. the sediments are extremely well sorted
  - c. the individual grains are commonly "frosted" - covered with tiny scratches
2. **Glacial Ice** as the transporting agent
    - a. moves all particle sizes - ions to boulders
    - b. the sediments are completely unsorted - called glacial till
    - c. individual particles are scratched, grooved, polished or may have one flat side

3. **Running Water** as the transporting agent
  - a. moves a fairly narrow range of particle sizes - more than wind, less than ice
  - b. particles are fairly well sorted - better than ice, less than wind
  - c. particles are well rounded
4. **Gravity** as the transporting agent
  - a. particles are found at the bottom of steep slopes or cliffs
  - b. particles are large, angular, and unsorted

H. **Running water (the most important agent)** can transport sediments 3 ways:

1. **Solution** - ions are dissolved in the water
2. **Suspension** - clay/colloids are carried right along with the water molecules
3. **Saltation** - solid sediments are rolled or bounced along the bottom of the stream channel
  - a. the velocity of the sediments is less than that of the water because friction between the channel and sediments slows them down
  - b. **bed load** - the material moved along the bottom of the stream channel
  - c. **downcutting** - weathering and erosion accomplished by running water causes the stream channel to become wider and deeper
    - 1) downcutting depends on 2 factors:
      - a) the bed load - the greater the bed load, the greater the rate of downcutting
      - b) stream velocity - the greater the velocity, the greater the rate of downcutting

I. **Stream Drainage Patterns** - an aerial view of streams and their tributaries - 4 different types

1. **Dendritic drainage** - develops on flat-lying sedimentary rocks with uniform resistance to erosion - Mississippi River watershed
2. **Rectangular/Block/Trellis drainage** - develops on folded, faulted, or jointed rocks with varying resistance to erosion - central Pennsylvania & Adirondack Mountains!
3. **Radial drainage** - develops on domed mountains with uniform resistance to erosion - White Mountains of New Hampshire
4. **Annular** - develops on domed mountains with rocks of varying resistance to erosion - Black Hills of South Dakota

J. **Factors that influence erosional rates in running water and glacial ice**

1. **Slope of the land** - as the slope of the land increases, the velocity of these erosional

agents increase, the amount of erosion accomplished increases, and the maximum size of particles transported increases

2. **Volume** (size/amount) of the erosional agent - as the volumes of these erosional agents increase, their velocities increase, the amount of erosion accomplished increases, and the maximum size of particles transported increases
3. **Position** within the erosional agent
  - a. if a stream or valley glacier is flowing in a straight line, the greatest velocity is in the center, below the surface, and above the bottom - friction is why
  - b. where a stream or valley glacier turns, curves, or meanders, the greatest velocity is towards the outside of the turn or curve, a little beneath the surface and above the bottom - inertia and friction are why
    - 1) erosion is greatest on the outside of a turn due to high water velocity
    - 2) deposition (streams dropping their sediments) is greatest on the inside of a turn due to low water velocity
    - 3) stream channel shape is effected because of asymmetrical downcutting

Stream erosion is greatest at waterfalls

1. streams erode at waterfalls by a process called undermining
2. the water at the base of the falls (plunge pool) erodes the rock there, leaving the rocks at the top of the falls to overhang
3. these overhanging pieces break off, fall into the plunge pool, and the waterfall recedes further upstream
  - a. Niagara Falls is a worldwide example of this recession

K. Man as an erosional agent - man increases erosional rates of soils by:

1. **Forestry** - the practice of clear cuttings - all vegetation is removed and without roots to hold the soil in place, it rapidly is eroded away - especially on slopes
2. **Strip Mining** - removing the overburden to get to the coal below - without vegetative cover, loose sediments and soils are washed away
3. **Construction** - clearing the land by bulldozing before building on it causes erosion of soils
4. **Improper Farming Techniques** - not plowing land at right angles to slopes promotes erosion of soils
5. **Salting Highways** - the salt (used to melt ice) is washed off to the side where it accumulates in the soil and prevents vegetative growth

**Denudation** - the stripping away of the vegetative ground cover with the loss of the holding power of their root systems

- L. **Deposition** - the process whereby sediments are dropped or released by an erosional system
1. Most deposition of sediments occurs in standing bodies of water - oceans & lakes
  2. Deposition is caused by the loss of kinetic energy by the sediments
  3. Deposition is caused by the loss of velocity of the erosional agent

There are 3 factors that influence the rate of sediment deposition:

- 1, **Sediment size** - as sediment size increases, settling rates increase and settling time decreases
  - a. as an erosional agent loses velocity, larger particles are deposited before smaller ones
2. **Sediment density** - as sediment density increases, settling rates increase and settling time decreases
  - a. as an erosional agent loses velocity, more dense particles are deposited before lower density ones
3. **Sediment shape** - as sediment shape grades from flat, angular shapes to spherical shapes, settling rates increase and settling times decrease
  - a. as an erosional agent loses velocity, rounder particles are deposited before flat, angular ones

M. Special Depositional Products

1. **Graded Bedding/Vertical Sorting** - a situation where particle size decreases towards the top of the layer
  - a. this occurs when a stream/river enters a standing body of water and loses velocity abruptly
  - b. the sediments settle out according to the 3 rules above
2. **Horizontal Sorting** - a situation where particle size decreases as distance from the shoreline increases
  - a. this occurs when a stream/river enters a standing body of water and loses velocity gradually

Both of these can form when a density current flows down the continental shelf of the ocean floor

Density current - a sediment rich, high density fluid which flows down the continental shelf - it's just muddy river water

- a. some larger streams/river continue to flow underneath the ocean on or near

the ocean floor for many miles

3. **Delta** - a fan shaped deposit of sediments at a stream's mouth where it enters a standing body of water
  - a. deltas may contain hundreds of layers of sediments, some of which show graded bedding, horizontal sorting, or cross-bedding
4. **Alluvial Fan** - a fan shaped deposit of sediments formed where streams flow out of the mountains and on to flat, arid plains
  - a. a "land delta"
5. **Cross Bedding** - a situation where layers of sediments are deposited at angles to one another as a result of a change in the direction of the erosional agent
  - a. these are found in sand dunes as well as deltas and alluvial fans

#### N. An Ideal Erosional Depositional System

1. At point A, the greatest potential energy exists in the system because it's at the highest elevation above sea level
2. From A to E, potential energy is transformed into kinetic energy and erosion will occur
  - a. the greatest erosion will occur at B because it is at the bottom of the steepest slope where the water velocity will be the greatest
3. From E to F, kinetic energy is transformed back into potential energy and deposition will occur
  - a. the greatest deposition will occur around E because the stream loses velocity when it enters the ocean and drops it's sediments according to the 3 rules
4. From A to F, some energy is "lost" due to friction between the water and the stream channel and the water and the air
  - a. the heat generated by friction escapes into the surrounding environment
  - b. the total energy of this system decreases from A to F
5. At F, the least amount of total potential and kinetic energies exists
  - a. the lowest elevation means the least potential
  - b. the lowest water velocity means the least kinetic
6. Sea level is the limit to which erosion can occur in this system
  - a. this is called base level - the elevation of the point below which erosion cannot occur
  - b. below sea level it's deposition, not erosion, that is occurring
7. Erosion will occur whenever kinetic energy exceeds potential



8. Deposition will occur whenever potential energy exceeds kinetic
9. An ideal erosional depositional system is in dynamic equilibrium
  - a. the total amount of erosion = the total amount of deposition
  - b. if the total amount of erosion were to change, the total amount of deposition would change by an equal amount

## LANDSCAPES & GEOMORPHOLOGY

A. **Landscapes** - the features of the Earth's surface at the interface between the atmosphere, hydrosphere, and lithosphere - topographic refers to landscapes

Landscapes are divided into 3 groups on the basis of:

1. elevation above sea level
2. type of underlying bedrock and bedrock structure
3. stream drainage patterns

NOTE : regardless of the type of landscape, the age of the surface is almost impossible to determine

B. Landscapes are divided into 3 groups:

1. **Mountains/Highlands** - areas of high elevation with many changes in slope and areas of steep gradients
  - a. streams are small, with steep gradients and high velocities
  - b. thin topsoils, little sub-soil, lots of exposed bedrock
2. **Plateaus/Uplands** - areas of high elevation, horizontal rock structure, with more level slopes than mountains
  - a. streams have gradual to steep gradients with medium to high velocities
  - b. soils are thin to thick and fertile in stream valleys
3. **Plains/Lowlands** - areas of low elevation with low slopes and gradients
  - a. streams have low gradients, low velocities, and meandering paths
  - b. soils are thick with well developed horizons and are well suited for agriculture

NOTE : the boundaries or interfaces between different landscape regions are distinct and easily observed

C. Factors that influence landscape development

1. **Uplifting Forces** - those forces that originate in the crust and raise the land, build mountains, and cause continental growth
  - a. volcanic activity, isotasy/isostatic rebound, earthquakes, continental drift, sea floor spreading, diastrophism (includes folding, faulting, tilting of the crust)
2. **Leveling Forces** - those forces, operating on or near the surface which break down

rocks, transport sediments, and level the land

- a. weathering, erosion, deposition, subsidence, gravity

NOTE : leveling forces are always at work on the surface, while uplifting forces may or may not be operating at a particular time or place

3. **Time** - landscapes undergo stages of development

- a. **youth** - uplifting forces are dominant, folding and faulting common, mountains with steep slopes are forming, and streams have V-shaped valleys

- b. **maturity** - leveling forces are dominant, landscapes become more cut up by running water, elevations of features decrease, downcutting of stream channels decreases, and lateral (sideways) erosion of stream channels increases

- c. **old age** - leveling forces are still dominant but at a lower rate, lower elevations than maturity, and lower slopes and gradients

- 1) peneplain - flat land at very low elevations - it's about as low and flat as weathering and erosion can ever get the land to be

- 2) **meanders, oxbow lakes** on broad flood plains are common features

- d. rejuvenation - uplifting forces are again dominant, elevations increase, streams gain new energy and step sided channels are formed

4. **Climate - the most important factor**

- a. arid climates - steep, angular slopes with sharp landscape features, sand dunes, intermittent streams, soils are thin, sandy, high in mineral salts and light in color

- b. humid climates - rounded slopes and smooth landscape features, permanent streams with high discharge values, soils are thick and well developed, high in organic content and dark in color

- c. glacial climates - covered earlier

5. **Rock Types and Structures**

- a. rocks which are highly resistant to weathering and erosion form ridges & cliffs

- b. rocks with low resistance to weathering and erosion form valleys and stream channels

- c. the underlying rock structure in an area determines the stream drainage pattern

6. **Man**

- a. denudation promotes soil erosion

- b. abuse of pesticides leads to unfavorable changes in the biosphere

- c. deforestation alters the landscape and the atmosphere
- d. air pollution decreases available solar energy
- e. burning fossil fuels enhances the greenhouse effect and global warming

#### **D. Human Population**

- A. at the time of the industrial revolution 2 things happened:
  - 1. farmers were able to produce more food at lower costs than ever before
  - 2. advance in medicine reduced infant mortality and greatly reduced death from diseases like tuberculosis, pneumonia, and smallpox
- B. at that point, human population took off
  - 1. by 1850, world population reached a billion
  - 2. by 1930 (less than 100 years later) it hit 2 billion
  - 3. by 1975 (40 years later) it hit 4 billion
  - 4. by 2000 (25 years later) it stands at 6 billion, and climbing
- C. Earth's population cannot continue to increase at this pace
  - 1. we exhaust all space, food, and energy resources
  - 2. as wealth spreads to less developed countries (where the population is growing at the greatest rate) it is likely that populations and their demands on the environment will stabilize

#### **E. New York and the Ice Ages**

- 1. Over the last 2 million years, NYS has experienced 4 separate ice ages
  - a. evidence suggests that ice ages have occurred at other times and in other places during the Earth's long history
- 2. **There are 2 types of glaciers:**
  - a. **valley/alpine glacier** - a long, slow-moving, wedge shaped stream of ice that occupies a valley between mountains
  - b. **continental glacier/ice sheets** - a large mass of ice covering large portions of whole continents so that only the highest mountain peaks remain uncovered
    - 1) most glacial features in NYS are a result of continental glaciation
- 3. **Glaciers move for a number of reasons:**
  - a. valley glaciers move under the influence of gravity - downhill
  - b. glaciers also exhibit plastic flow - under the pressure of the weight of overlying ice, solids behave like thick liquids and flow outward in all directions
  - c. at the bottom of glacial ice, pressure causes some melting, ice grains slip and slide past each other and the whole mass moves

#### 4. Glacial features

- a. striations - large, parallel scratches in bedrock formed when sediments carried in glacial ice are dragged across the bedrock
  - 1) striations show the direction that the ice sheet advanced (N to S)
  - 2) really fine striations are called glacial polish
  - 3) really deep striations are called glacial grooves
- b. **glacial trough** - a U-shaped valley produced by valley glaciation
  - 1) waterfalls are common where tributaries empty into a trough
- c. **till** - unsorted and unstratified rock materials deposited directly by ice
- d. **outwash** - sorted and stratified deposits made by streams of glacial meltwater
- e. **terminal moraines** - piles of unsorted soil and rock that mark the farthest advance of the ice sheets
  - 1) **Long Island** is part of a terminal moraine
  - 2) The **Finger Lakes** of central NYS are valleys dammed by terminal moraines
- f. **drumlins** - long, smooth, teardrop shaped hills made of till
  - 1) they are found in swarms - advancing glaciers ran over pre-existing moraines left from previous glacial advances
  - 2) the long axis of the drumlins points in the direction of the advance
- g. **outwash plains** - broad, flat areas of stratified deposits left by glacial meltwater
- h. eskers - long, winding ridges of sediments that mark the location of meltwater streams flowing in tunnels underneath the ice
- i. kames - small, cone-shaped hills of stratified sand and gravel
- j. **kettles** - circular hollows found on moraines and outwash plains
  - 1) form when blocks of glacial ice are buried with sediments, then melt, and the sediments slump into the cavity that is left
- k. **kettle lakes** - lakes that form when kettles fill with liquid water
- l. **erratics** - large boulders dropped by glacial ice sheets that don't match the bedrock upon which they rest

#### F. Coastal Processes

- 1. The edges of the oceans are places of rapid change as a result of waves and currents

- a. the vast majority of ocean waves are caused by winds
  - b. the height of waves depends on 3 factors, the length of time the wind blows, the length of open water over which the wind blows, & wind velocity
2. Waves “break” when they near shore because the bottom of the water in the wave drags along the sea floor and slows down while the top doesn’t
- a. the energy carried by breaking waves changes the sediments along the beach
  - b. the sediments are abraded, rounded, and reduced in size
3. Most waves strike the shoreline at an angle
- a. the motion of the water up the beach is called swash - remember, it’s at an angle to the beach
  - b. the motion of the water back down the beach is called backwash - it’s directly back towards the ocean - at right angles to the ocean
    - 1) a severe backwash is called an undertow
  - c. repeated breaking waves push water forward at angle and backwards perpendicular to the shore
  - d. this results in a current moving almost parallel to the shore called a **longshore current** - the resulting motion of the sediment is called “**longshore drift**”
4. **Longshore currents** transport much sediment down the beach, parallel to the beach
- a. the current can carry enough sand to form a sandbar across the mouth of a bay - a bay is just an indentation in the shoreline
  - b. a **spit** is a sandbar attached to the land at one side of the bay
  - c. a **baymouth bar** is a sandbar that completely crosses the bay
  - d. a spit with a curved end is called a hook
  - e. **barrier islands** are large sandbars running parallel to the shore but not connected to the shore directly - form where the beach is straight
  - f. lagoons - the water behind a sandbar that is protected from wind and waves
    - 1) Fire Island in NYC
    - 2) Miami Beach, Fla.
    - 3) Padre Island, Tex. Is 100 miles long
5. **None of these features mentioned above are permanent**
- a. longshore currents destroy as well as form such features
    - 1) if sand is not replenished by rivers & streams, the currents carry away what is there
  - b. severe storms like hurricanes can radically modify coastal features

- c. pounding waves remove sand, too
  - d. a seasonal cycle exists - generally deposition of sand in the summer,  
erosion of sand in the winter (strong storms)
6. **Jetties/Groins** - structures of rock jutting out into the ocean at right angles to the shoreline
- a. in theory, they prevent sand from being carried away by longshore currents
  - b. in reality, sand is deposited on one side of the jetty and carried away from the other side
  - c. the beach actually is eroded away as a result
  - d. in addition they cause the waves to strike the beach at a steeper angle and the waves have more energy to carry sand away in the backwash
7. The solution - don't build permanent structures on beaches, bars, or barrier islands!