Topic 9 Section 1

Overview: weather plays a large role in the rock cycle. The actions of humans, other living things, and weather cause rocks to break into smaller pieces which eventually are carried to the ocean as sediments which will form sedimentary rock

Weathering – the chemical and physical breakdown of rocks at or near Earth's surface

Chemical weathering – the breakdown of rock through a change in mineral or chemical composition

Oxidation is a common form of chemical weathering

Dissolution by water can lead to chemical weathering

Decaying leaves can form acids that cause chemical weathering

Carbon dioxide dissolves in water forming carbonic acid which causes chemical weathering, especially the weathering of carbonates (calcite, marble, and limestone)

Carbonic acid dissolution of limestone and marble can cause sinkholes and caves and can, indirectly, form limestone terraces and limestone 'icicles' or stalactites

Physical weathering – the breakdown of rock into smaller pieces without chemical change

Some common causes of physical breakdown of rocks include:

- frost action – the freeze thaw cycle – water fills small crack then expands when it freezes causing the cracks to enlarge (the freeze thaw cycle combined with pressure from car tires when the ice thaws causes potholes in roads)
- tree and other plant roots
- pressure changes – mining, cave formation, erosion, glacial melting will reduce the pressure on rocks allowing them to expand and crack
- abrupt temperature changes cause the surface of rocks to expand while the interior does not expand
- abrasion – as gravity, running water, or wind carry rock particles over other rocks, grinding or abrasion occurs resulting in rounding angular rock edges

Factors affecting the rate and type of weathering – these factors include variations in location, composition, size of rocks, and climate conditions

Exposure – rate and type of weathering depend on the exposure of rocks to water and air

Generally, the closer to the Earth's surface the faster weathering will occur

In the Northern Hemisphere, the south faces of mountains will be exposed to more insolation and moisture which results in different types of weathering and different type of soil formation

Particle size – smaller particles have more surface area which increases exposure and therefore increases the rate of weathering

Mineral composition – carbonates weather very fast due to natural formation of carbonic acid while quartz is resistant to acid chemical weathering

Climate

Chemical weathering occurs most in warm moist climates

Cold climates with a freeze thaw cycle allow frost action to become significant but if it is so cold that thawing does not occur, frost action becomes insignificant

Generally, the warmer the climate the faster weathering occurs

Soil formation

Soil – a mixture of rock particles and organic matter on Earth's surface that supports rooted plants

Soils can form in place as a result of weathering

Living things play a role in soil formation – burrowing animals increase exposure to water and air, plant roots widen cracks in rocks, decaying leaves and plants form acids that dissolve rock

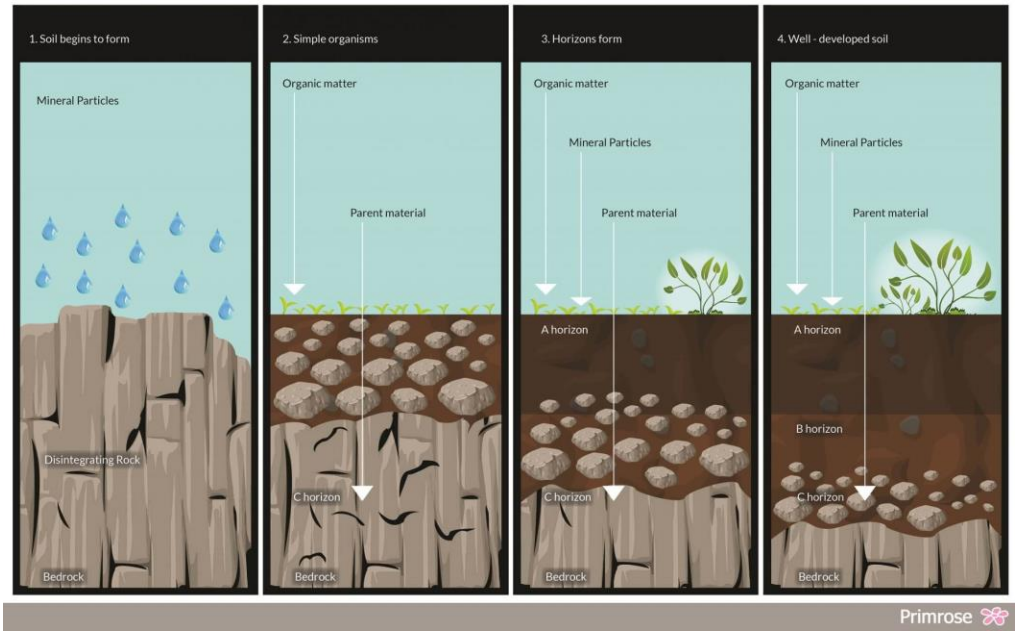
Dead leaves and other organic matter form *humus* – a part of soil that provides plant nutrients

Soils begin with parent material such as bedrock at the surface which begins to weather

Over time, soils develop horizontal layers with distinctive profiles

Soils formed in place will have some characteristics of the parent material

The most important factor in soil formation is climate



Soils can also be transported from another place, usually by wind, water, or glaciers

Sometimes already formed soils are transported

Other times, sediments are transported that form soil at the new location

In NYS, soils are the result of sediments deposited by glaciers and their meltwater that have weathered into an A horizon but not mature enough to form a B horizon (like 3 in the graphic above)

Some areas of NYS have true or mature soils due to transport by flooding streams

Topic 9 Section 2

Erosion – transport of sediments that result when rock is weathered into small particles

Sediments are displaced from their source by a transporting system

Transporting systems of erosion have several components:

- an agent of erosion:
  - streams
  - waves
  - glaciers
  - turbidity current
  - wind
  - ocean currents
  - human activity
- the sediments being moved
- a driving force

The driving force for most types of erosion is gravity

The process is ongoing because interior heat raises landmasses upward (orogeny)

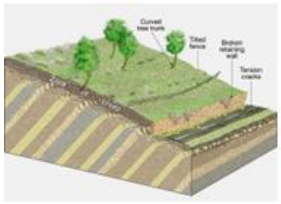
Insolation is important to erosion because it drives the water cycle that creates glaciers and streams and it also drives the winds which create waves and ocean currents

Mass movement or direct gravity erosion or landslides

Mass movement involves two major forces that oppose one another

- the constant downward pull of gravity
- friction which tends to keep objects in place

Types of mass movement

Soil Creep	Debris Flow	Mud Flow (debris flow)	Rock Fall (debris fall)
			
Gradual downhill movement of soil	**Rapid downslope plastic flow of a mass of debris**	**Downward flow of fine particles (mud) and large amounts of water**	**Rapid falling of pieces of rock from a cliff or steep slope**
< 1 cm/year	**1 mm/day to 1 km/hr**	**1 to 5 km/hr**	**> 4 km/hr**

Other conditions leading to mass movement include:

- earthquakes
- wave erosion
- side cutting by streams
- road building activity

As shown in the figures above, there is a lot of variation in types and the speed of mass movement

Mud slides are a special case of debris flow in which large amounts of water are present

Rock fall usually results from frost action

Stream side cutting is part of meander development

Running water erosion and streams

Running water is often considered to be the most common natural agent of erosion

- the constant downward pull of gravity
- friction which tends to keep objects in place

Stream – running water confined to a channel

Large rivers or narrow channels are all considered streams in Earth Science

Smaller streams that flow into larger streams are called *tributaries*

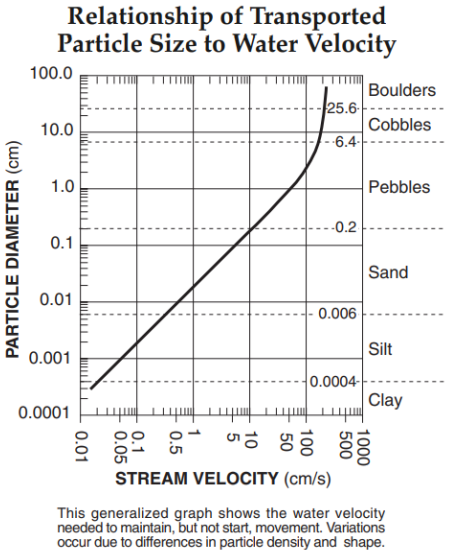
If water flows through a stream channel a major portion of the year the stream is considered to be permanent

Different methods that streams can carry sediments:

- in solution – the sediments are dissolved
- in suspension – small, solid sediments are carried throughout the water in the stream
- rolling, sliding, or bouncing along the bottom resulting in stream abrasion
  stream abrasion results in characteristic rounding and surface features

The method by which a stream carries sediments varies with the stream speed

The size of particles which a stream carries varies with the stream speed



This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

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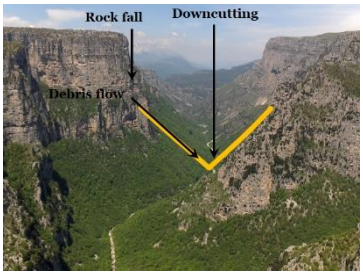
Stream channels

Over time, steams carve deeper channels

V-shaped valleys are formed by streams

The valley shape is the result of:

- runoff
- downcutting
- mass movement



Watersheds

The area of land drained by any one stream is a *watershed*

Just as streams can vary in size, so do watersheds (from a few square feet to most of a continent, as the Mississippi River)

Divide – a region of higher land that separates one watershed from another watershed

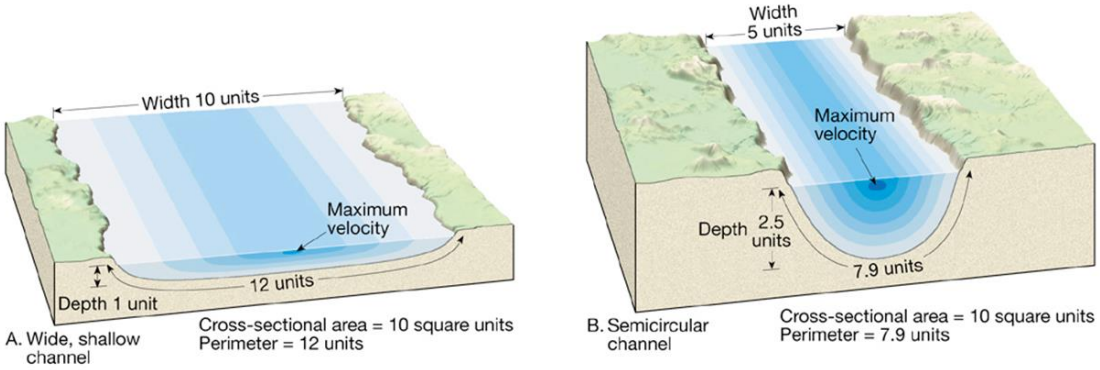
In the United States, the Rocky Mountains form a continental divide

Streams east of the Rockies drain into the Atlantic Ocean and streams to the west drain into the Pacific Ocean

Stream velocity

Three factors determine stream velocity:

- the gradient
- discharge – the volume of water that passes a given point per unit time
- stream channel shape



The more surface area a channel has in contact with the moving water, the slower the water will move (due to friction)

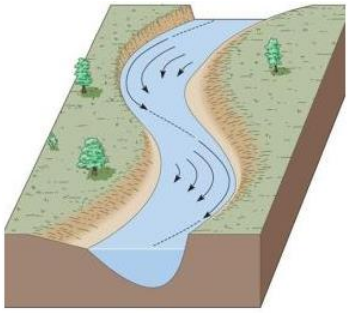
Not all parts of the stream will have the same velocity

Semicircular channels will allow the highest stream velocities

In straight channels, the center of the stream near the surface has the highest velocity

Around curves, maximum velocity will shift to the outside of the curve

Cutting will also shift somewhat toward the outside of the curve

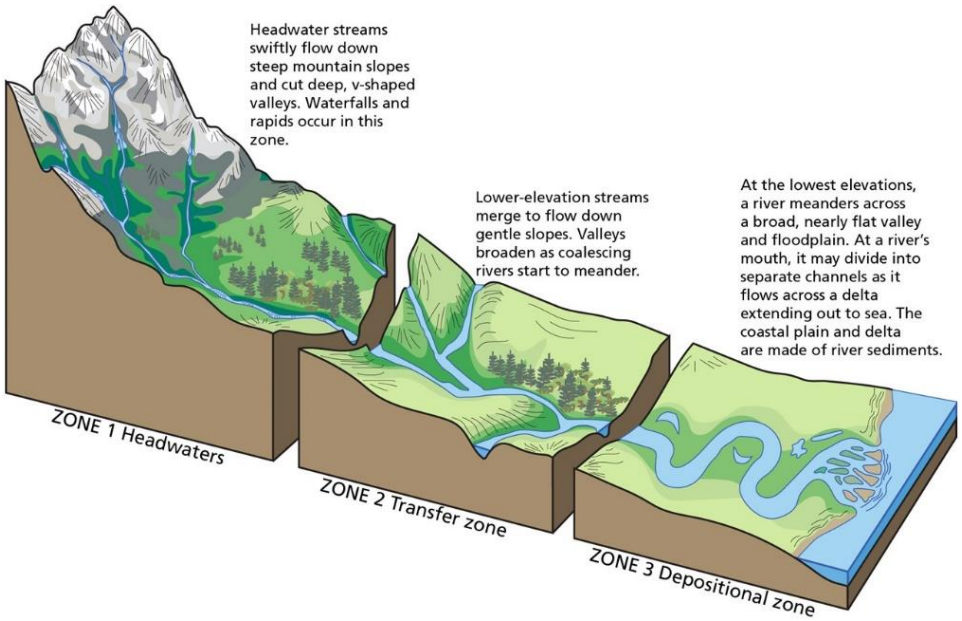


Solid sediments generally move slower than the stream

Higher velocity streams can carry larger sediments (see the Relationship of Transported Particle Size to Water Velocity table in the ESRT on page 6)

Higher velocity streams can also carry higher volumes of sediments

Evolution of a stream

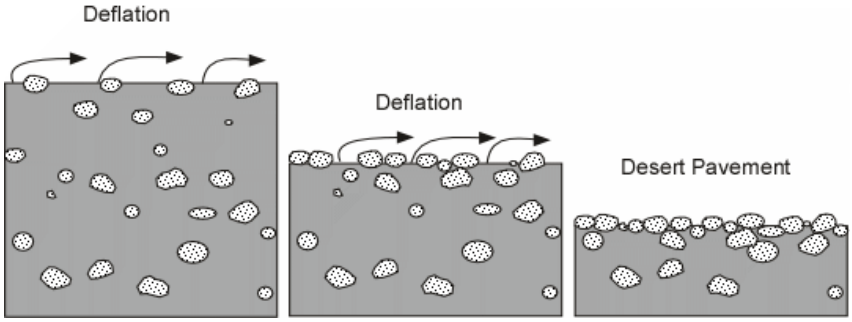


Wind erosion

When loose sediments the size of sand or smaller are present, especially in arid regions, solid surfaces in that region are susceptible to wind erosion

Two main aspects of wind erosion are:

- deflation – lowering of the land surface by loss of small sediments removed by wind
  deflation will result in the formation of desert pavement



- abrasion or *sandblasting* – the effect of small particles on stationary objects as wind carries sediments

  Since winds usually lift sand grains less than 1 meter above the surface, most sandblasting occurs at the base of objects like large rocks and telephone poles

Sandblasting also results in a distinctive shape to smaller rocks that are too large to be carried by the wind

Such rocks will have a more angular appearance than stream abrasion and the surfaces of both the sands and the rocks will appear frosted

Glacial erosion

Glacier – a naturally formed mass of ice and snow that moves downhill on land under the influence of gravity

Mountain glaciers – found in high mountain valleys around the world

Ice-sheet (or continental) glaciers cover huge landmass regions

Glaciers have ever changing boundaries determined by accumulation and wasting

Wasting includes:

- melting
- iceberg formation
- sublimation

If there is more accumulation than wasting, the glacier will *advance*

If wasting occurs faster than accumulation, the glacier will *retreat*

Glaciers are constantly moving whether they are advancing or retreating

Glacier movement is often by *plastic flow* – the glacier acts like a fluid and many of its movements are like those of a stream (faster in the middle and slower at the edges, faster near the top and slower near the bottom due to friction)

Sometimes glaciers slide at the bottom due to a layer of liquid water at the bottom

Types and features of glacial erosion

- rocks frozen to the bottom act like sandpaper causing parallel grooves and scratches
- rocks that fall on the surface get carried far away and drop during a retreat – *erratics*
- glaciers erode valley walls and floors changing V-shapes to U-shapes – *troughs*
- glaciers can bury ice that melts and leaves bowl-shaped basins – *kettles*
- glaciers can form mountain horns
- plucking occurs in zones of fractured rocks

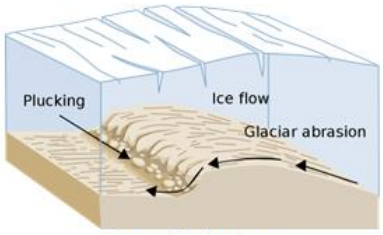
Glacial grooves

Glacial erratic

Glacial trough

Glacial basin or kettle

Glacial horn

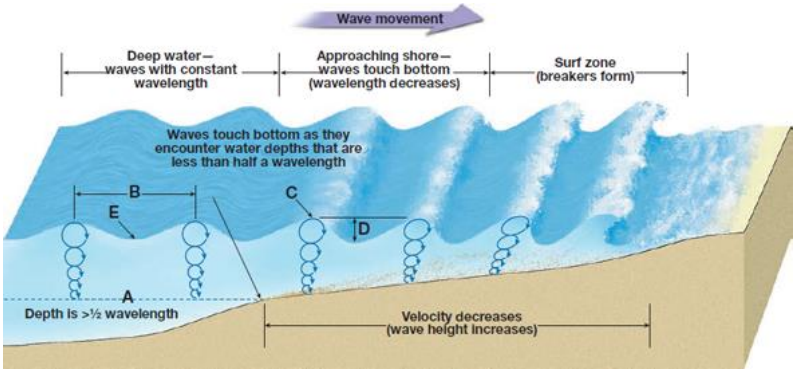


Glacial plucking

Wave and current erosion

Wind adds energy to surface water forming waves

Interaction of waves and bottom near the shore causes waves to break and pound the shore



This action usually drags sand to the shore forming a beach

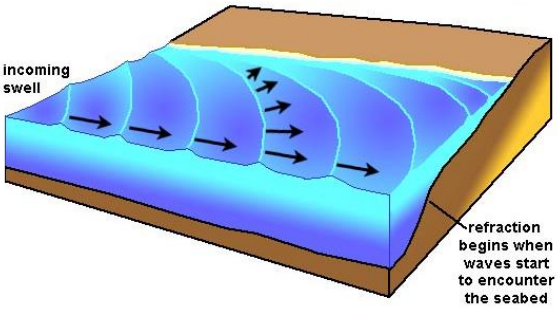
During storms, the sand can be dragged back away from the shore

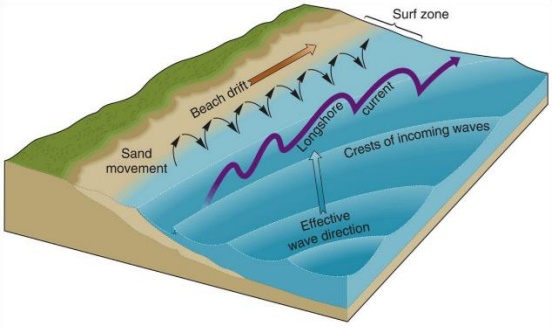
Waves arrive at an angle causing refraction

Refraction causes longshore currents which push sand down the shore

Water tends to return to the ocean straight down hill

This combination causes sand to move in a zig-zag pattern





Sediment features and erosional agents –identifying erosional agents from sediment features

- wind, beach, or stream erosion will make solid sediments smooth, rounded and smaller
  - wind blown sediments usually appear pitted or frosted with flat surfaces
- glacial sediments are often rounded only on the top side (*subrounded*) with scratches
- mass movement most often results in very angular sediments

river or stream

wind

glacial

gravity

People and erosion

Recently it has been determined that people are currently the major agent of erosion of land

The following human activities expose soil to agents of erosion and vastly increase erosion rates:

- construction projects
- road building
- mining
- deforestation
- overgrazing
- poor farming methods

Methods and decisions people can make to restore past or decrease erosional damage:

- replant logged forests
- restore coastal vegetation
- set limits on grazing
- no-till farming and contour plowing
- design highways with gentler slopes