Chapter 2
Rocks: Materials of the Solid Earth

EARTH SCIENCE
ESC 1001
QUIZ Chapter 3

Name________________________ **Ed Meyers**

Match the following words with their definition and/or description:

1. E Zone of Saturation
2. D Porosity
3. A Cone of Depression
4. K Oxbow Lake
5. F Mass Wasting
6. G Zone of Aeration
7. J Floodplain
8. H Base level
9. I Meandering Streams
10. C Alluvium

A. The lowering of the water table, in the shape of a cone, around a pumping well

B. A materials capacity for transmitting fluid

C. Well sorted sediment deposited by a stream

D. The percentage of a material's total volume that is pore space

E. The zone below the water table in which all the pore spaces are filled with water

F. Downslope movement of soil and rock under influence of gravity

G. The zone above the water table that contains both water and air

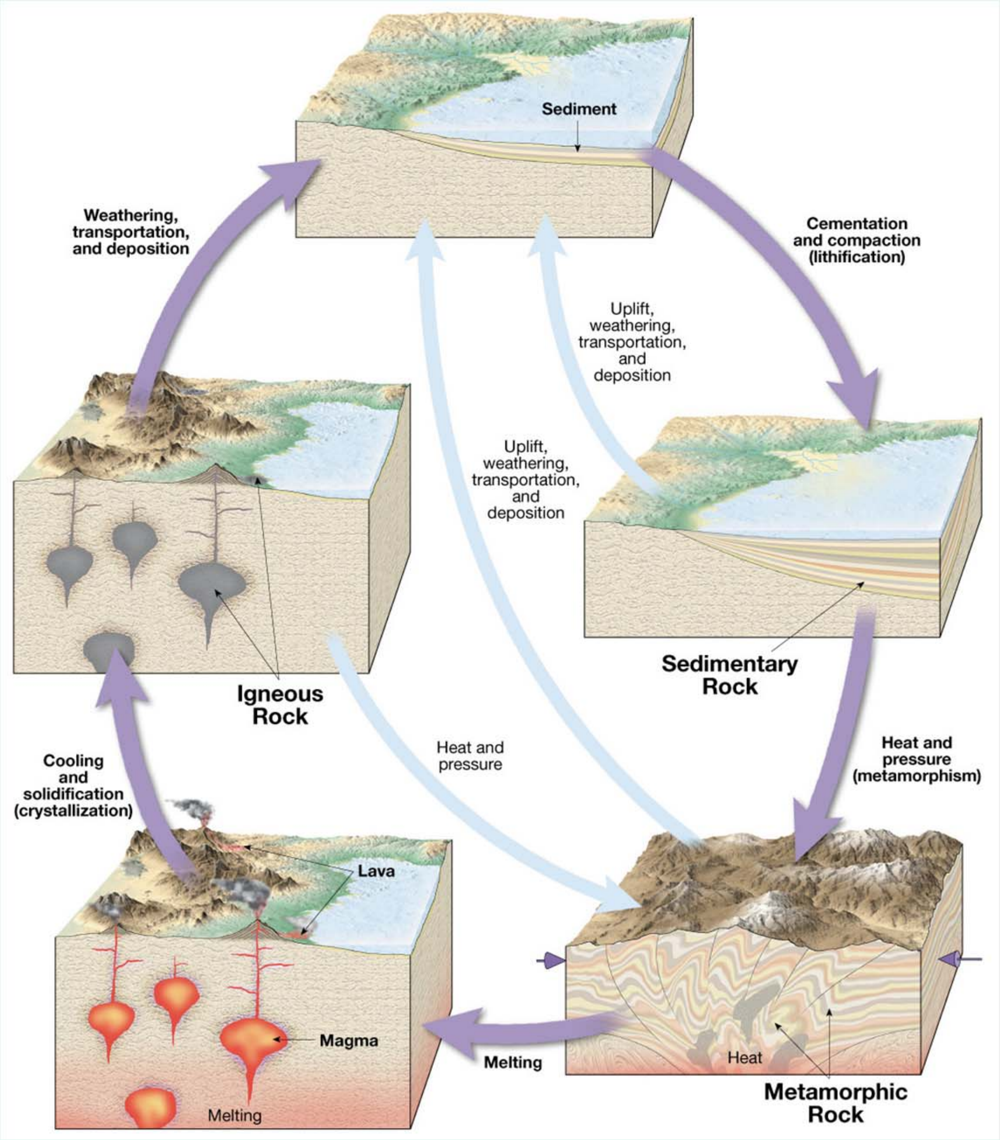
H. The lowest limit to which a stream can erode

I. A stream with a single sinuous channel with sweeping bends curves

J. A low lying relatively flat area adjacent to a stream that is partly or completely covered by water when the stream overflows it's banks

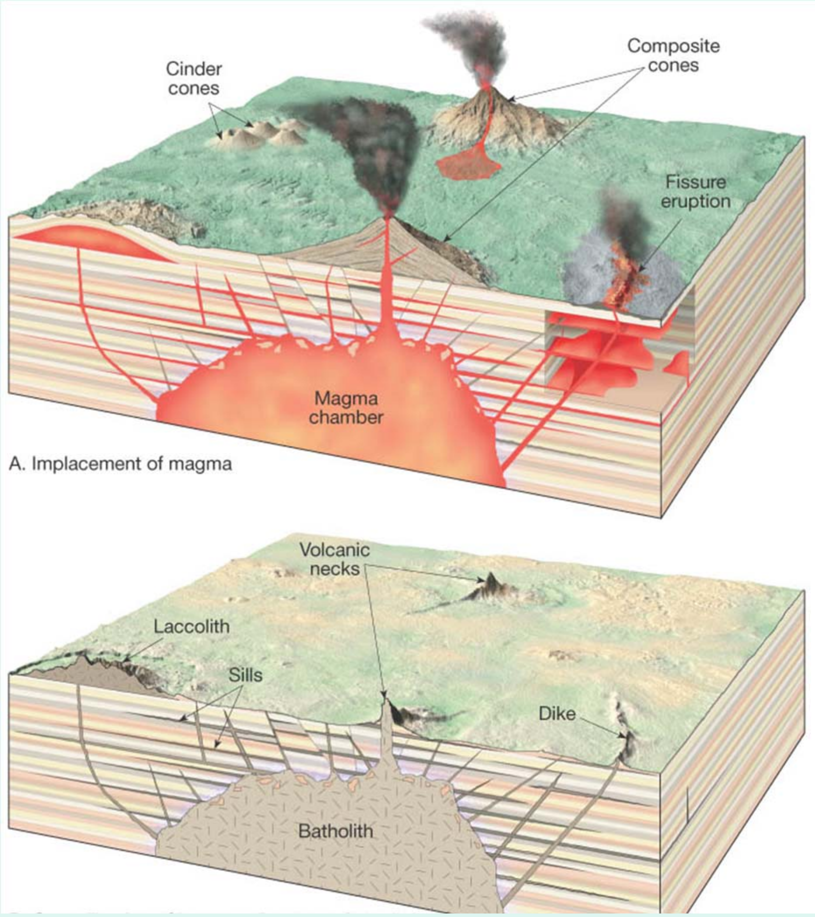
K. A cutoff meander filled with water

The Rock Cycle



Igneous Rocks

Form as magma cools and crystallizes



Rocks formed inside Earth are called *plutonic* or *intrusive* rocks

Igneous Rocks

- **Rocks formed on the surface**
  - **Formed from *lava* (a material similar to magma, but without gas)**
  - **Called *volcanic* or *extrusive* rocks**

Classification of Igneous Rocks

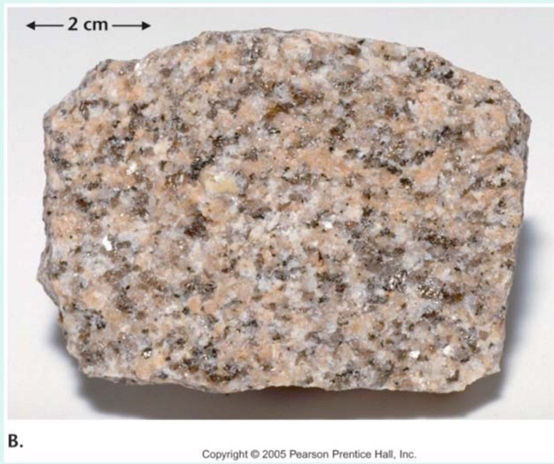
Chemical Composition	Granitic (Felsic)	Andesitic (Intermediate)	Basaltic (Mafic)	Ultramafic
Dominant Minerals	Quartz Potassium feldspar Sodium-rich plagioclase feldspar	Amphibole Sodium- and calcium-rich plagioclase feldspar	Pyroxene Calcium-rich plagioclase feldspar	Olivine Pyroxene
TEXTURE – Phaneritic (coarse-grained)	**Granite**	**Diorite**	**Gabbro**	**Peridotite**
TEXTURE – Aphanitic (fine-grained)	**Rhyolite**	**Andesite**	**Basalt**	**Komatiite** (rare)
TEXTURE – Porphyritic	"Porphyritic" precedes any of the above names whenever there are appreciable phenocrysts			Uncommon
TEXTURE – Glassy	**Obsidian** (compact glass) **Pumice** (frothy glass)			
Rock Color (based on % of dark minerals)	0% to 25%	25% to 45%	45% to 85%	85% to 100%

Texture and Composition

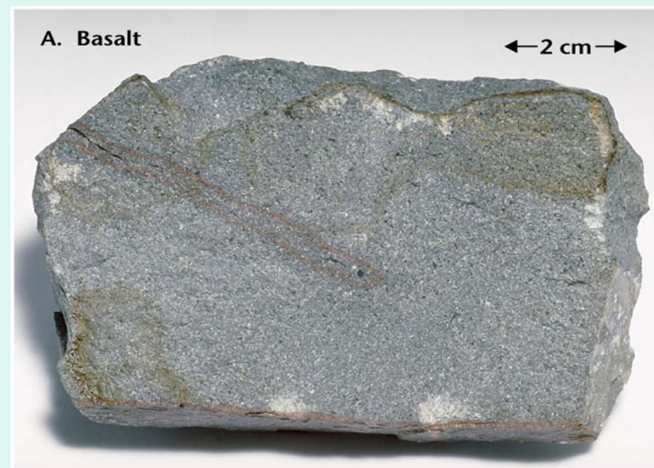
Felsic (quartz rich)

Mafic (quartz poor)

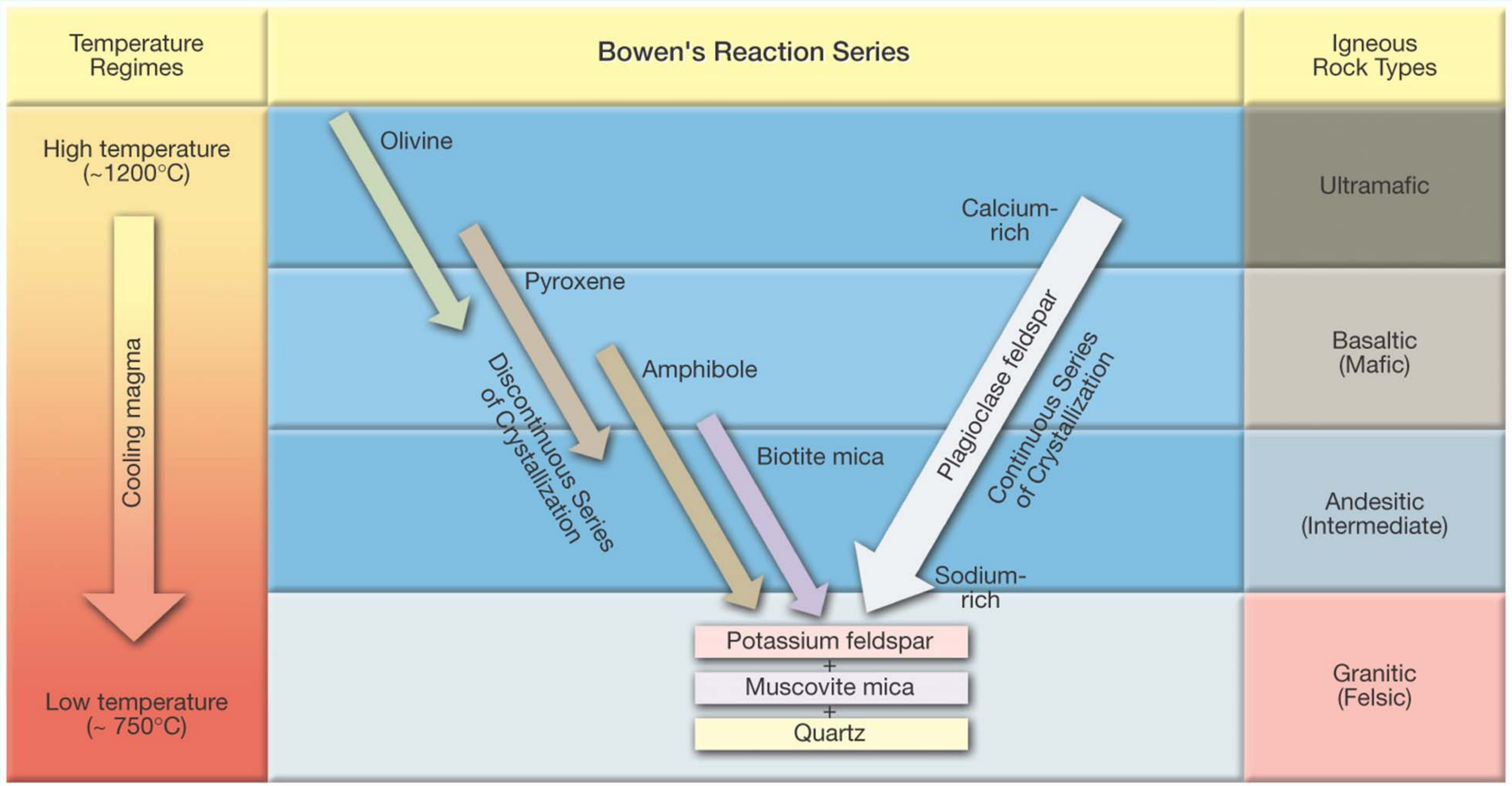
Coarse Grain



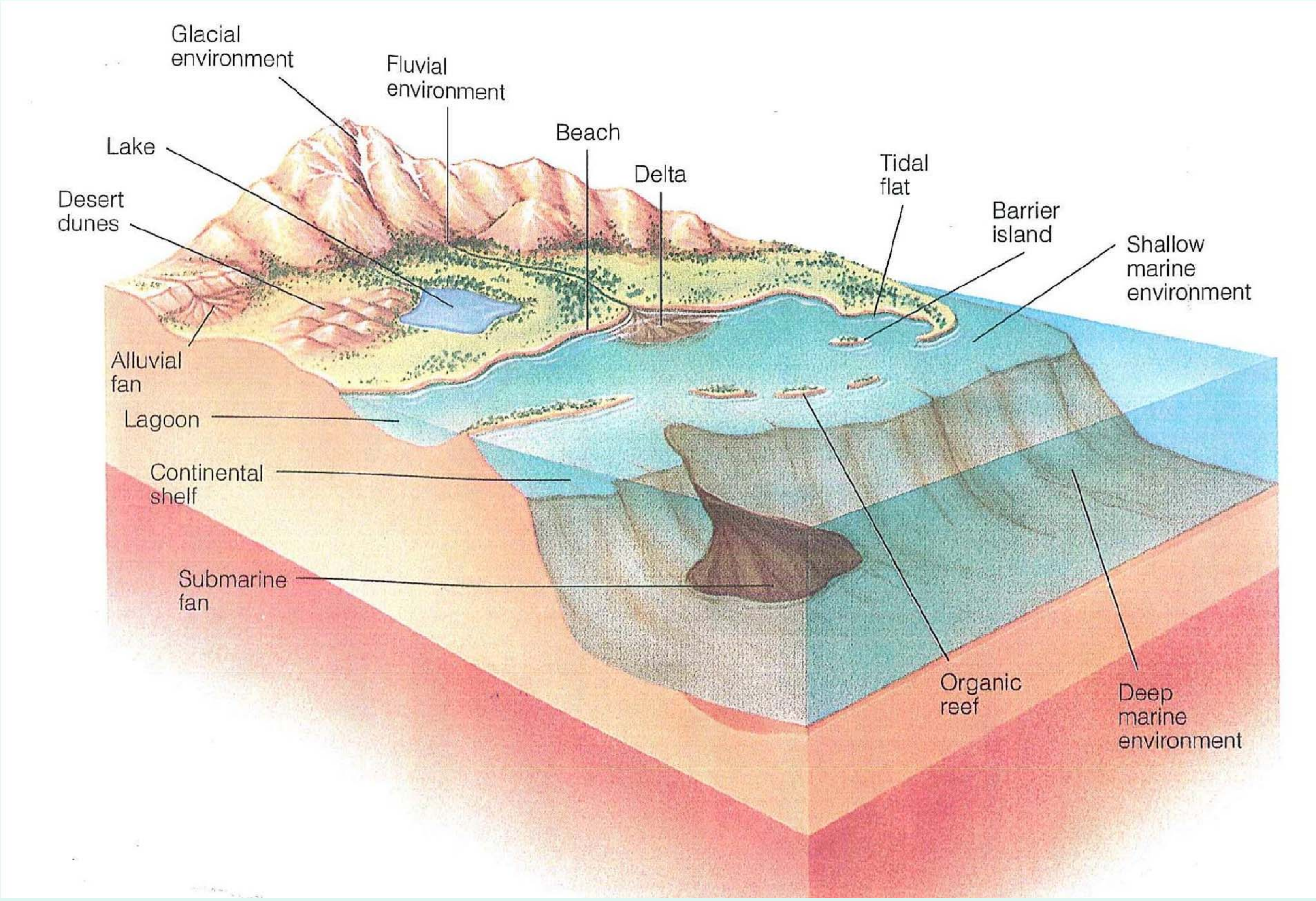
Fine Grain



Bowen's Reaction Series



Sedimentary Rocks – Formation



Classification of Sedimentary Rocks

Detrital Sedimentary Rocks			
Texture (grain size)		**Sediment Name**	**Rock Name**
Coarse (over 2 mm)		Gravel (Rounded fragments)	**Conglomerate**
		Gravel (Angular fragments)	**Breccia**
Medium (1/16 to 2 mm)		Sand (If abundant feldspar is present the rock is called **Arkose**)	**Sandstone**
Fine (1/16 to 1/256 mm)		Mud	**Siltstone**
Very fine (less than 1/256 mm)		Mud	**Shale**

Chemical Sedimentary Rocks			
Composition	**Texture** (grain size)	**Rock Name**	
Calcite, $CaCO_3$	Fine to coarse crystalline	**Crystalline Limestone**	
		Travertine	
	Visible shells and shell fragments loosely cemented	**Coquina**	**Biochemical Limestone**
	Various size shells and shell fragments cemented with calcite cement	**Fossiliferous Limestone**	**Biochemical Limestone**
	Microscopic shells and clay	**Chalk**	**Biochemical Limestone**
Quartz, SiO_2	Very fine crystalline	**Chert (light colored) Flint (dark colored)**	
Gypsum $CaSO_4 \bullet 2H_2O$	Fine to coarse crystalline	**Rock Gypsum**	
Halite, NaCl	Fine to coarse crystalline	**Rock Salt**	
Altered plant fragments	Fine-grained organic matter	**Bituminous Coal**	

Metamorphic Rocks

Metamorphic agents

- Heat
- Pressure (stress)
  - From burial *(confining pressure)*
  - From *differential stress* during mountain building
- Chemically active fluids
  - Mainly water and other volatiles
  - Promote recrystallization by enhancing ion migration

Classification of Metamorphic Rocks

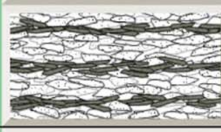
Rock Name		Texture		Grain Size	Comments	Parent Rock
Slate	Increasing Metamorphism	Foliated		Very fine	Excellent rock cleavage, smooth dull surfaces	Shale, mudstone, or siltstone
Phyllite				Fine	Breaks along wavey surfaces, glossy sheen	Slate
Schist				Medium to Coarse	Micaceous minerals dominate, scaly foliation	Phyllite
Gneiss				Medium to Coarse	Compositional banding due to segregation of minerals	Schist, granite, or volcanic rocks
Marble		Nonfoliated		Medium to coarse	Interlocking calcite or dolomite grains	Limestone, dolostone
Quartzite				Medium to coarse	Fused quartz grains, massive, very hard	Quartz sandstone
Anthracite				Fine	Shiny black organic rock that may exhibit conchoidal fracture	Bituminous coal

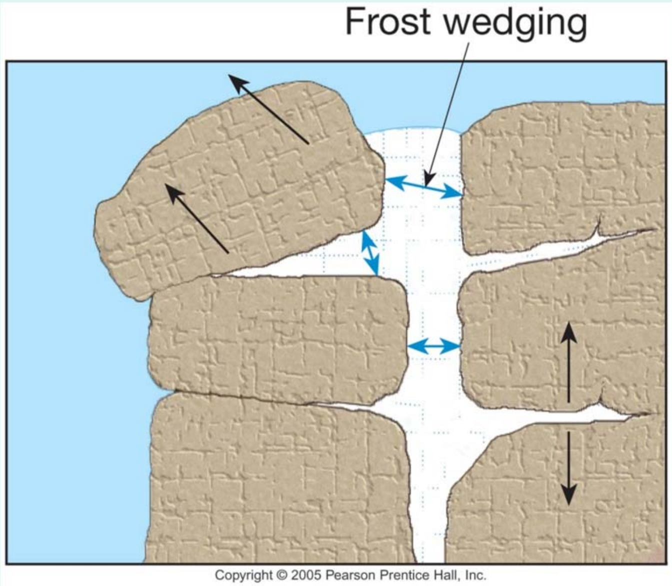
Figure 2.27

Weathering of Rocks

- ***Weathering of rocks can occur chemically and/or physically***

Weathering of Rocks

- ***Mechanical weathering*** **is the physical breaking apart of Earth materials**
  - ***Frost wedging*** **= splitting of rocks due to alternate freezing and thawing of water in cracks or voids**



Mechanical weathering

Chapter 3
Landscapes Fashioned by Water

Chapter 3

1. Mass Wasting
2. The Hydrologic Cycle
3. Surface Water
4. Groundwater

Earth's External Processes

- **Weathering**, **mass wasting**, and **erosion** are all called external processes because they occur at or near Earth's surface
- **Internal processes, such as mountain building and volcanic activity, derive their energy from Earth's interior**

Mass Wasting: The Work of Gravity

- ***Mass wasting*** **is the downslope movement of rock and soil under the direct influence of gravity**
- **No slope is stable- the force of gravity eventually cause material to move down slope**

Cliffs of Dover

Mass Wasting: The Work of Gravity

- **Controls and triggers of mass wasting**
  - ***Water*—Reduces the internal resistance of materials and adds weight to a slope**
  - **Oversteepening of slopes (angle of repose)**

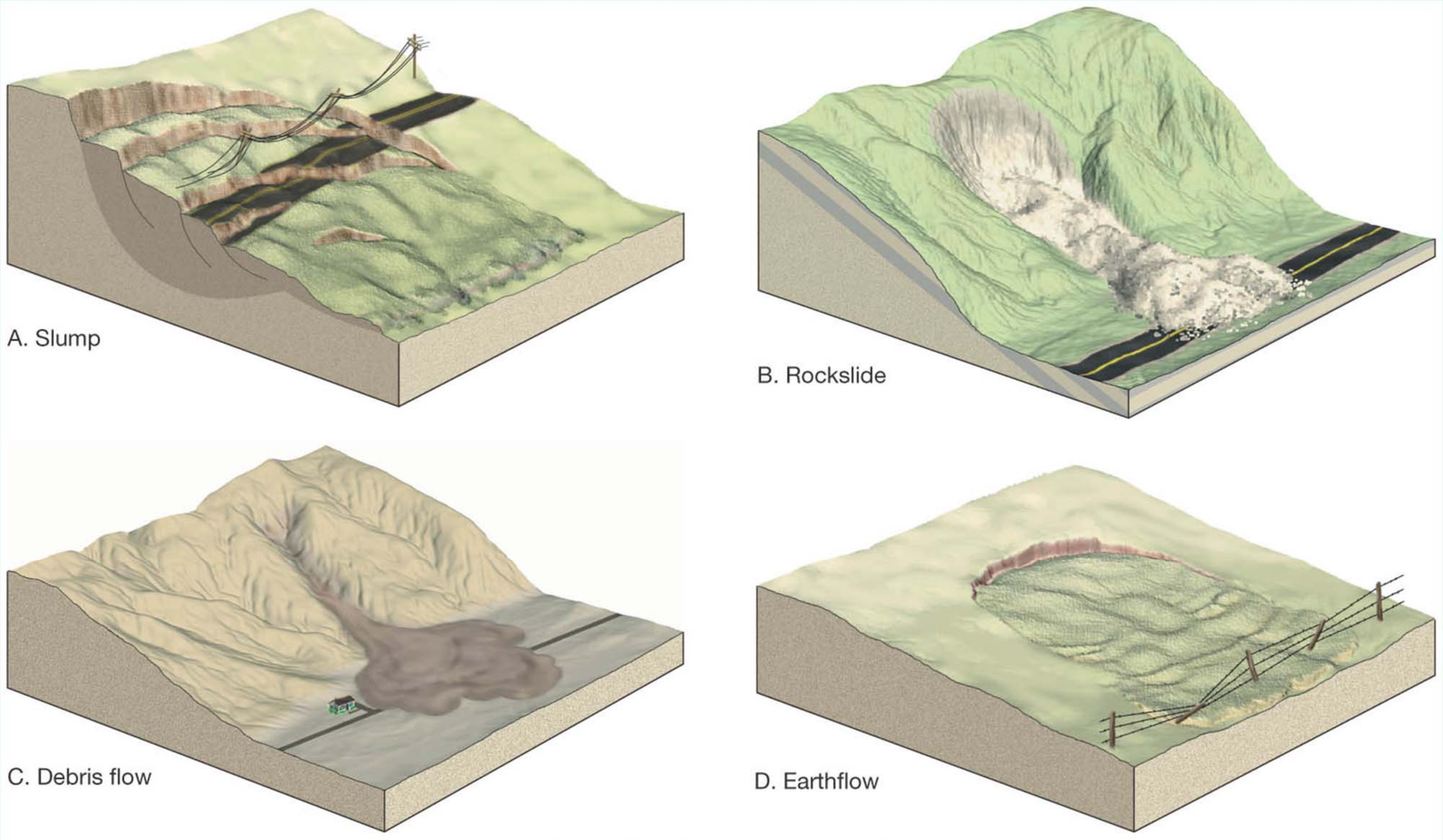
Angle of repose

 G. Leavens/Photo Reseachers, Inc.

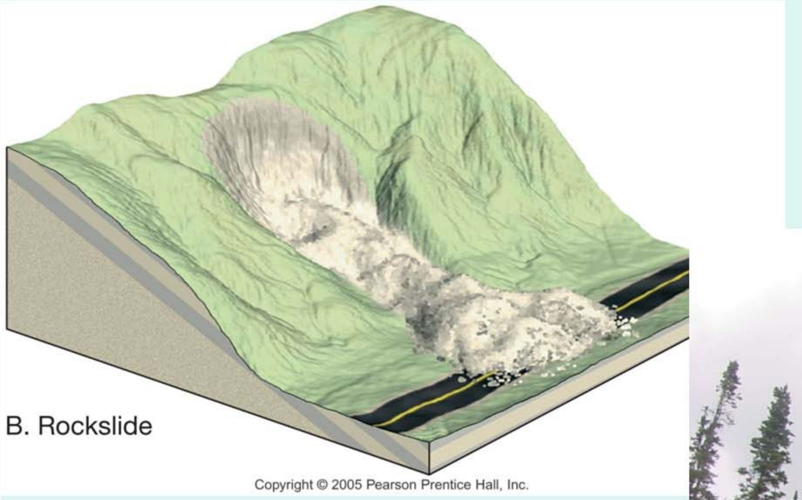
Mass Wasting: The Work of Gravity

- **Controls and triggers of mass wasting**
  - **Removal of vegetation**
    - **Root systems bind soil and regolith together**
    - **(East Coast vs West Coast)**
  - **Earthquakes**
    - **Earthquakes and aftershocks can dislodge large volumes of rock and unconsolidated material**

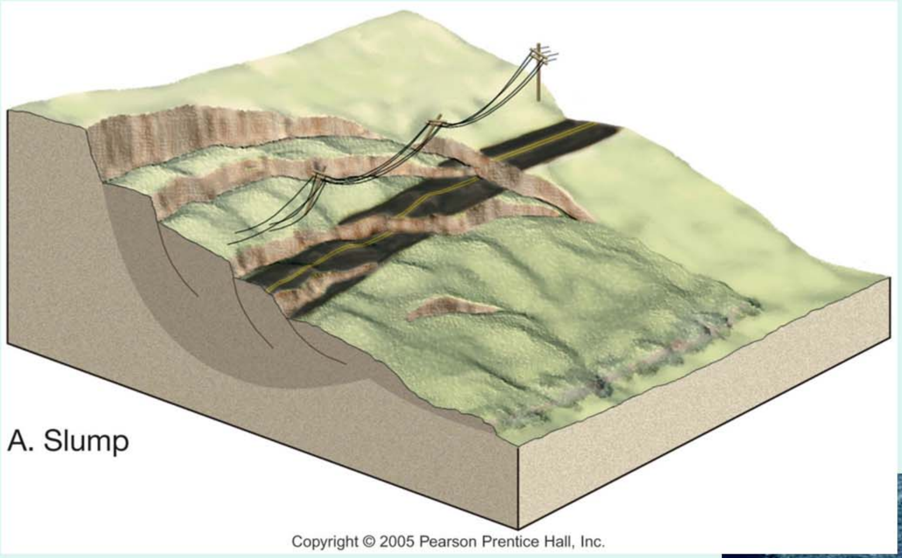
Mass Wasting



Mass Wasting – Rock Slides



Mass Wasting – Slumping

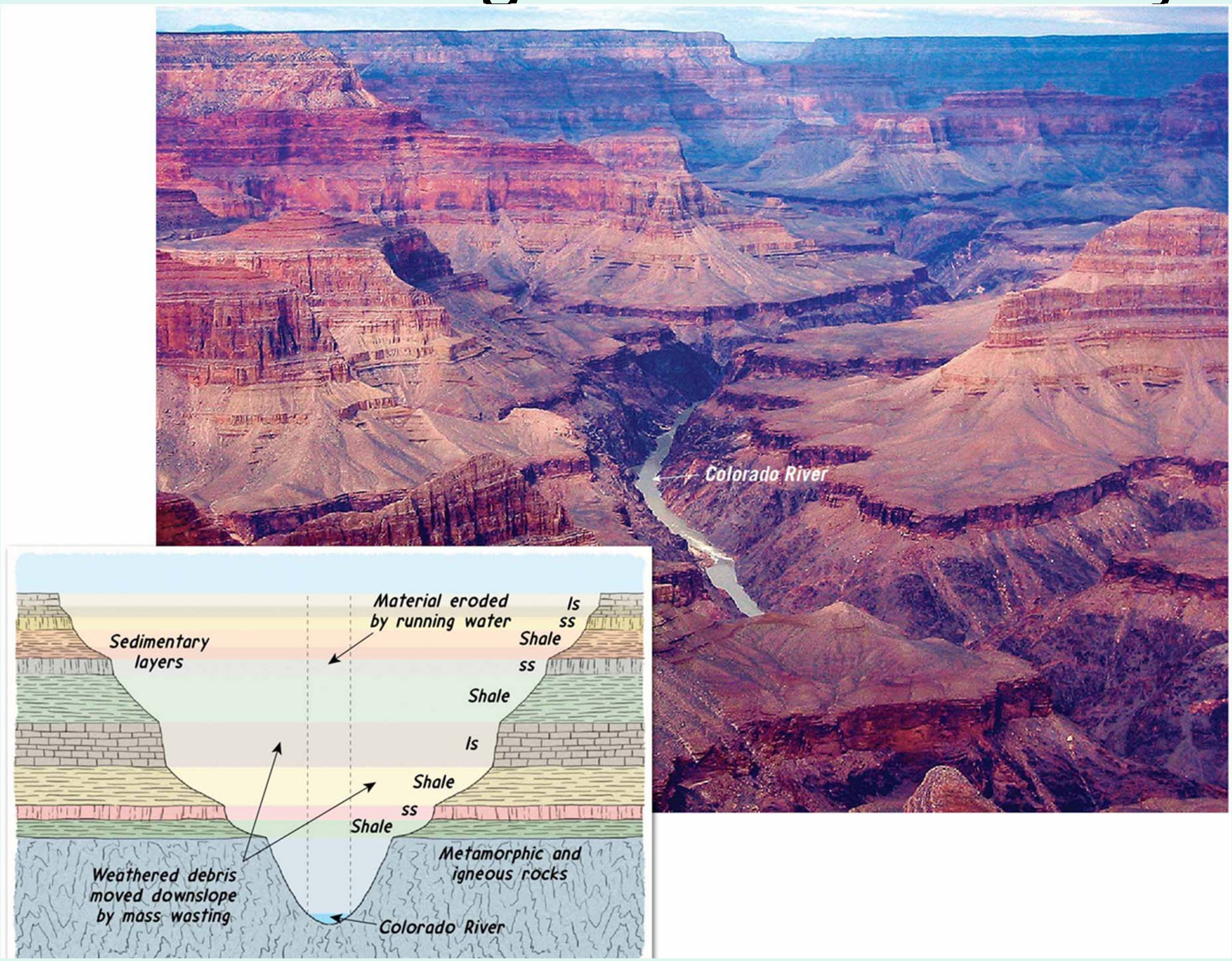


Mass Wasting – Slumping

Mass Wasting = the downslope movement of material under the influence of gravity.

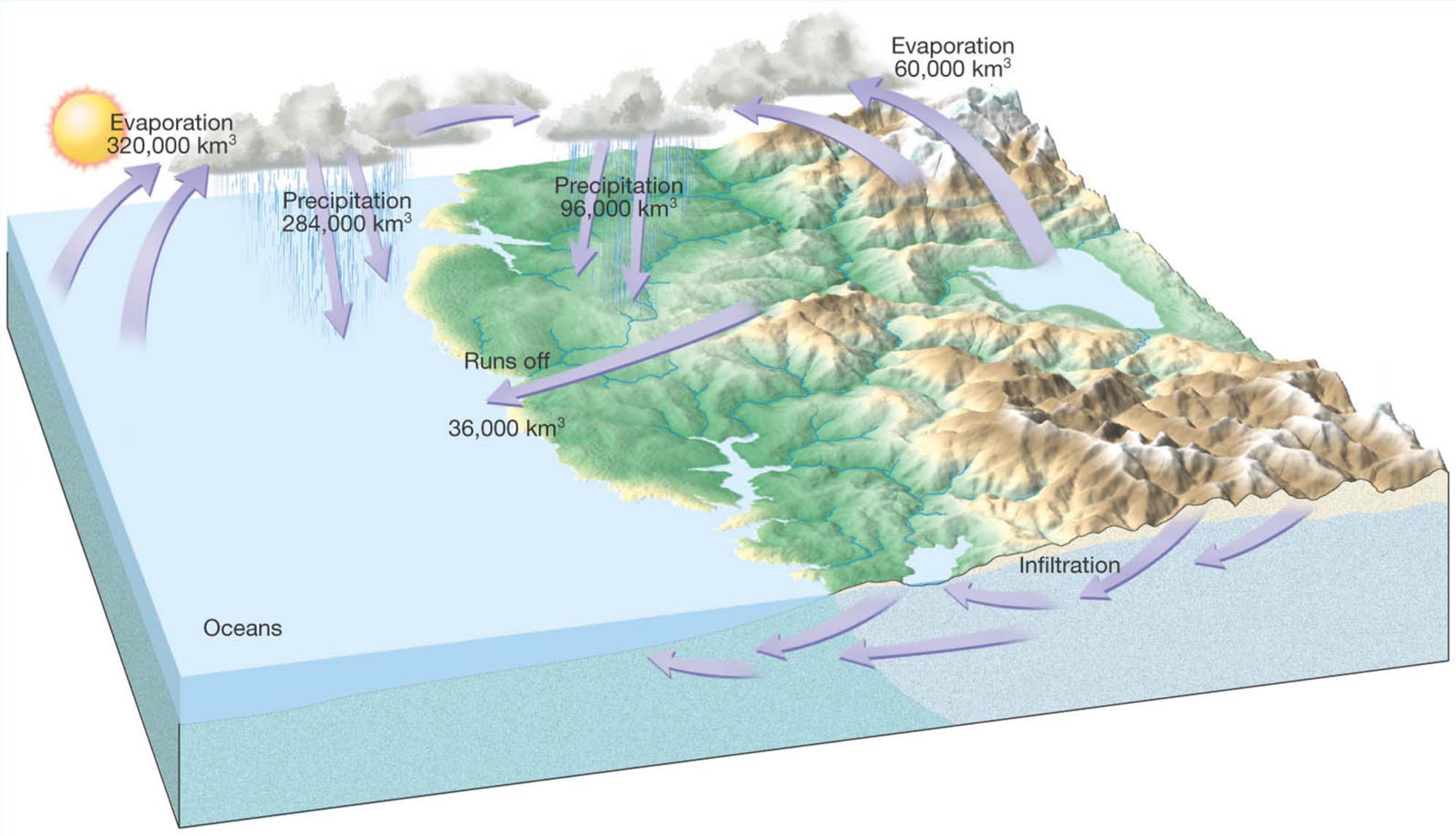
For Sale

Mass Wasting- forms river valleys

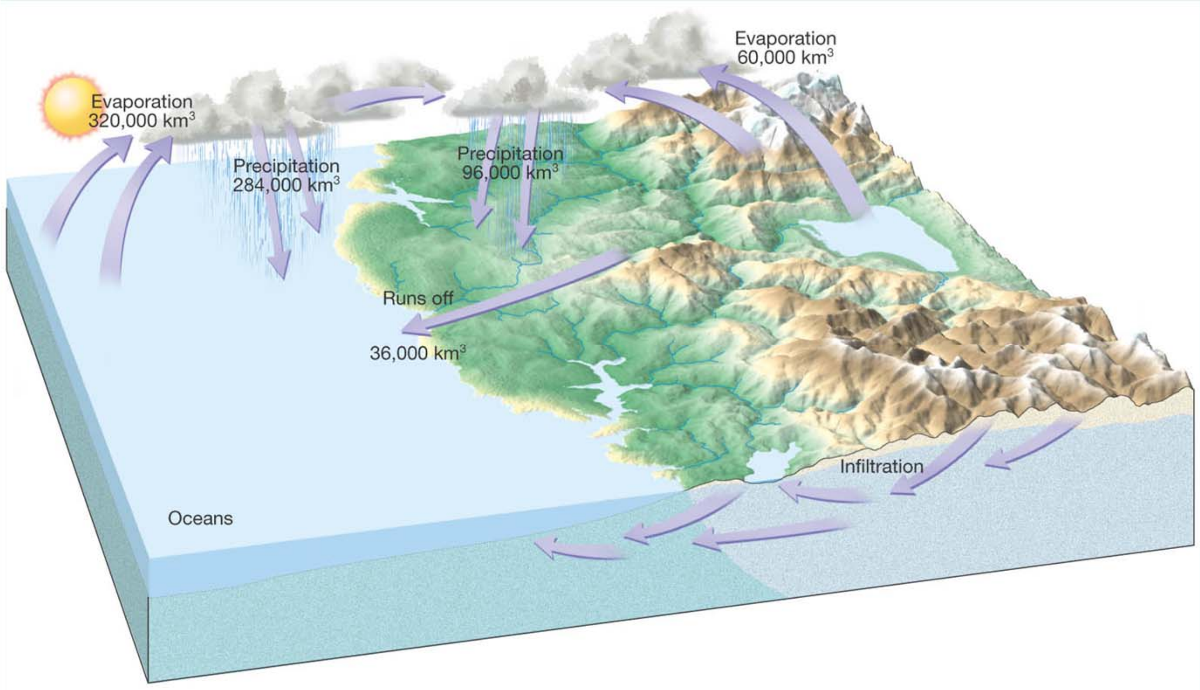


Water Cycle

The *water* cycle is a summary of the circulation of Earth's water supply



The Water Cycle



Water Cycle in Balance

Key Components of the water cycle:

Precipitation

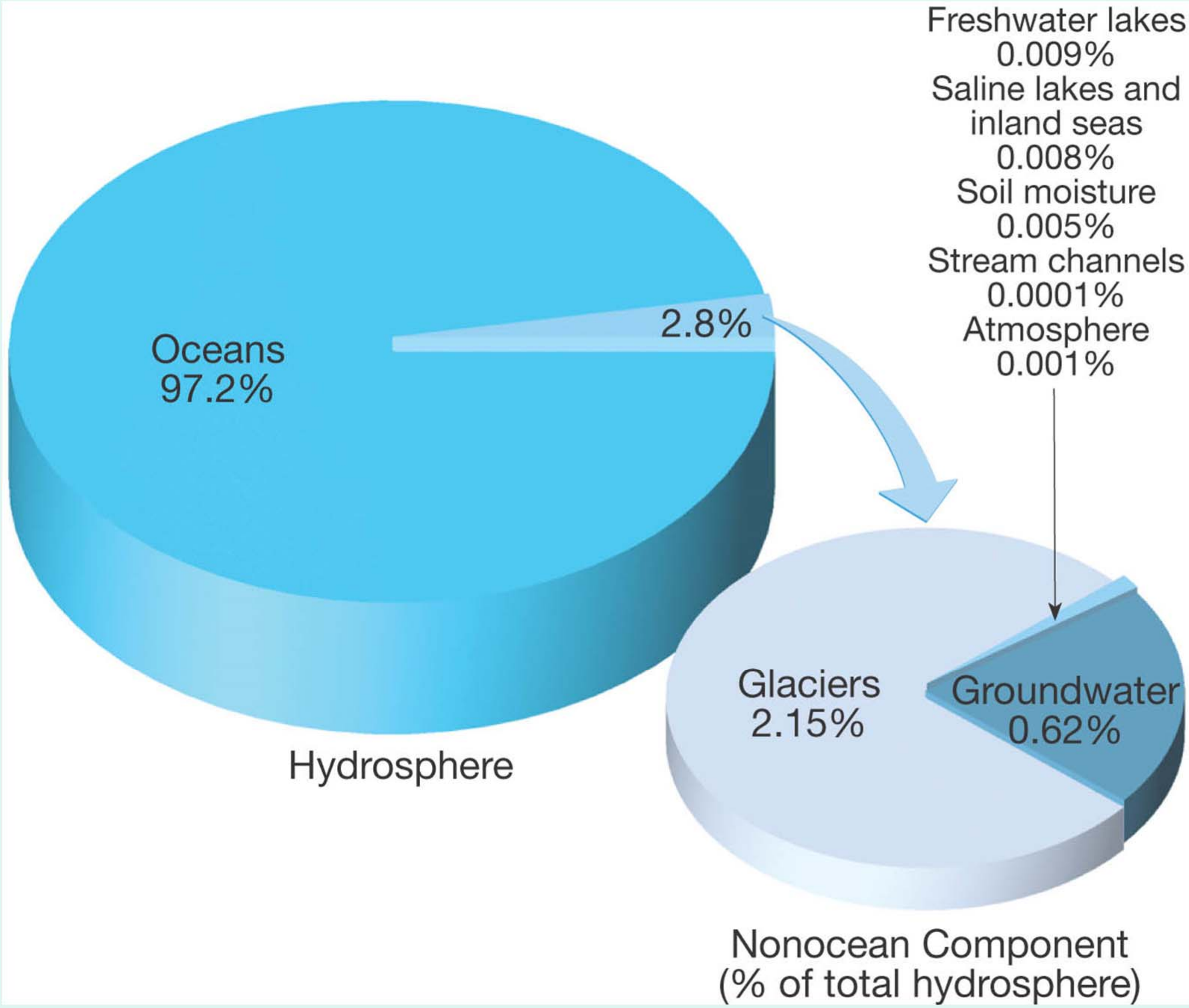
Evaporation

Infiltration

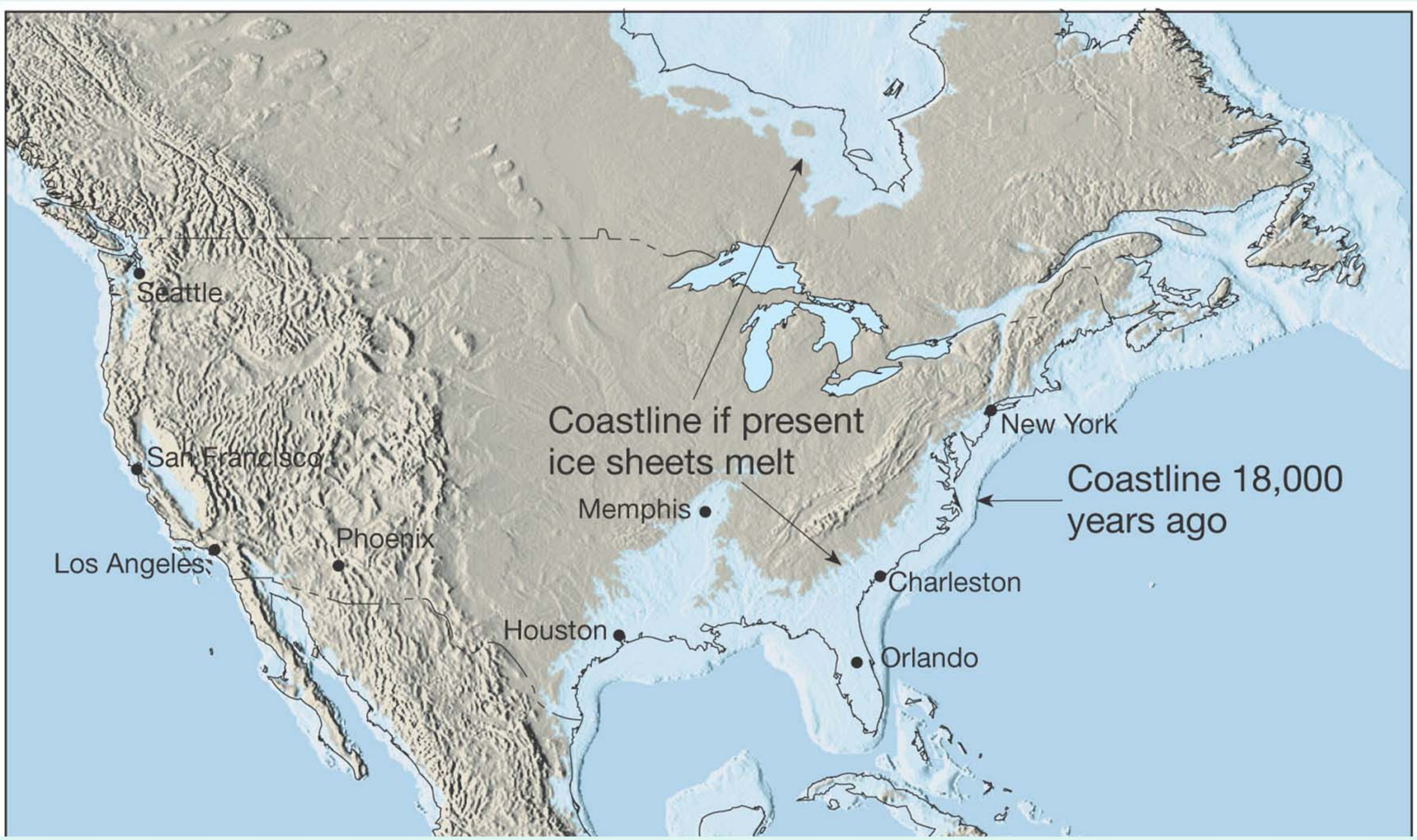
Runoff

Transpiration

Distribution of Earth's Water



The Water Cycle



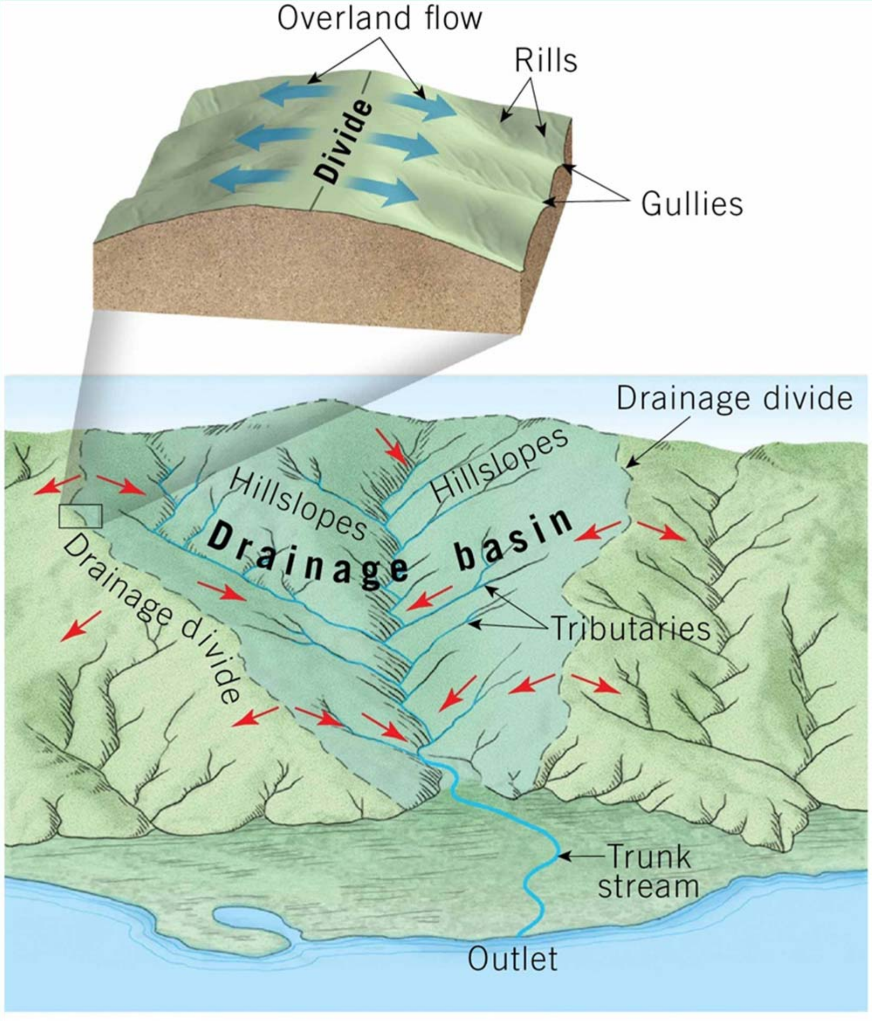
Water Cycle Out of Balance

Running Water

Water eventually flows back to the ocean – the speed and path it takes can vary from location to location

Running Water

- Small streams converge to rivers
- Drainage basins (separated by divides) are the land area that contribute water to a river system



Valencia Drainage

Drainage Basin of the Mississippi River

Running Water

Where do streams come from?

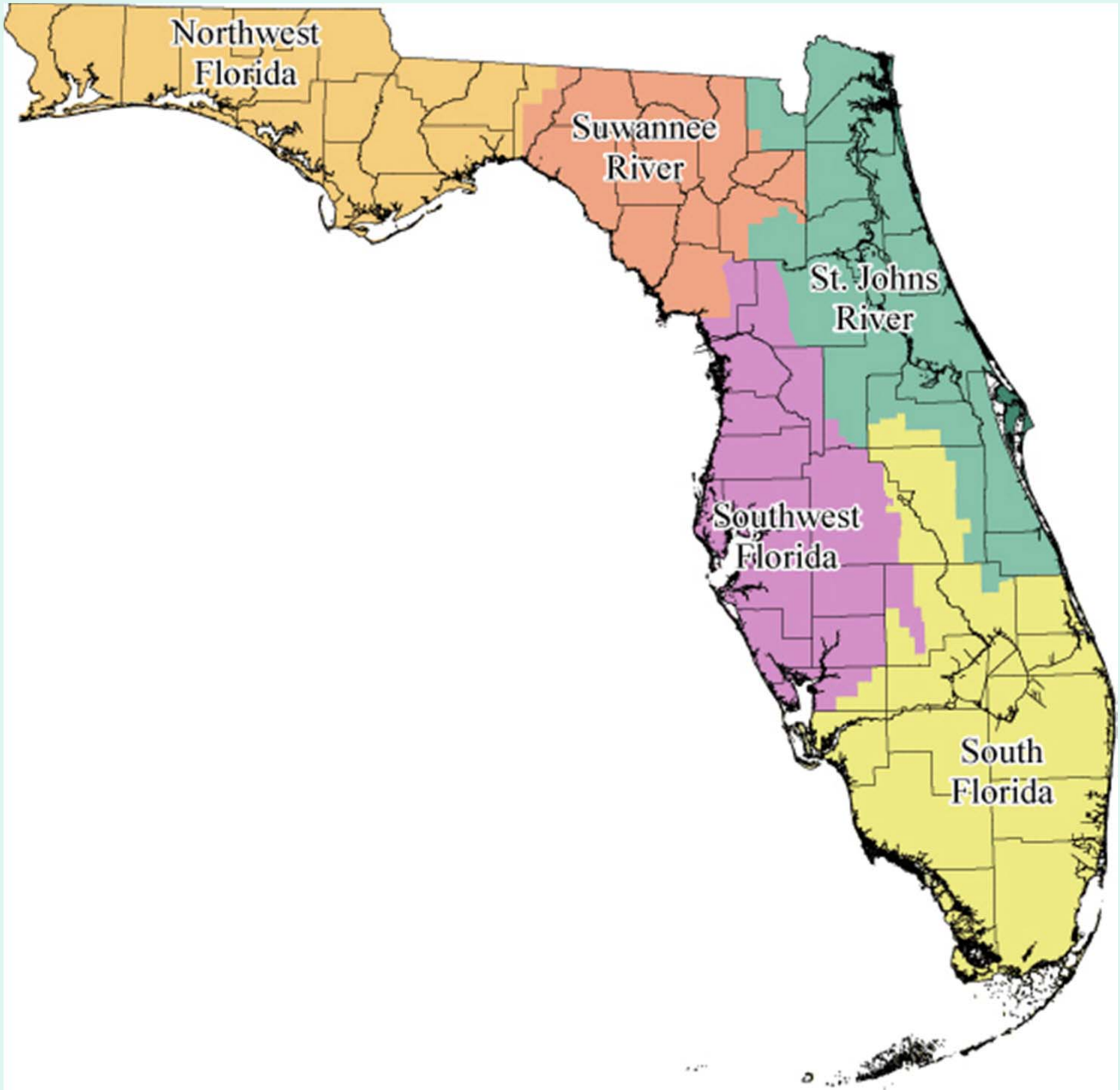
a.

The Colorado river come from small streams on the slopes of mountains. Their source water can be snowmelt from the mountains or rainwater

The source of the Mississippi is a small lake in Minnesota

Drainage Basin of the St Johns River

Drainage Patterns



Drainage Basins and Patterns

- **Drainage pattern**
  - **Pattern of the interconnected network of streams in an area**
  - **Common drainage patterns**
    - ***Dendritic***
    - ***Radial***
    - ***Rectangular***
    - ***Trellis***

Drainage Patterns

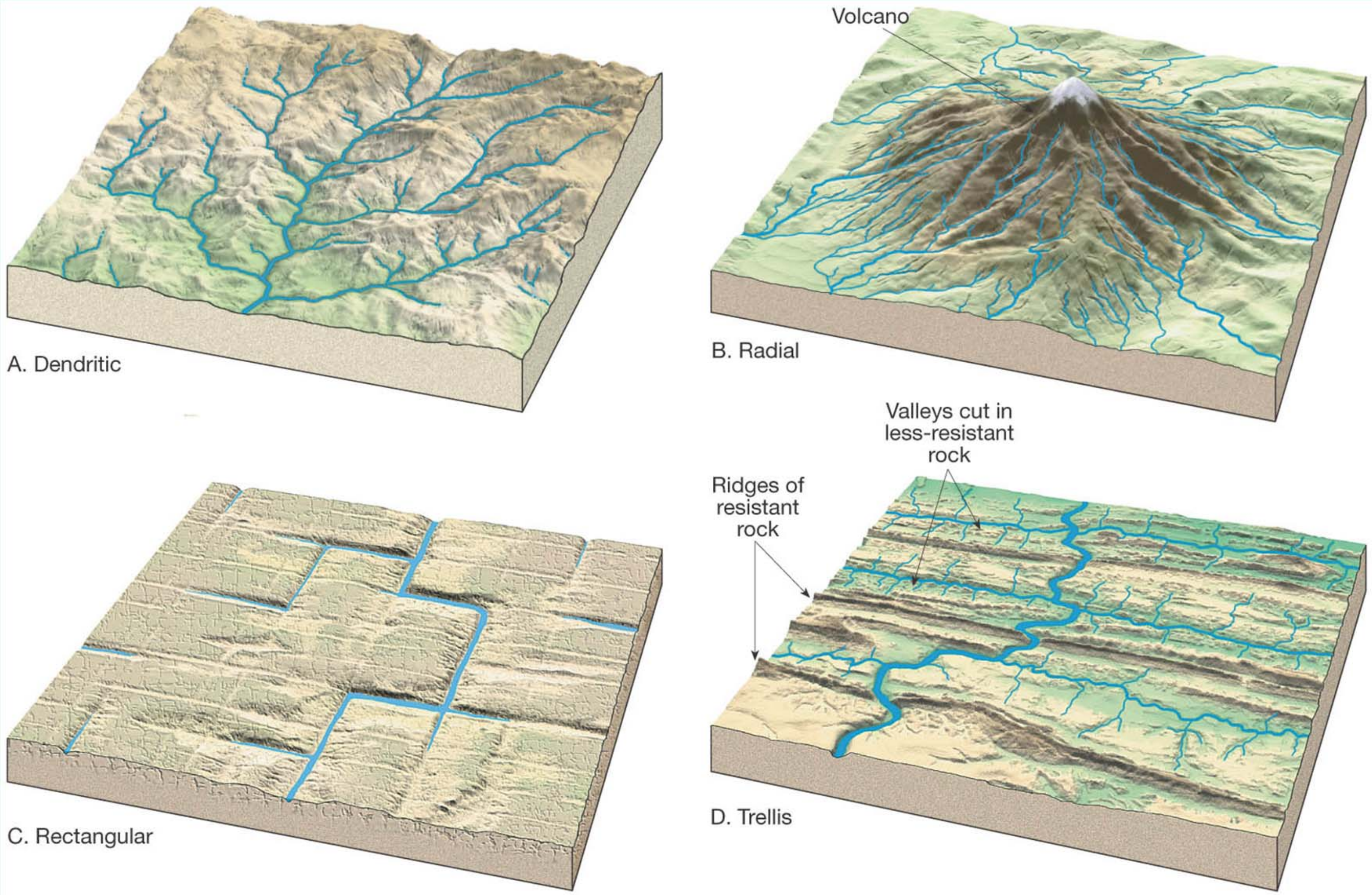
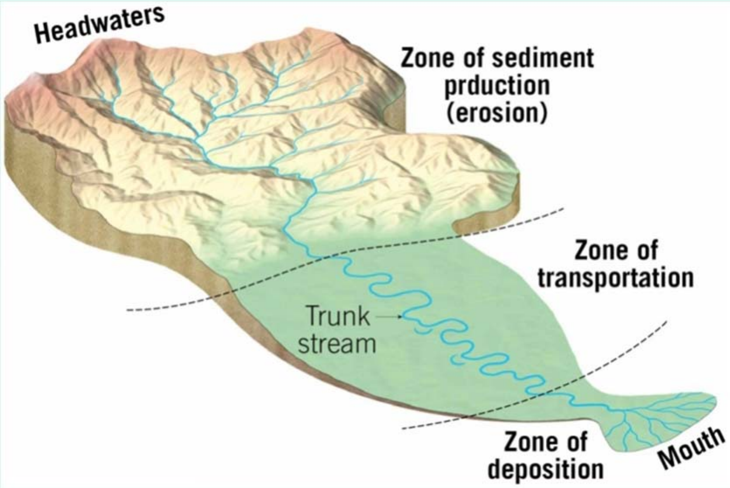


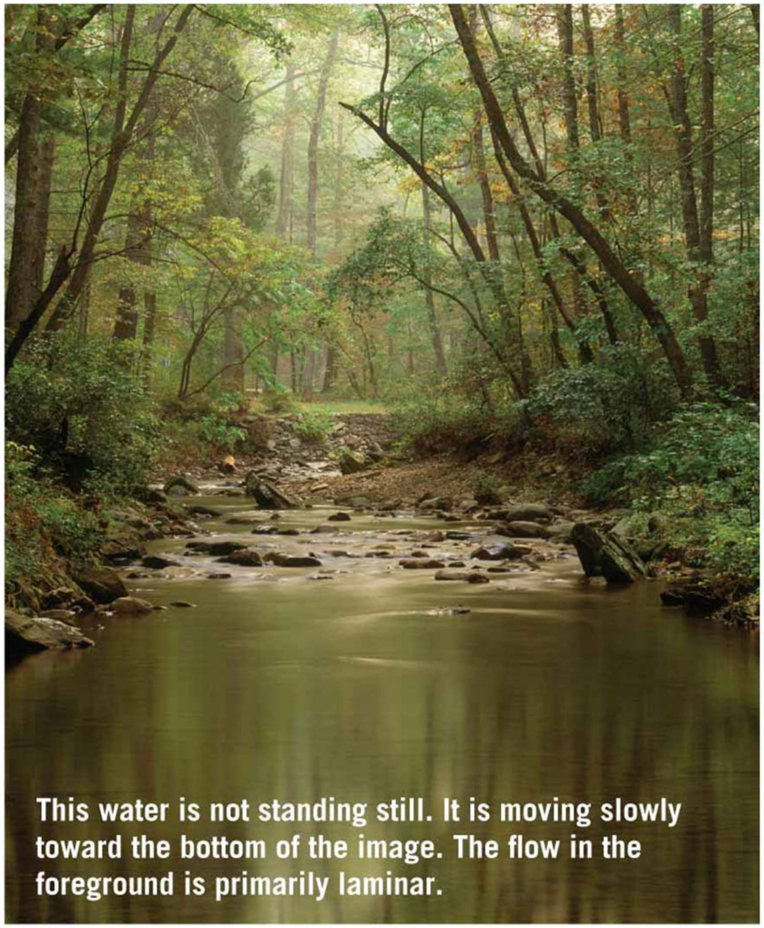
Figure 3.22

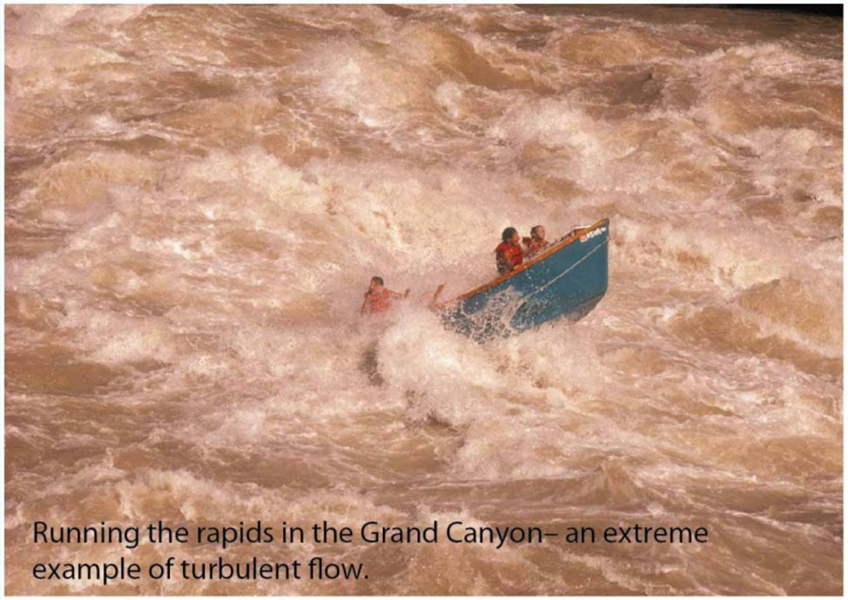
Running Water

- A river system carries water from an entire drainage basin
  - Includes three zones:
    - Sediment production (erosion dominant)
    - Sediment transport
    - Sediment deposition



Stream Flow - Velocity

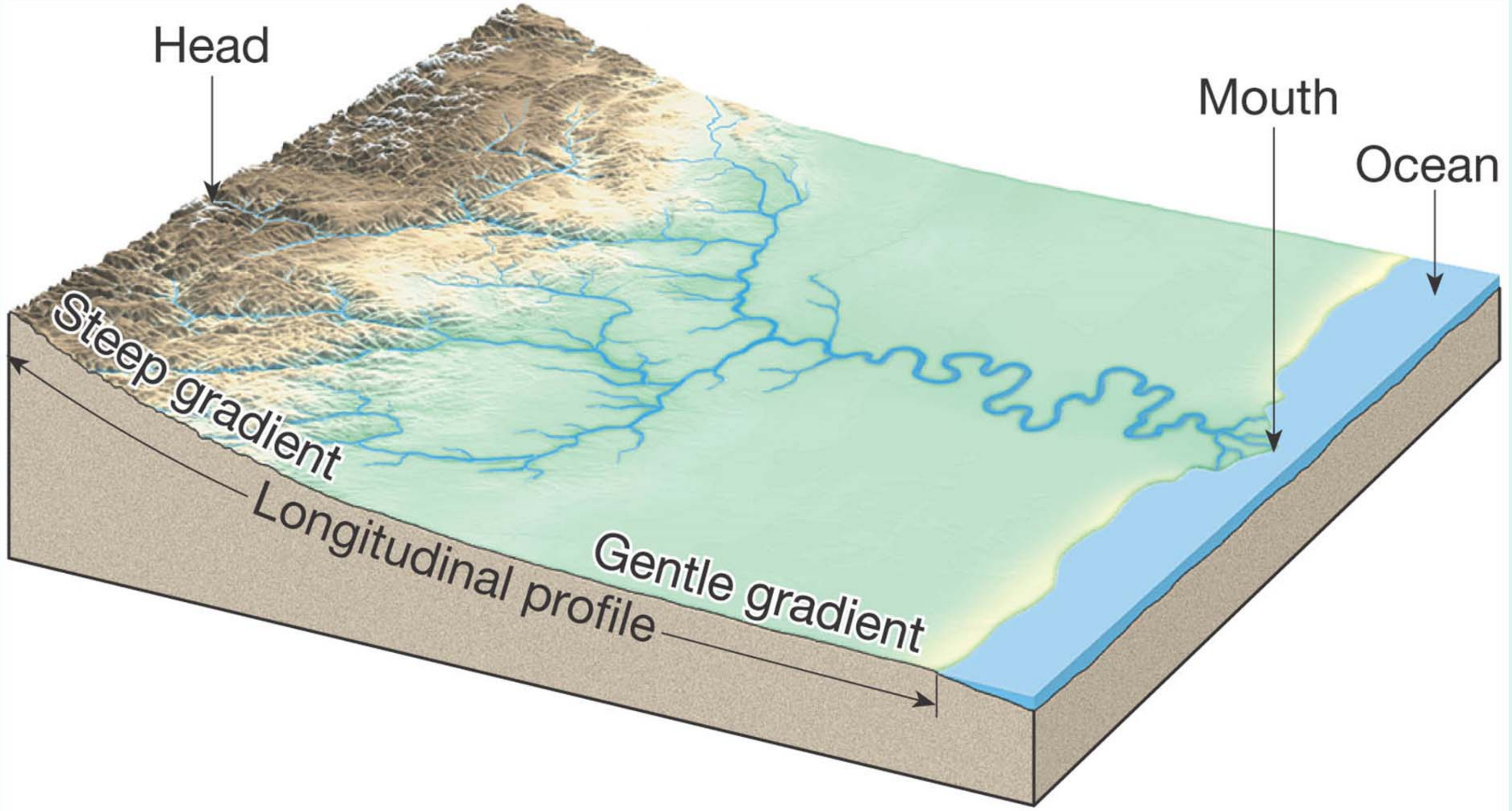




Slow moving = laminar flow

Fast moving = turbulent flow

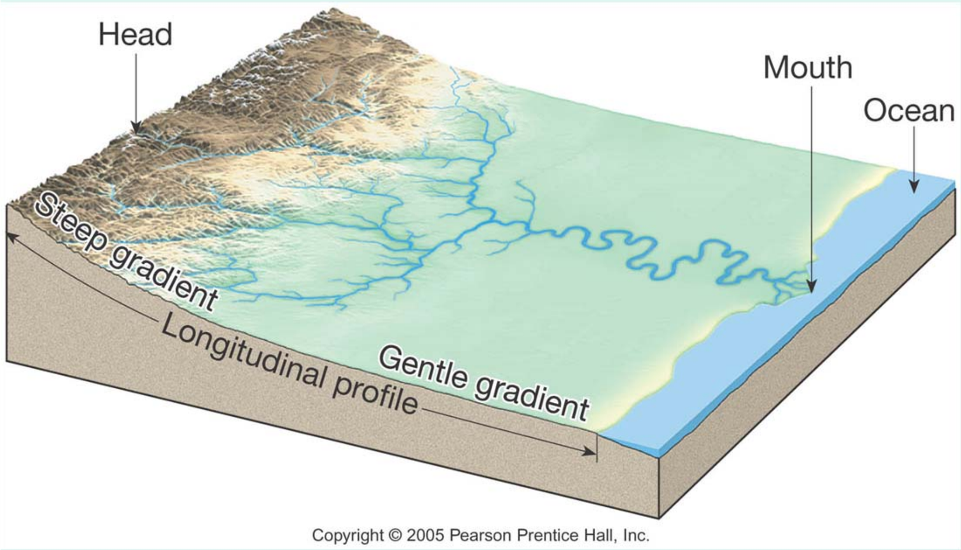
Longitudinal Profile of a Stream

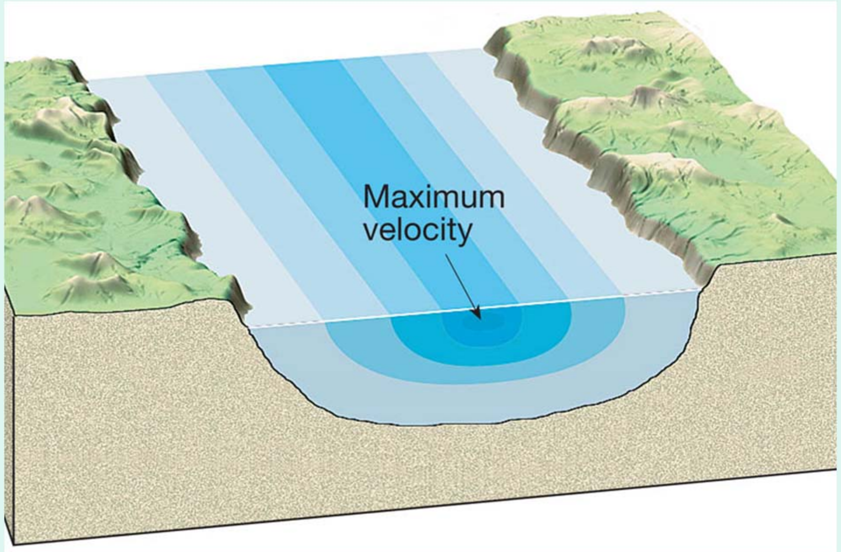


Running Water

Factors that determine velocity

- –***Gradient*** **or slope**
- –**Channel characteristics including shape, size, and roughness**
- –**Discharge—The volume of water moving past a given point in a certain amount of time**

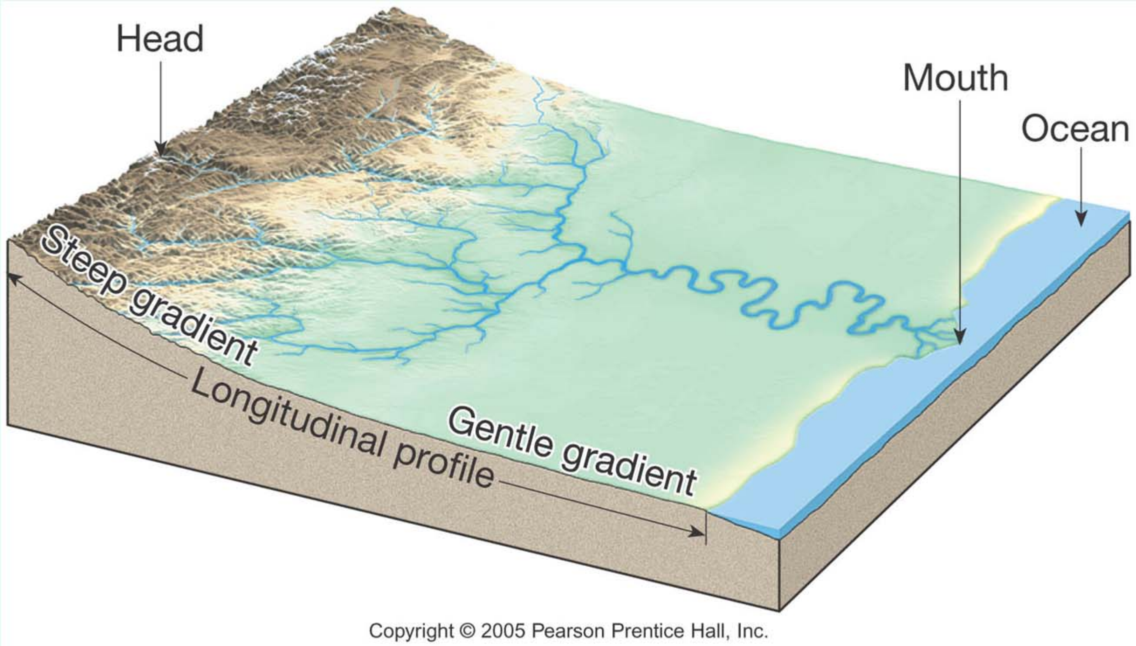




Running Water

Changes from upstream to downstream

Gradient decreases downstream



Factors that increase downstream

- Velocity
- Discharge
- Channel size
- Channel Smoothness

Factors Affecting Stream Flow

© Rob Howard/Corbis

The Work of Streams

- **Stream erosion**
  - **Lifting loosely consolidated particles by**
    - ***Abrasion***
    - ***Dissolution***
  - **Stronger currents lift particles more effectively**

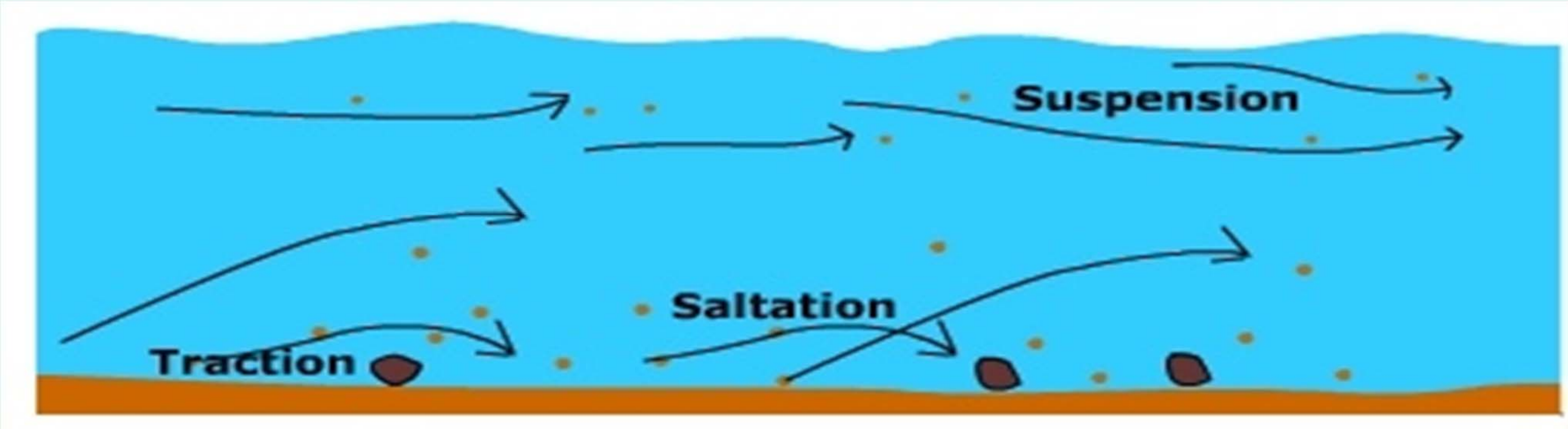
The Work of Streams

Transport of sediment by streams

Transported material is called the stream's *load*

Types of load

– *Dissolved load*
– *Suspended load*
– *Bed load*



The Work of Streams

Transport of sediment by streams

- Transported material is called the stream's *load*
- *Capacity*—the maximum load a stream can transport

The Work of Streams

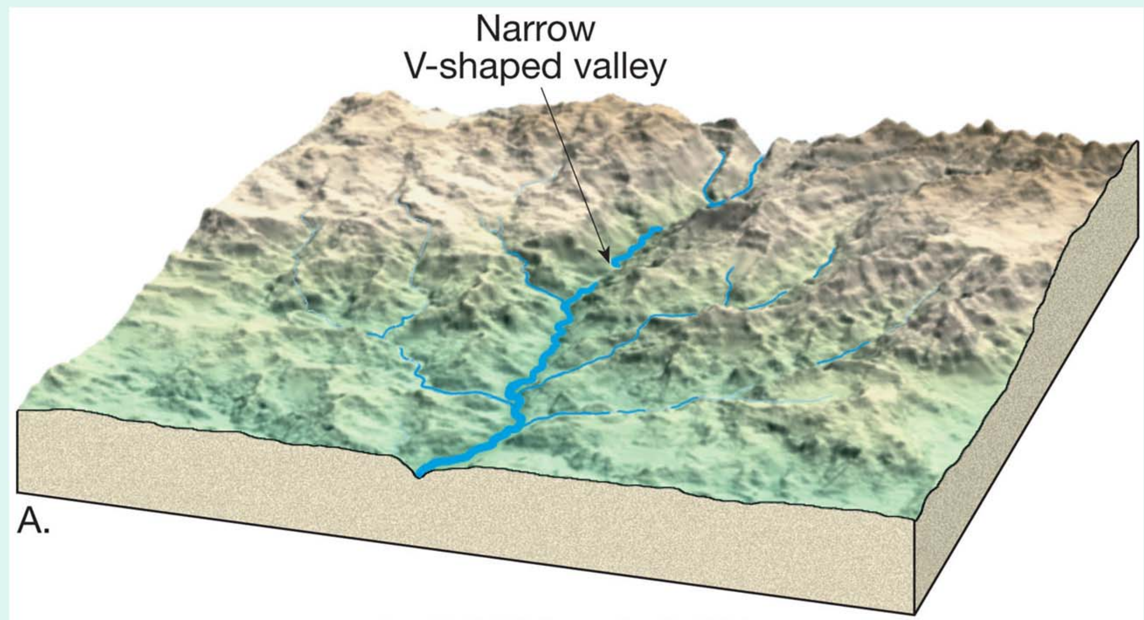
Competence

- **Indicates the maximum particle size a stream can transport**
- **Determined by the stream's velocity**

Stream Channels

Bedrock Channels

- ***V-shaped*** **narrow valleys**
- **Downcutting into the bedrock**
- **Features often include rapids and waterfalls**



Stream Channels

Alluvial Channels

Braided Streams

- Bed load (gravel) and variable discharge

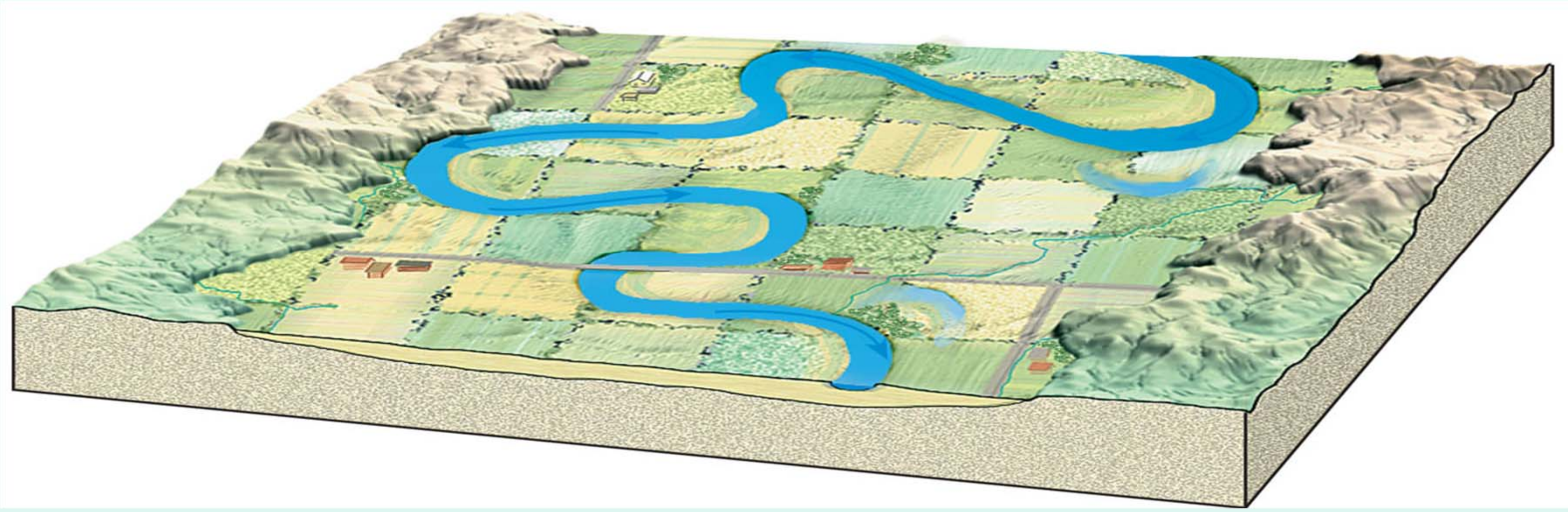
Meandering Streams

- Suspended load (clay) and constant discharge

Alluvial Channels

Downward erosion is less dominant and erosion occurs on outside edges of channel

Stream energy is directed from side to side forming a *floodplain*



Erosion and Deposition Along a Meandering Stream

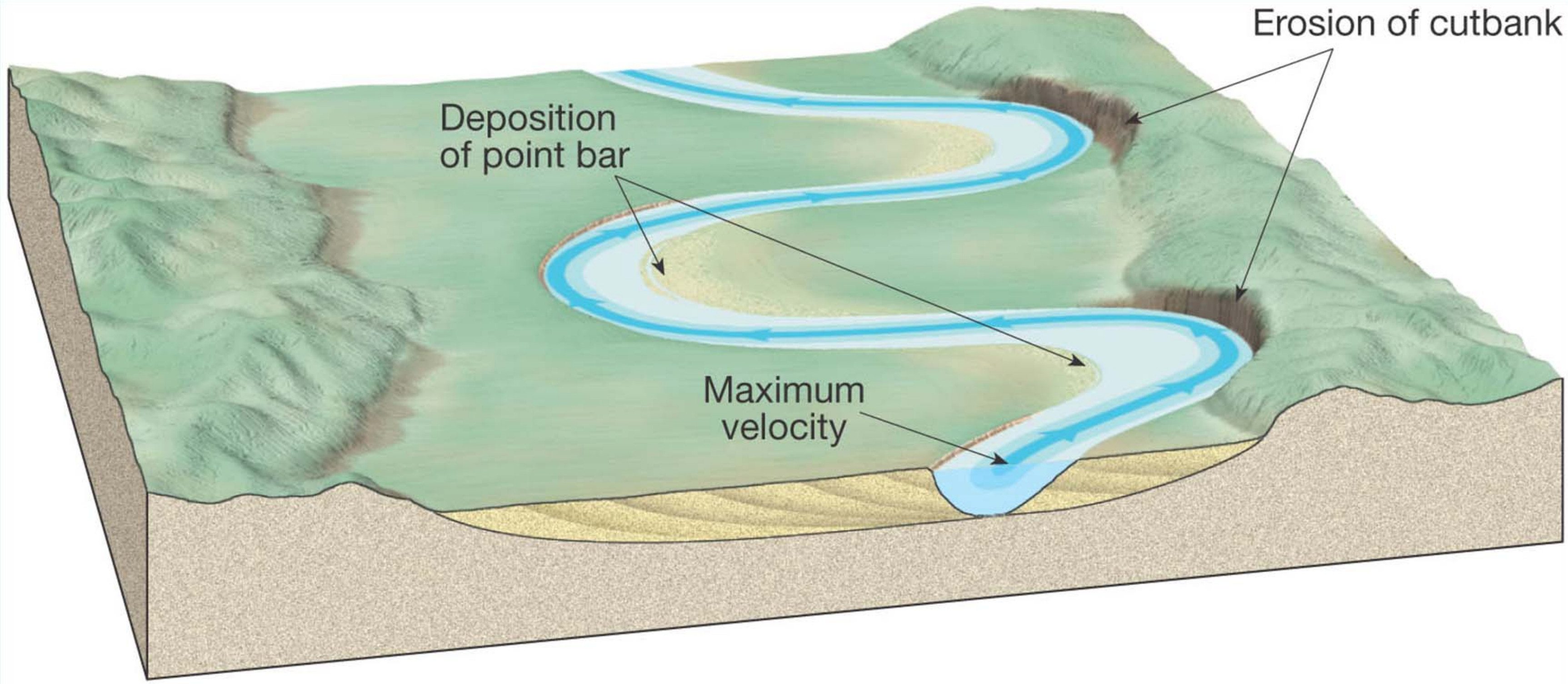


Figure 3.17

0 %

Loading

St Johns River

Base Level

- **Base level and stream erosion**
  - ***Base level* is the lowest point to which a stream can erode – the point where the stream looses it's energy**
  - **Two general types of base level**
    - **Ultimate (sea level)**
    - **Local or temporary**

Base Level

- **Base level and stream erosion**
  - **Changing conditions causes readjustment of stream activities**
    - **Raising base level causes deposition**
    - **Lowering base level causes erosion**

Adjustment of Base Level to Changing Conditions

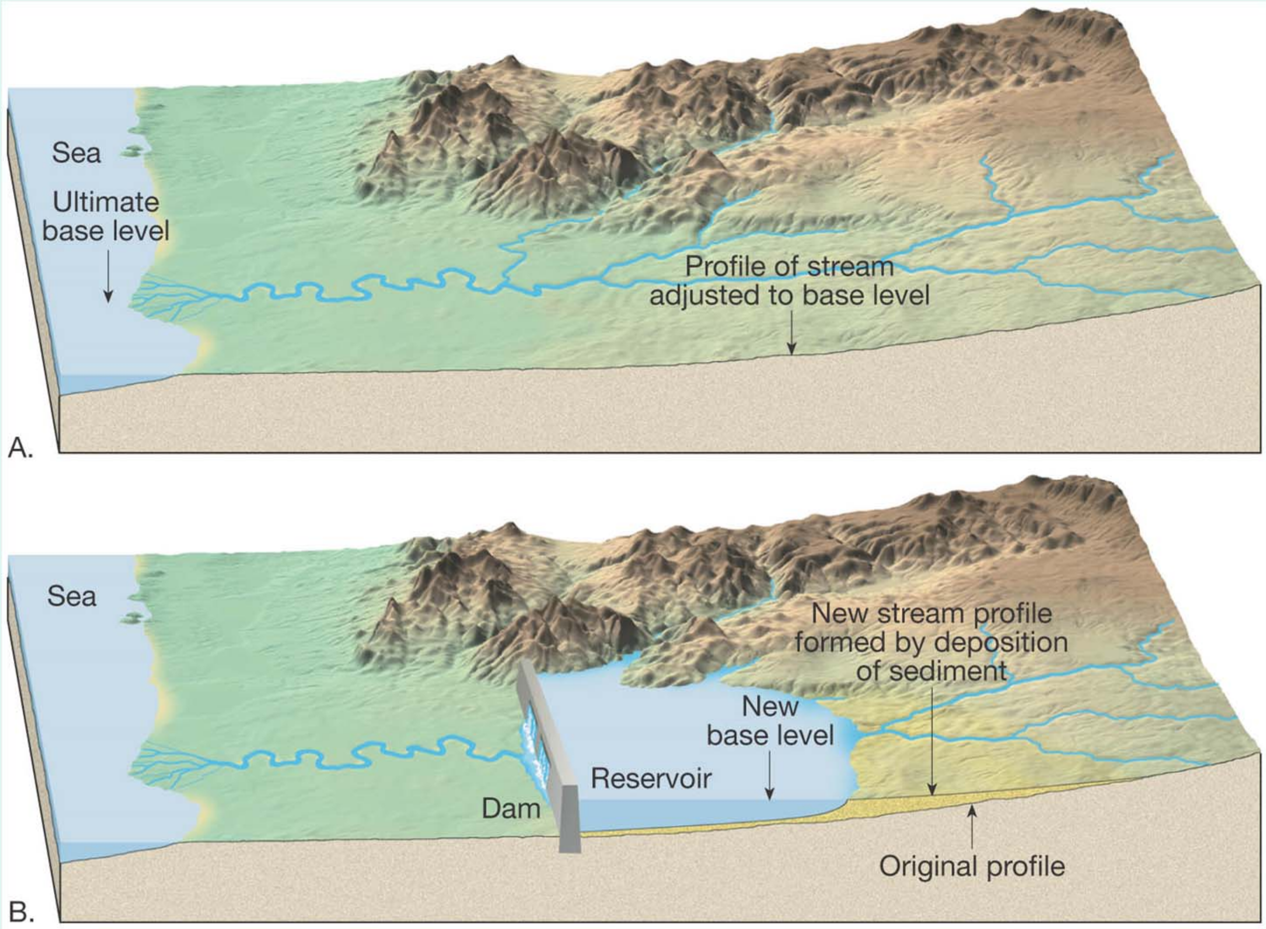
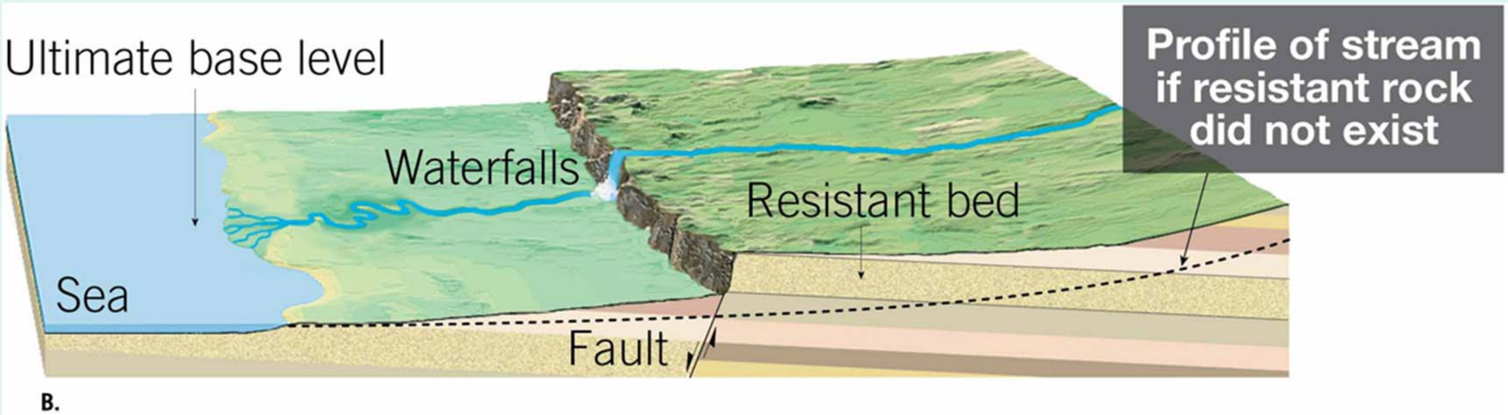


Figure 3.9

Base Level



Ultimate base level
Profile of stream if resistant rock did not exist
Waterfalls
Resistant bed
Sea
Fault
B.

A Waterfall Is an Example of a Local Base Level

The Work of Streams

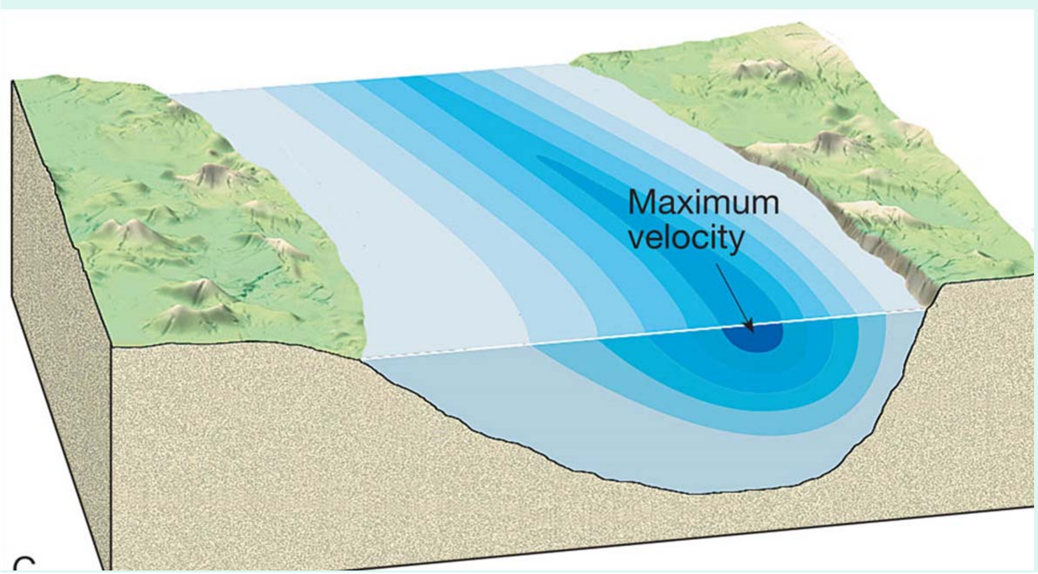
Deposition of sediment by a stream

Caused by a decrease in velocity

- –Competence is reduced
- –Sediment begins to drop out

Stream sediments

- –Generally well sorted
- –Stream sediments are known
- –as *alluvium*



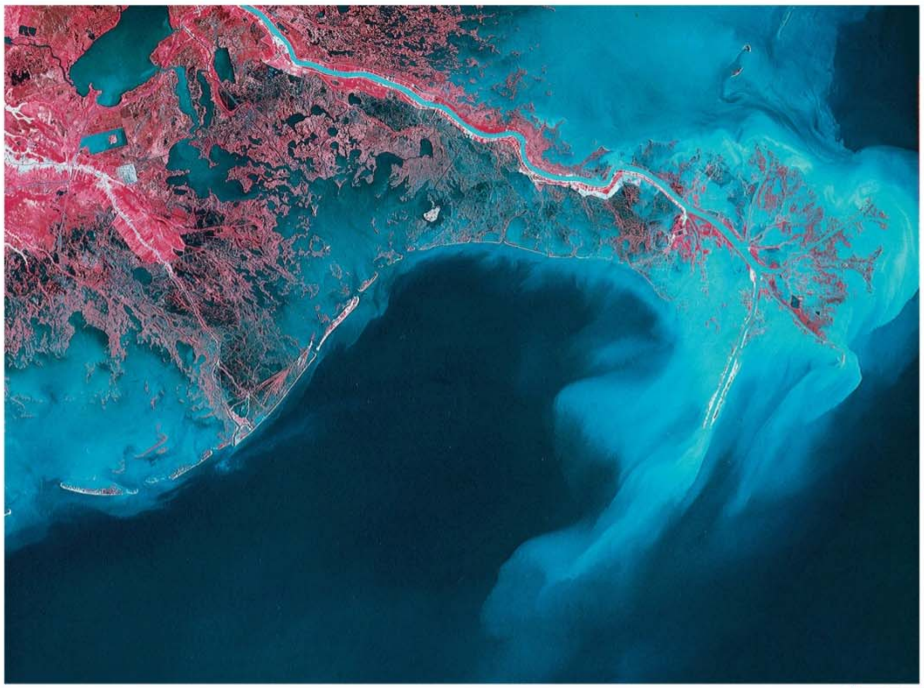
The Work of Streams

Deposition of sediment by a stream

Delta—Body of sediment where a stream enters a lake or the ocean

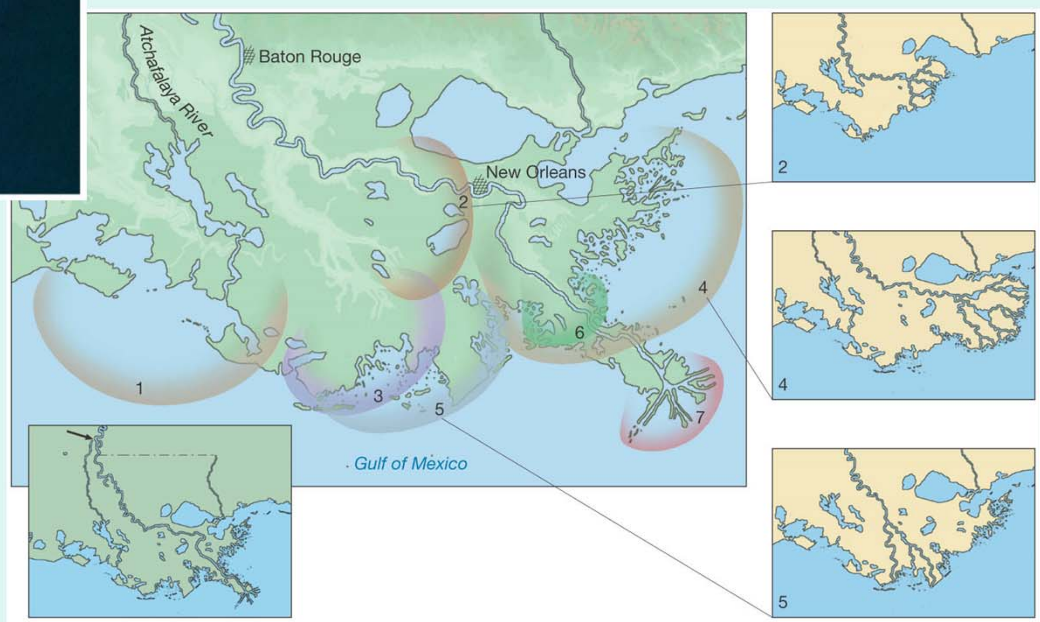
- Results from a sudden decrease in velocity

Deltas – New Orleans



Bird Foot Delta

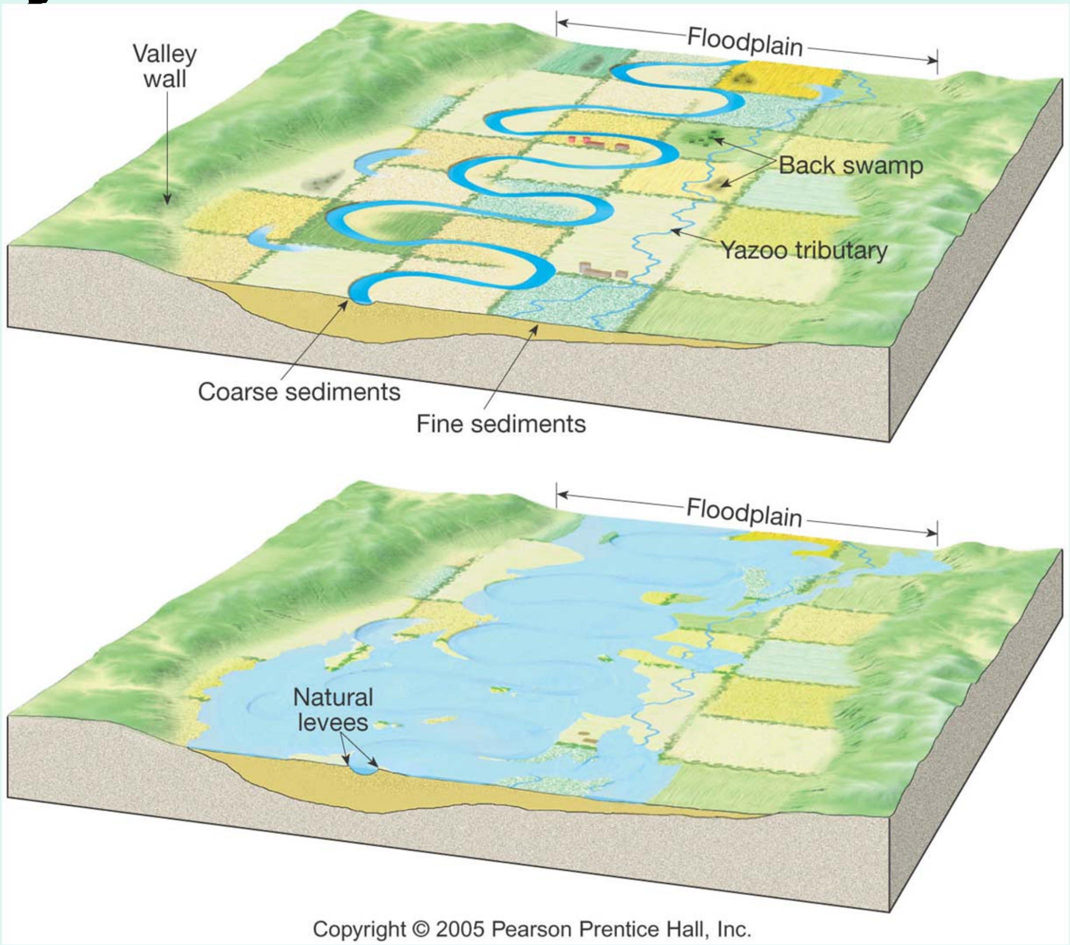
Changes in Deposition Location



The Work of Streams

Deposition of sediment by a stream

Natural levees—Form parallel to the stream channel by successive floods over many years



0 %

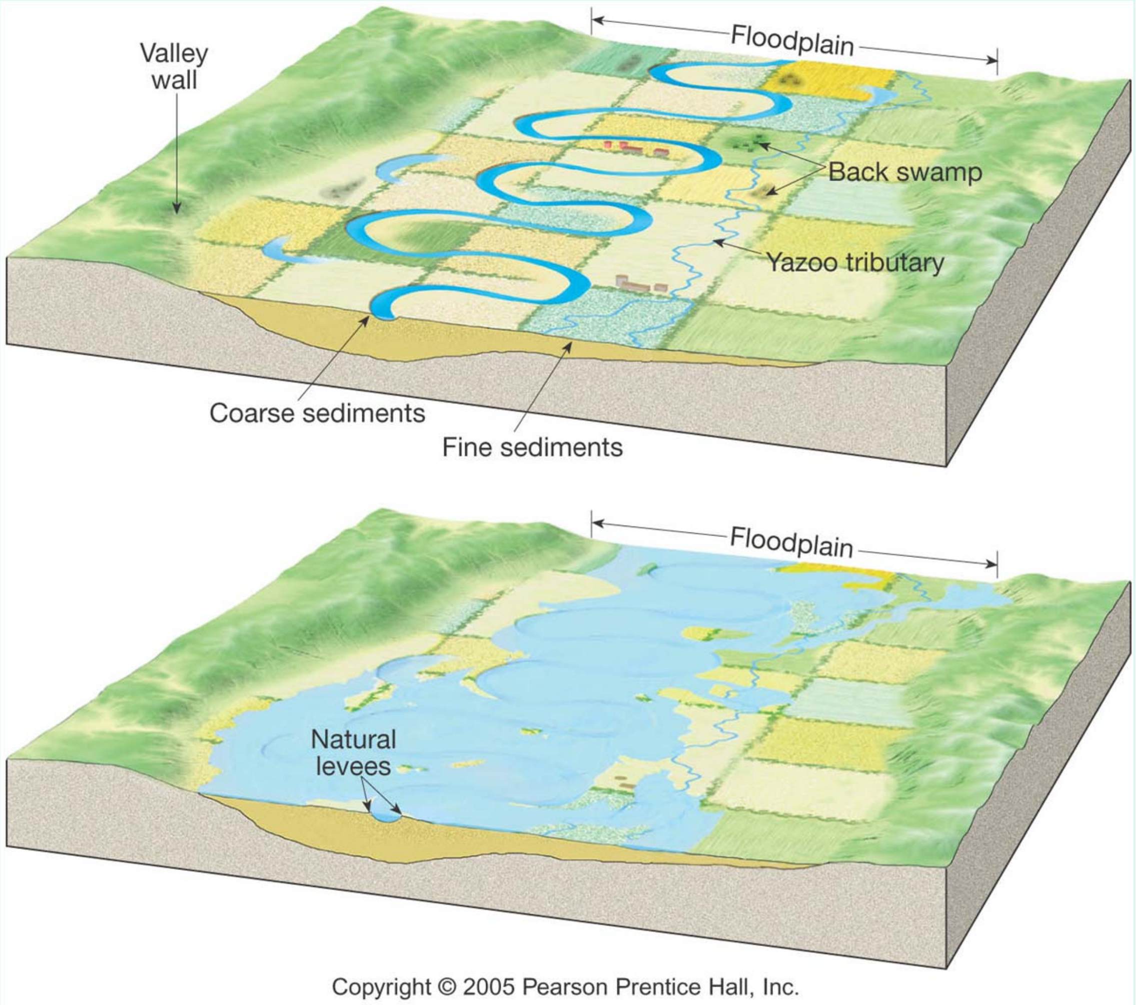
Loading

The Work of Streams

Deposition of sediment by a stream

Floodplain deposits

- **–Back swamps**
- **–*Yazoo tributaries***



Stream Valleys

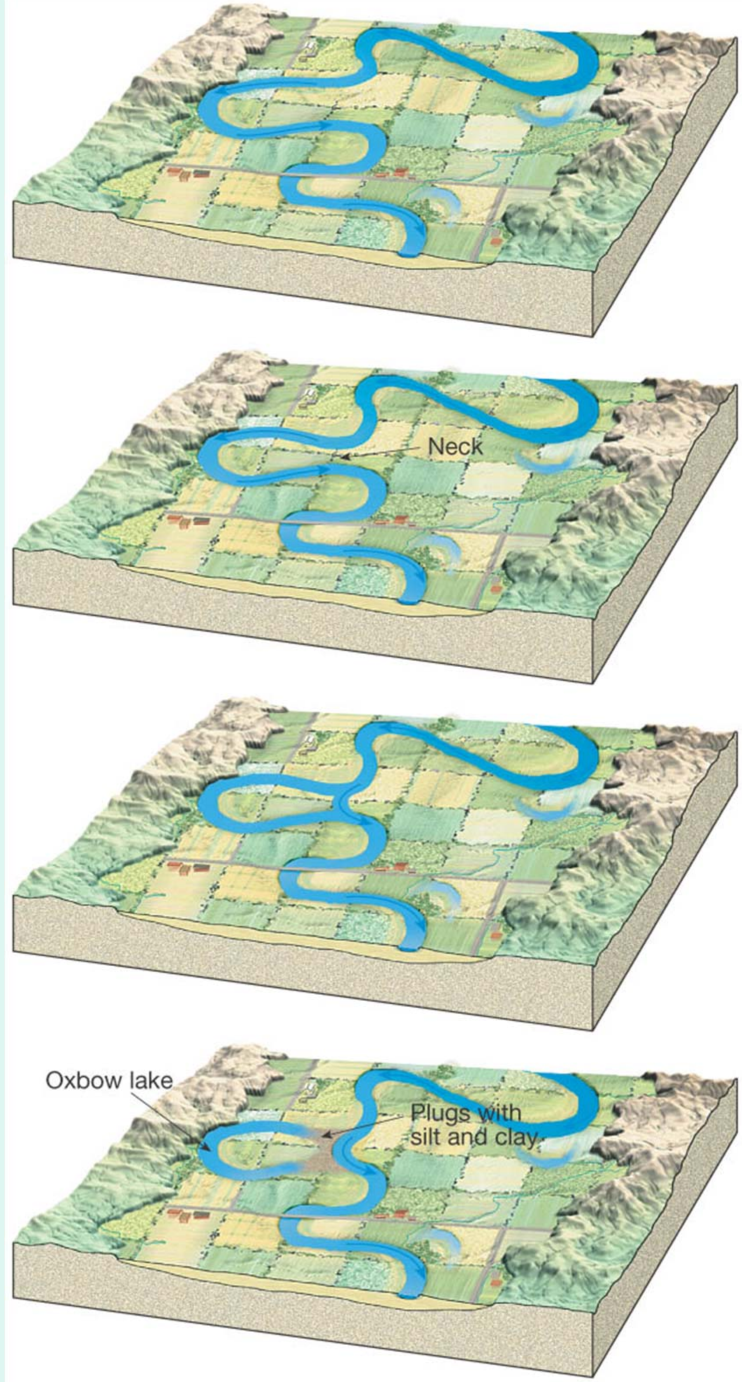
- **Features of wide valleys often include**
  - ***Floodplains***
    - **Erosional floodplains**
    - **Depositional floodplains**
      - » ***Meanders***
      - » **Cut banks and *point bars***
      - » **Cutoffs and *oxbow lakes***

A Meander Loop on the Colorado River

0 %

Loading

Erosion and Deposition Along a Meandering Stream



Floods and Flood Control

- **Floods and flood control**
  - **Floods are the most common and most destructive geologic hazard**
  - **Causes of flooding**
    - **Result from naturally occurring and human-induced factors**
    - **Causes include heavy rains, rapid snow melt, dam failure, topography, and surface conditions**

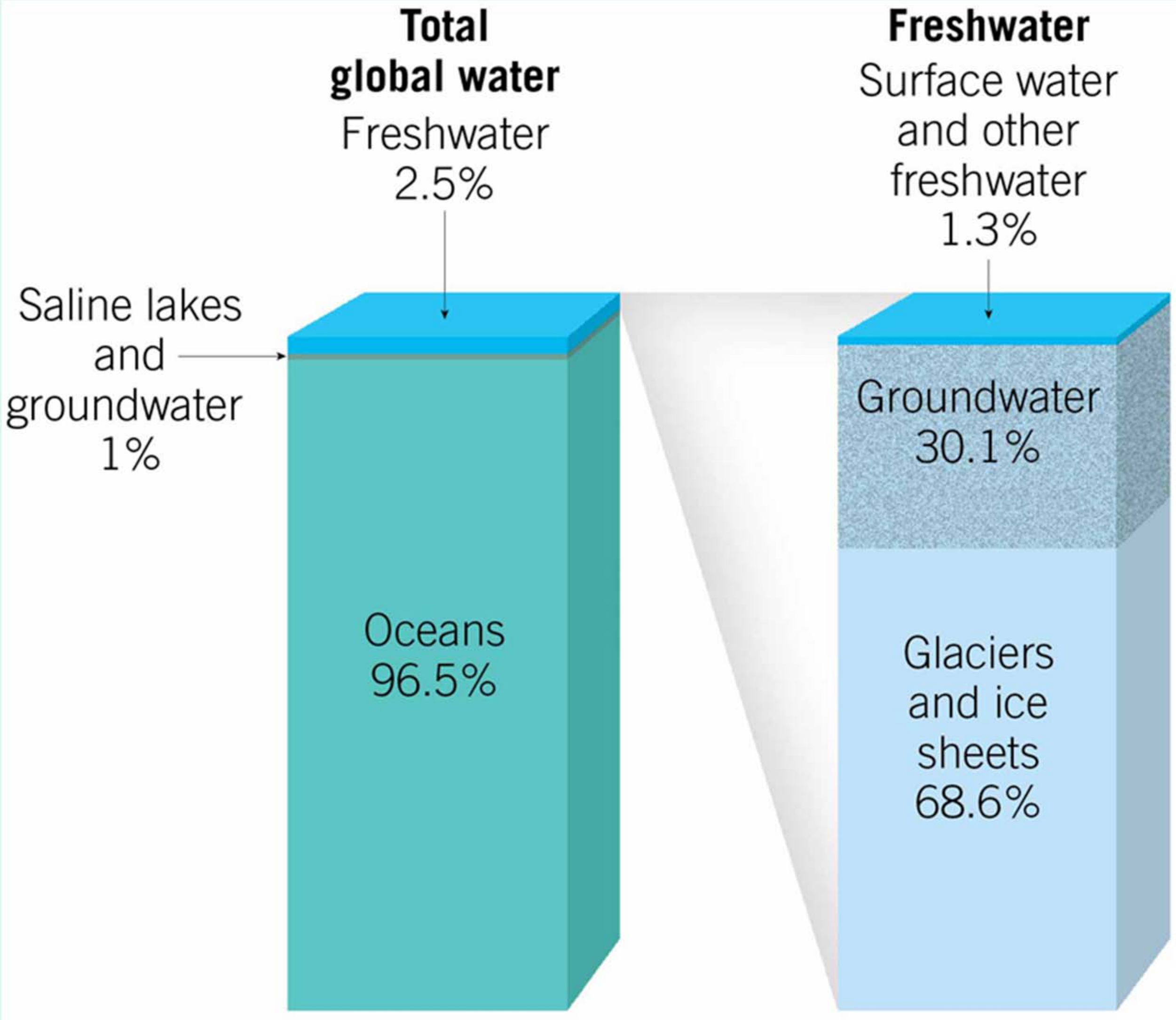
Arizona Flooding- Sept 2014

Floods and Flood Control

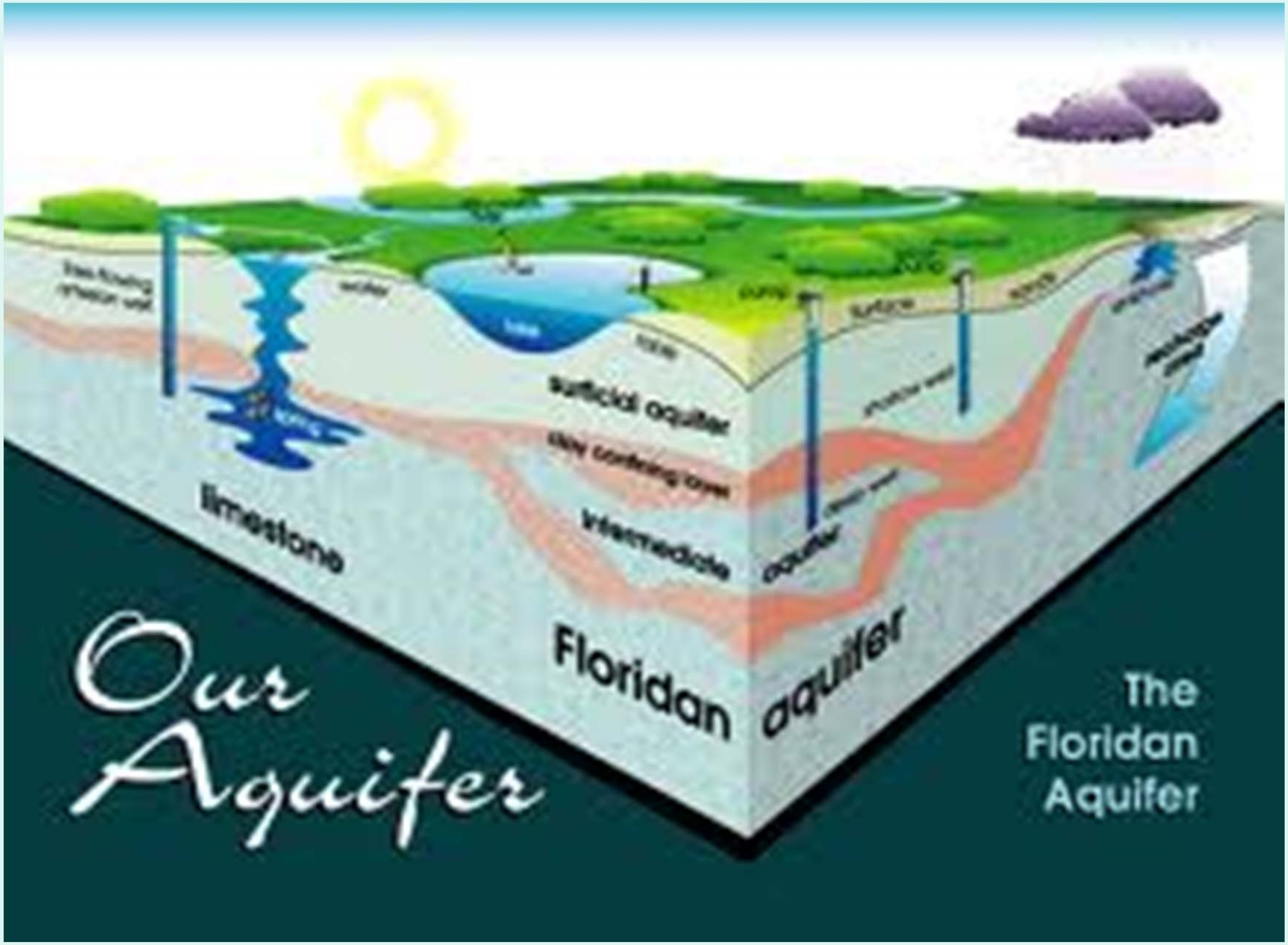
- **Floods and flood control**
  - **Flood control**
    - **Engineering efforts**
      - » **Artificial levees**
      - » **Flood-control dams**
      - » ***Channelization***
    - **Nonstructural approach through sound floodplain management**

Groundwater

Largest freshwater reservoir for humans



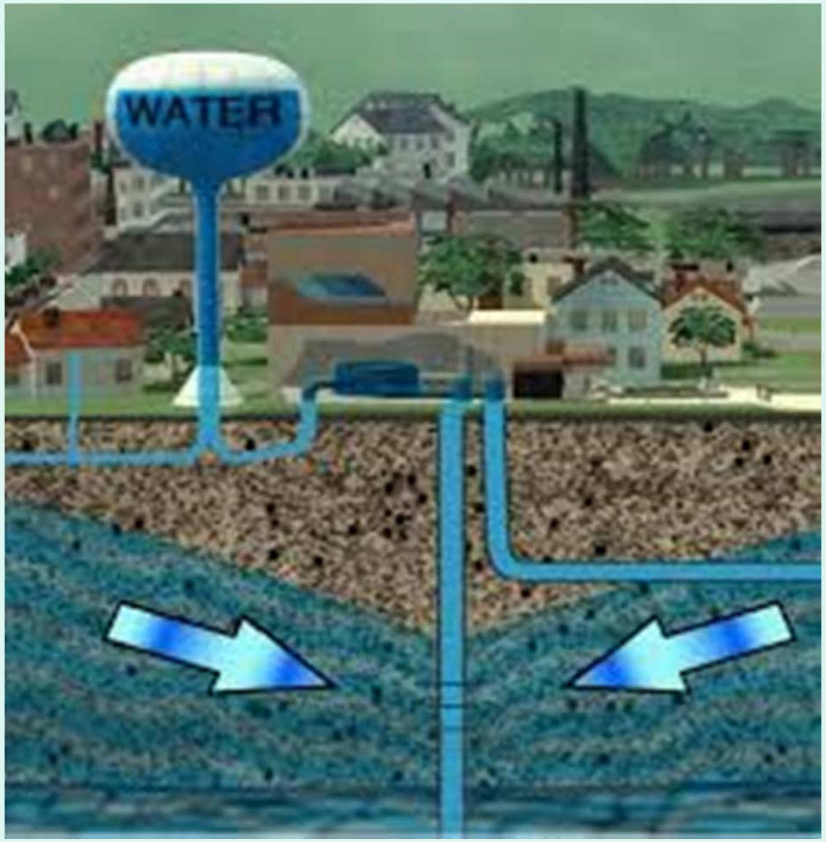
The Florida Aquifer



Water Source

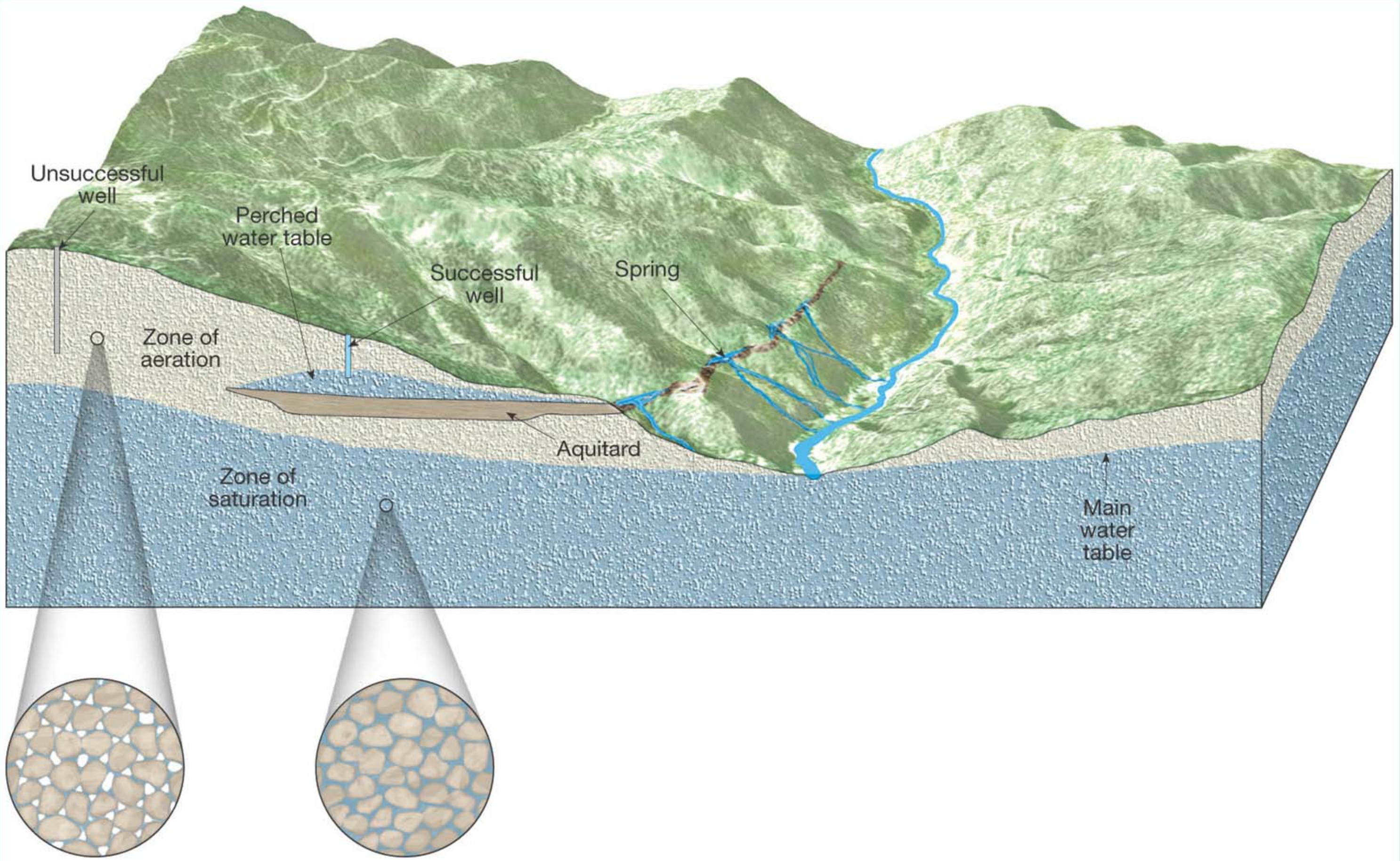
Old School

New School



Florida's Source of Water

Features Associated with Subsurface Water



Water Beneath the Surface

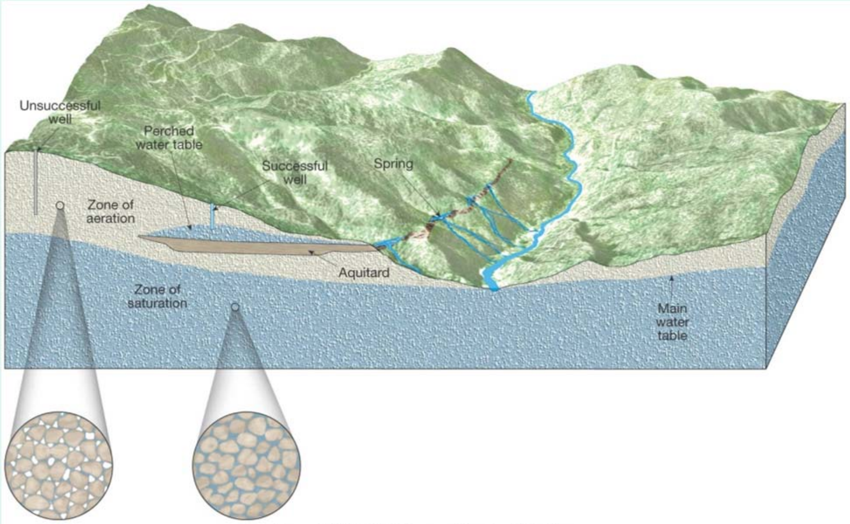
Distribution and movement of groundwater

Distribution of groundwater

Zone of aeration

Unsaturated zone

Pore spaces in the material are filled mainly with air



Water Beneath the Surface

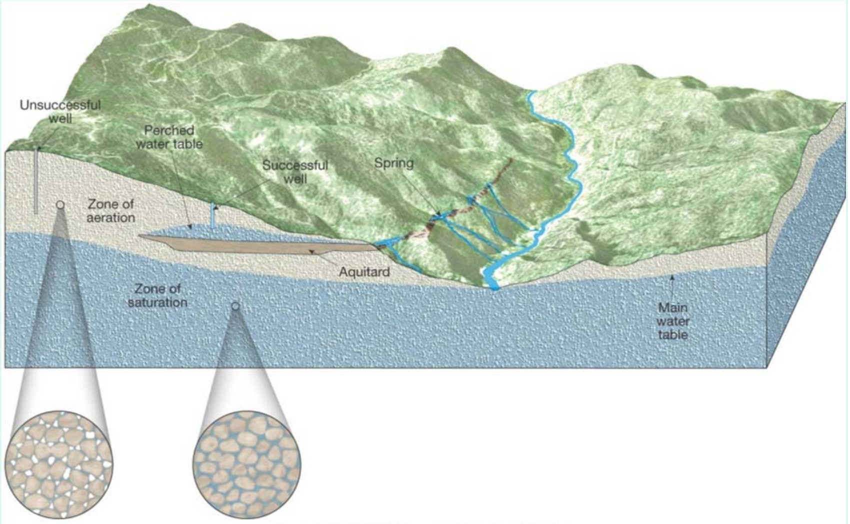
Distribution and movement of groundwater

Distribution of groundwater

Zone of saturation

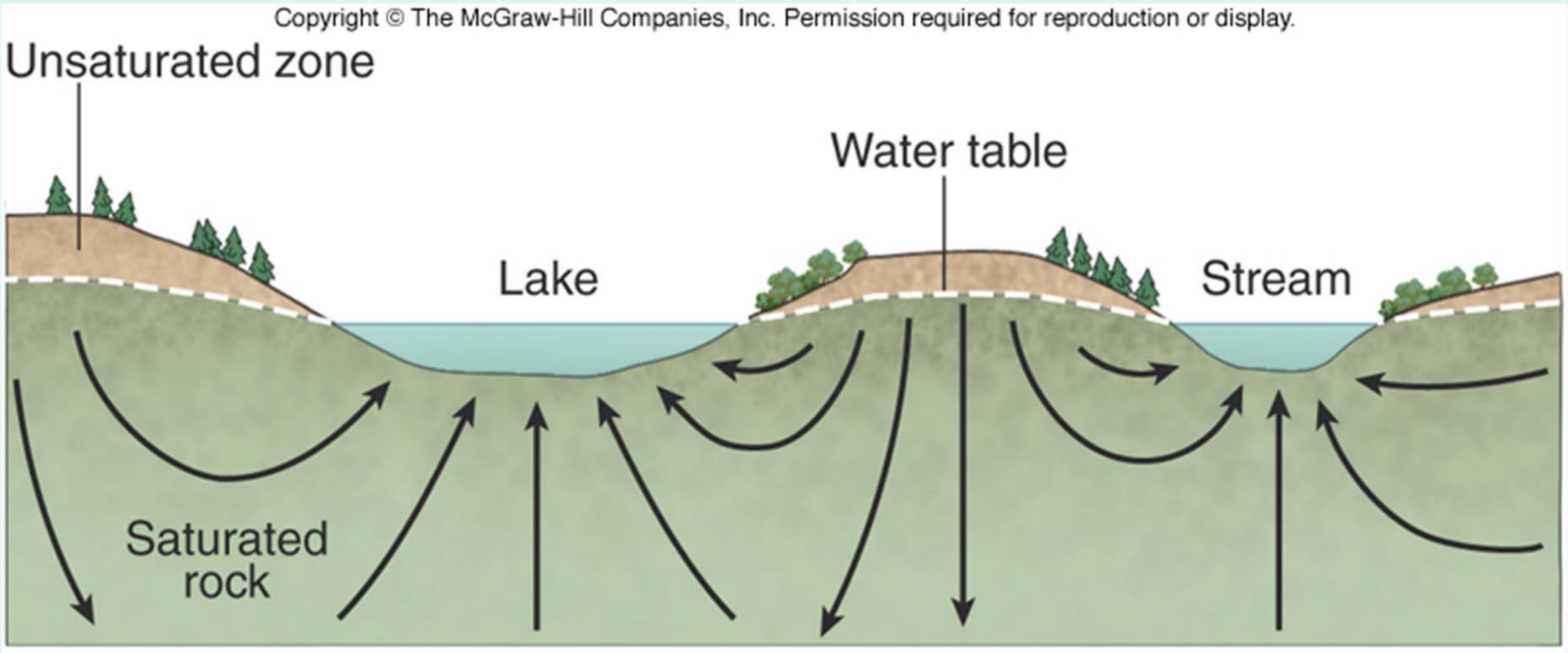
- All pore spaces in the material are filled with water
- Water within the pores is *groundwater*

Water table—The upper limit of the zone of saturation



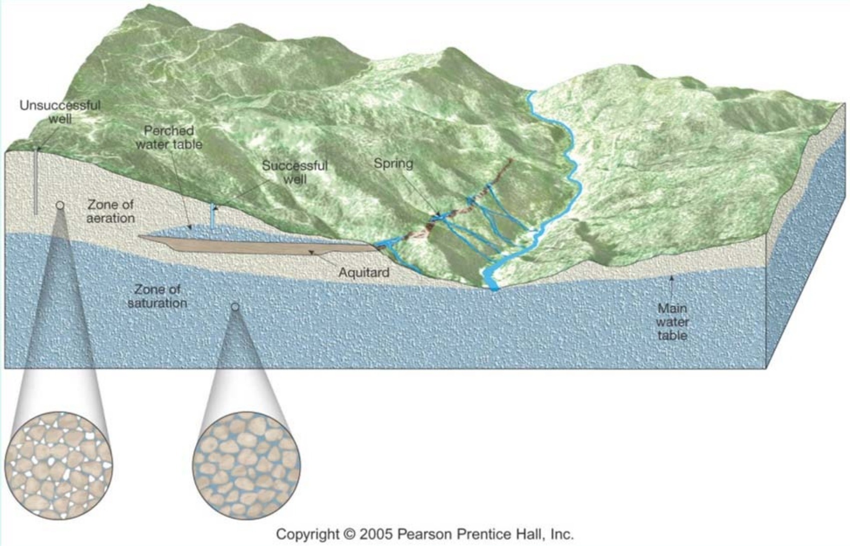
Water Beneath the Surface

The Water Table



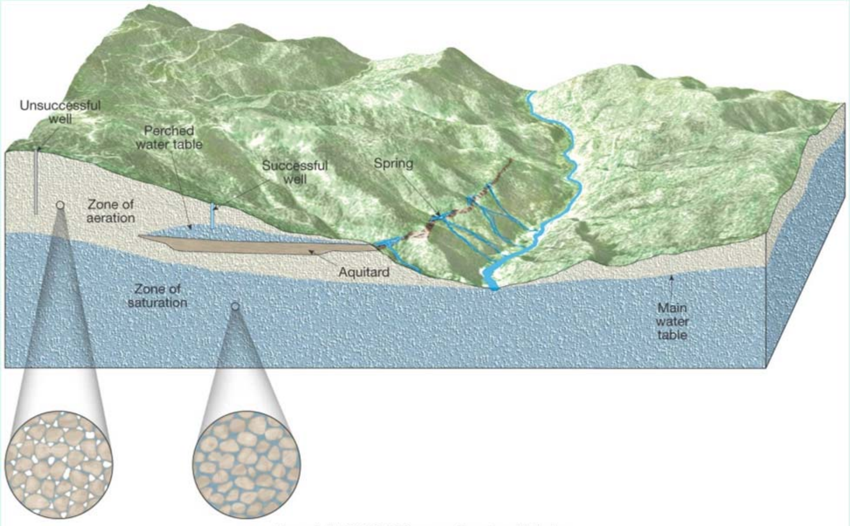
Water Beneath the Surface

- **Movement of groundwater**
  - ***Porosity***
    - **Percentage of pore spaces**
    - **Determines how much groundwater can be stored**



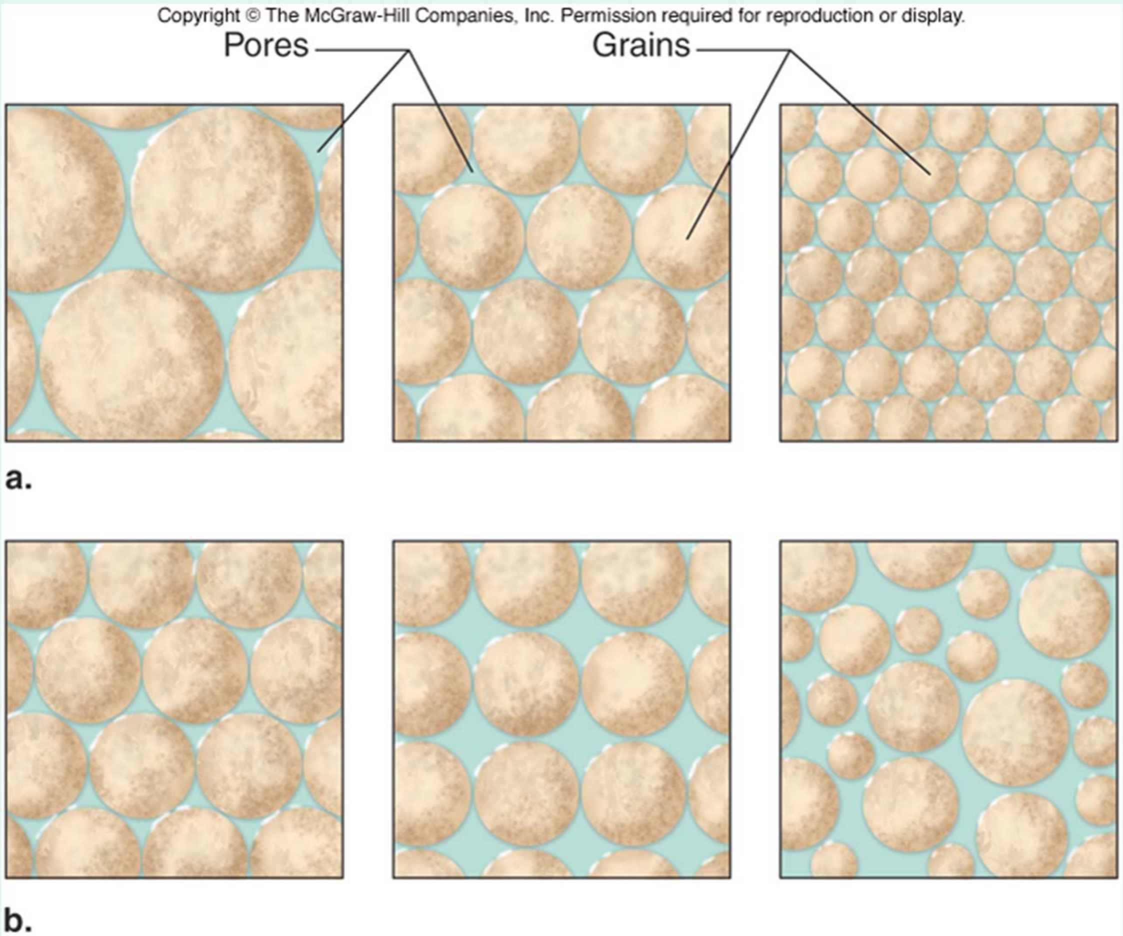
Water Beneath the Surface

- **Movement of groundwater**
  - ***Permeability***
    - **Ability to transmit water through connected pore spaces**
    - ***Aquitard*—An impermeable layer of material**
    - ***Aquifer* —A permeable layer of material**



Water Beneath the Surface

Porosity and Permeability



Porosity = the proportion of a material that is made up of spaces.

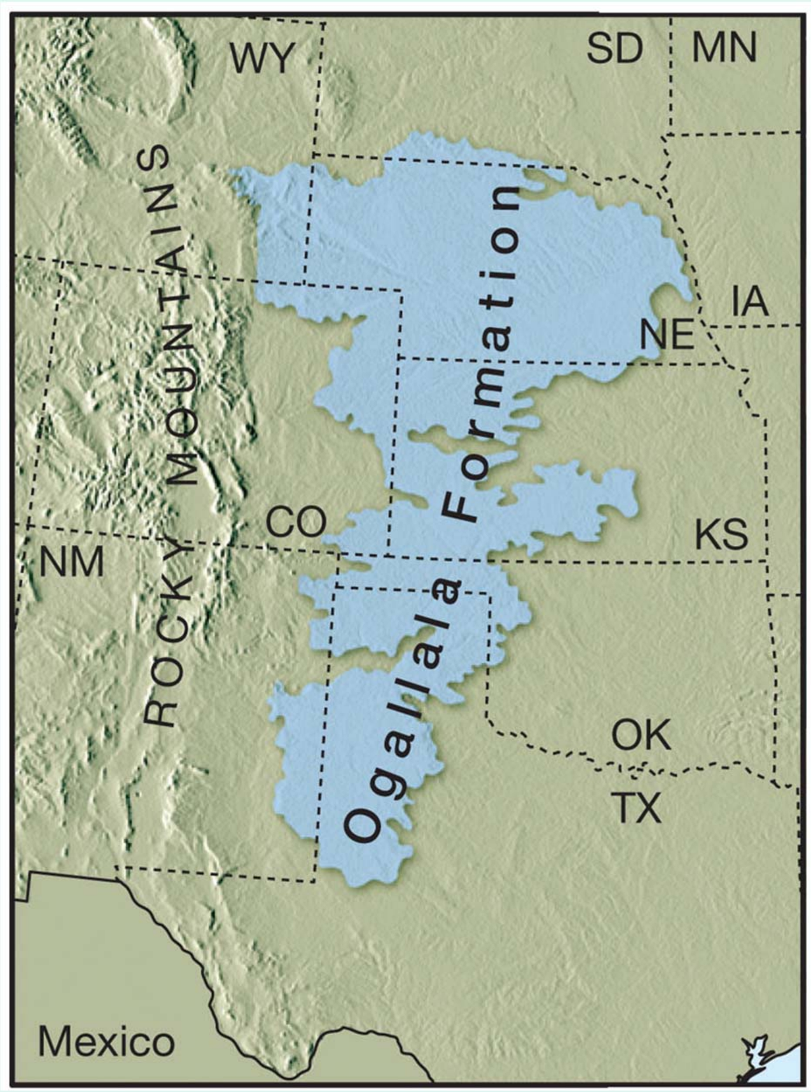
(e.g. if ½ the total volume of a rock is pore space, the porosity is 50%)

Depends on size and arrangement of the grains (better sorted – higher porosity).

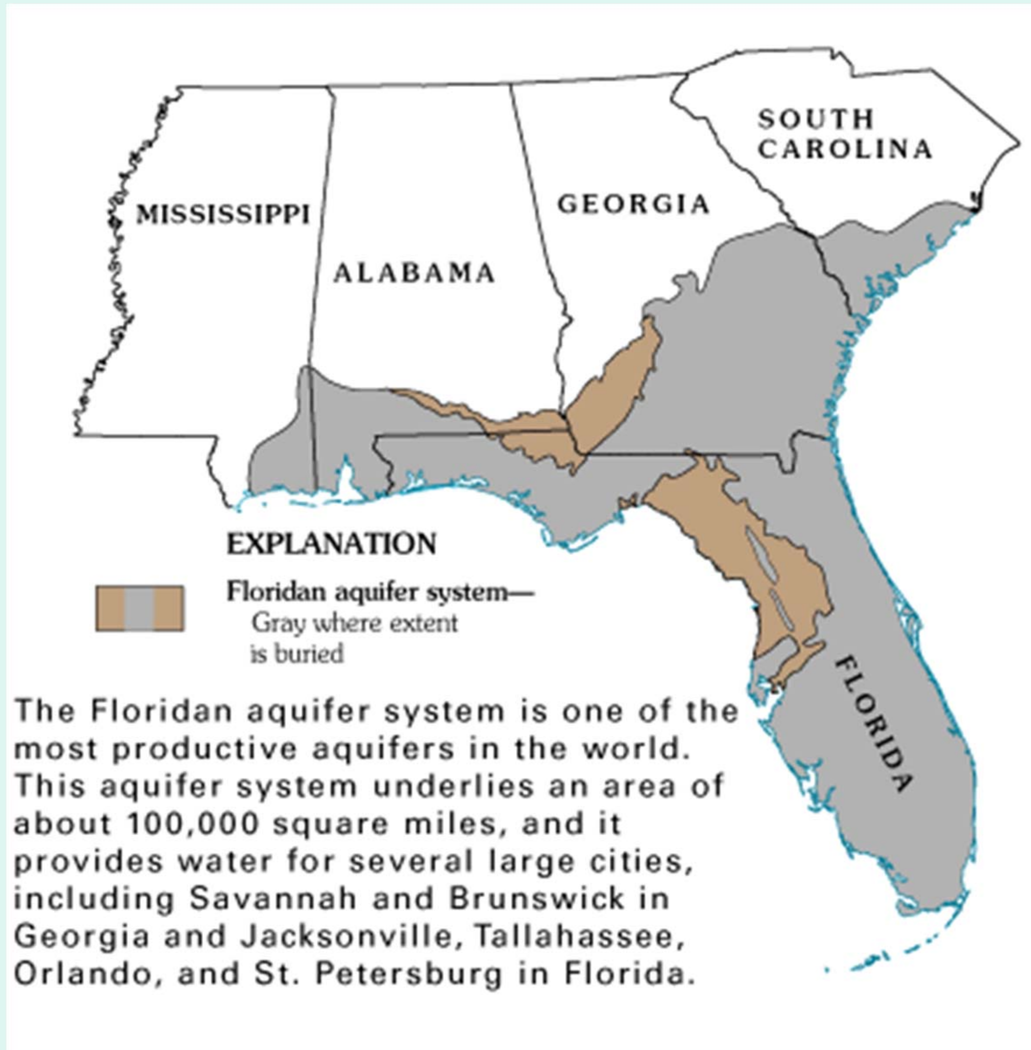
Water Beneath the Surface

Porosity and Permeability

Aquifers



WY
SD
MN
ROCKY MOUNTAINS
Ogallala Formation
IA
NE
CO
KS
NM
OK
TX
Mexico



SOUTH CAROLINA
MISSISSIPPI
GEORGIA
ALABAMA
FLORIDA
EXPLANATION
Floridan aquifer system—
Gray where extent
is buried
The Floridan aquifer system is one of the most productive aquifers in the world. This aquifer system underlies an area of about 100,000 square miles, and it provides water for several large cities, including Savannah and Brunswick in Georgia and Jacksonville, Tallahassee, Orlando, and St. Petersburg in Florida.

Aquifers and Drinking Water

Which is better to drink?

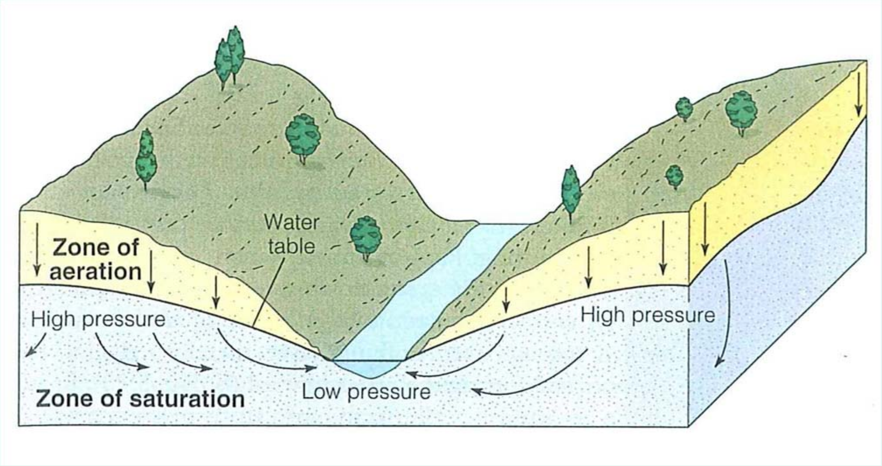
© David Aubrey/CORBIS

© Royalty-Free/Corbis

Groundwater

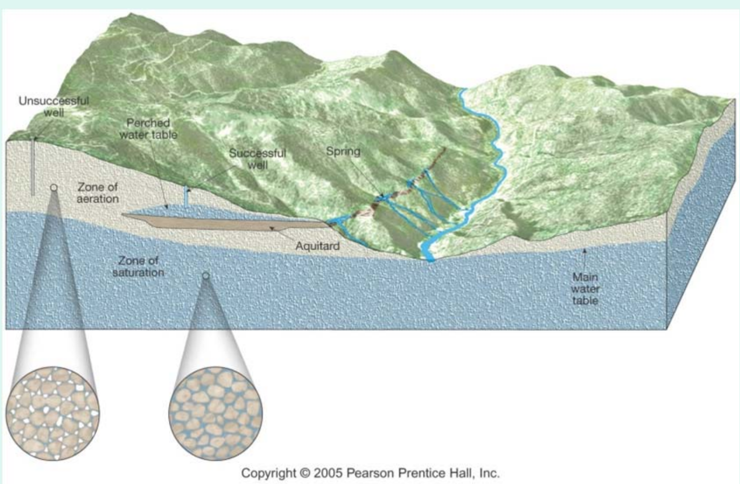
Geological roles

- As an erosional agent, dissolving by groundwater produces
  - *Sinkholes*
  - *Caverns*
- An equalizer of stream flow



Groundwater Features

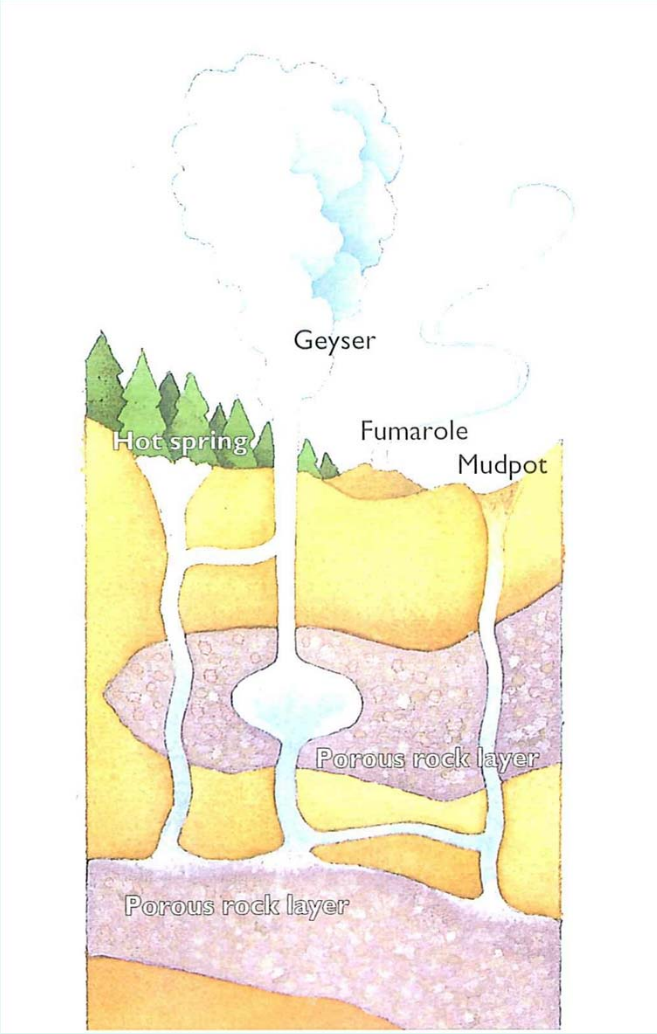
- **Springs**
    - ***Cold Springs (East Coast)***
    - ***Hot springs* (West Coast)**
        - **Water is 6–9ºC warmer than the mean air temperature of the locality**
        - **Heated by cooling of igneous rock**



Hot and Cold Springs

Groundwater Features

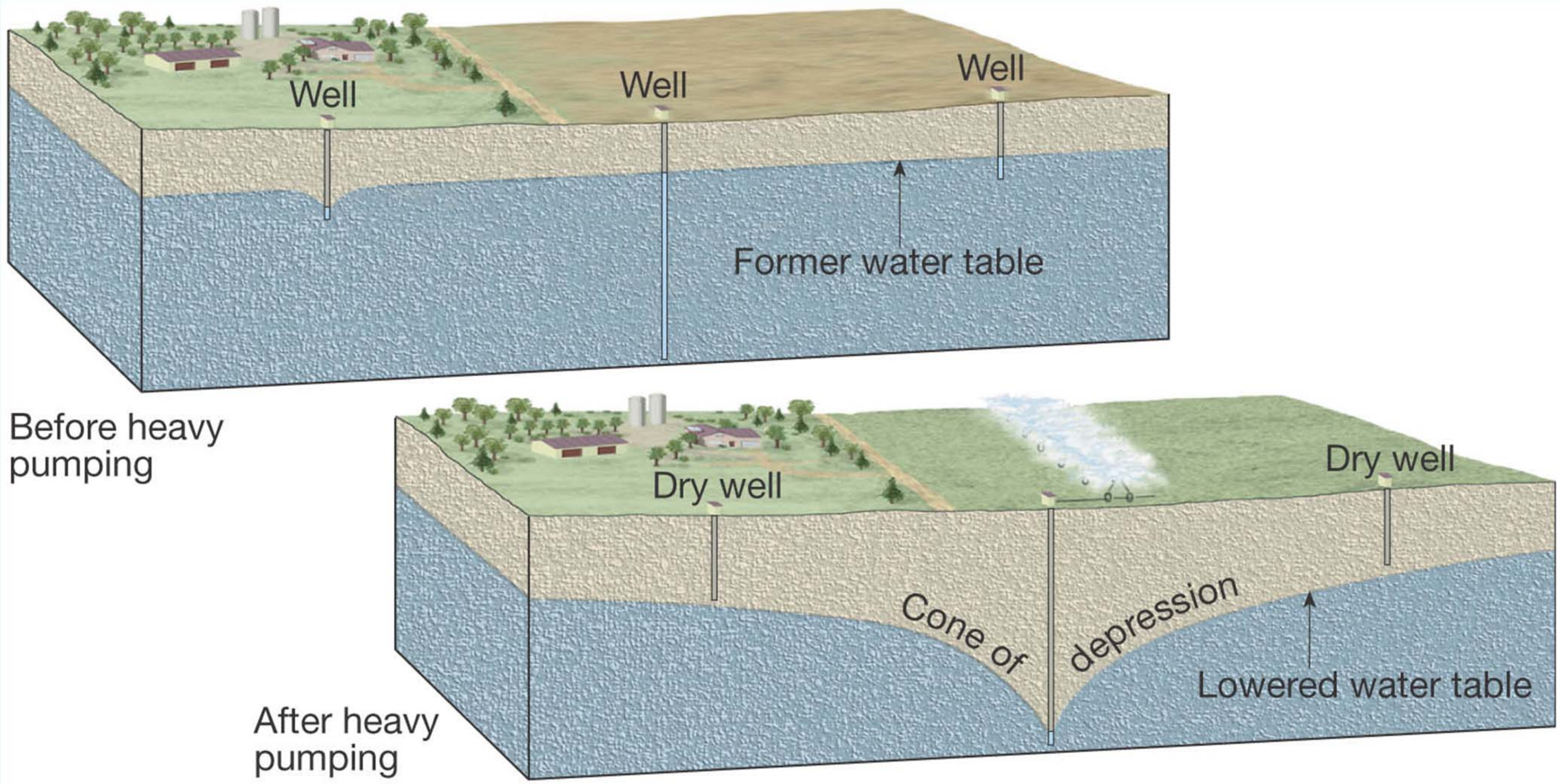
- ***Geysers***
  - **Intermittent hot springs**
  - **Water turns to steam and erupts**

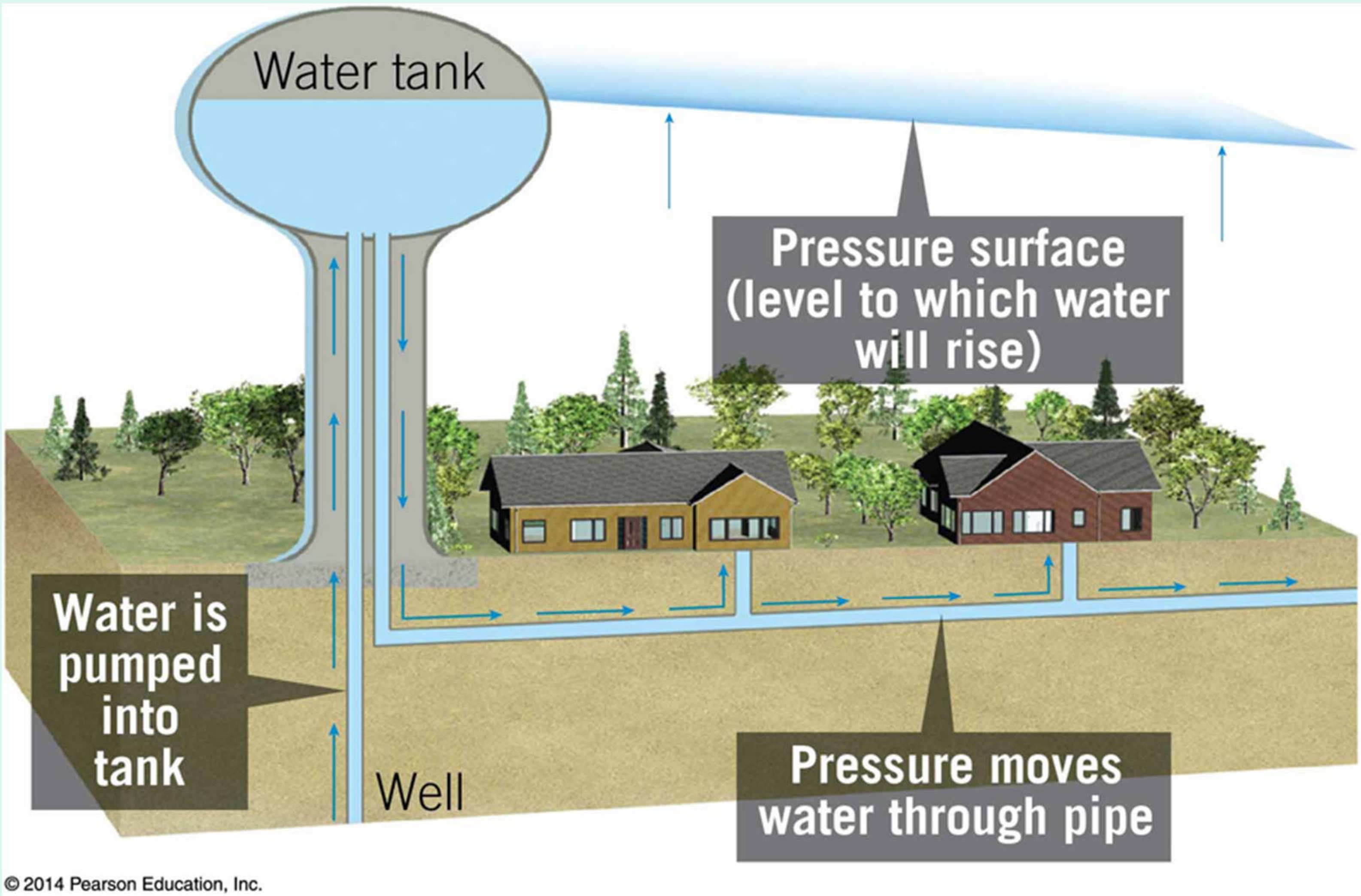


Water Beneath the Surface

- **Wells**
  - Pumping can cause a drawdown (lowering) of the water table
  - Pumping can form a *cone of depression* in the water table

Pumping Wells and Cone of Depression




Water tank
Pressure surface (level to which water will rise)
Water is pumped into tank
Well
Pressure moves water through pipe
© 2014 Pearson Education, Inc.

Water Beneath the Surface

- **Artesian Wells**
  - Water in the well rises higher than the initial groundwater level
  - Artesian wells act as “natural pipelines” moving water from remote areas of recharge great distances to the points of discharge

An Artesian Well Resulting from an Inclined Aquifer

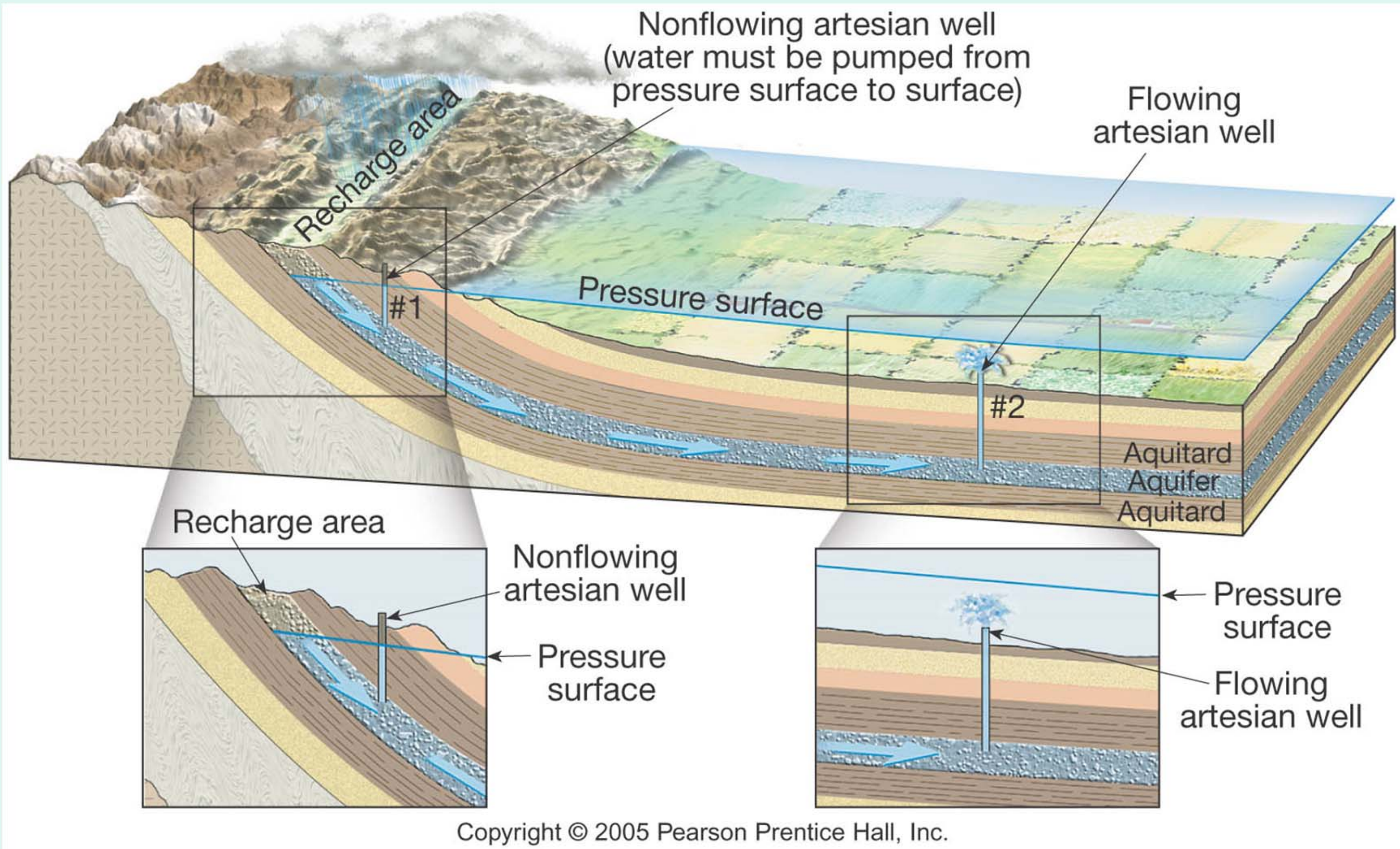
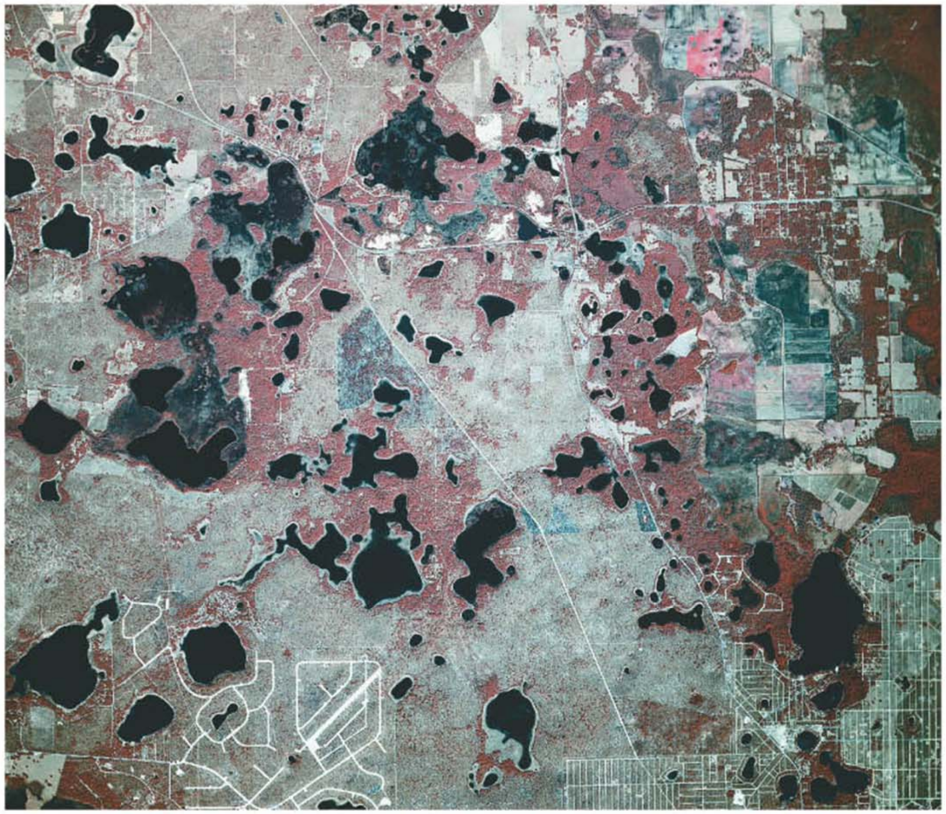


Figure 3.29

Water Beneath the Surface

- **Karst topography**
  - **Formed by dissolving rock at, or near, Earth's surface**
  - **Common features**
    - ***Sinkholes*—Surface depressions**
    - **Sinkholes form by dissolving bedrock and cavern collapse**
    - **Caves and caverns**
  - **Area lacks good surface drainage**

Erosion Features - Karst Topography and Sinkholes

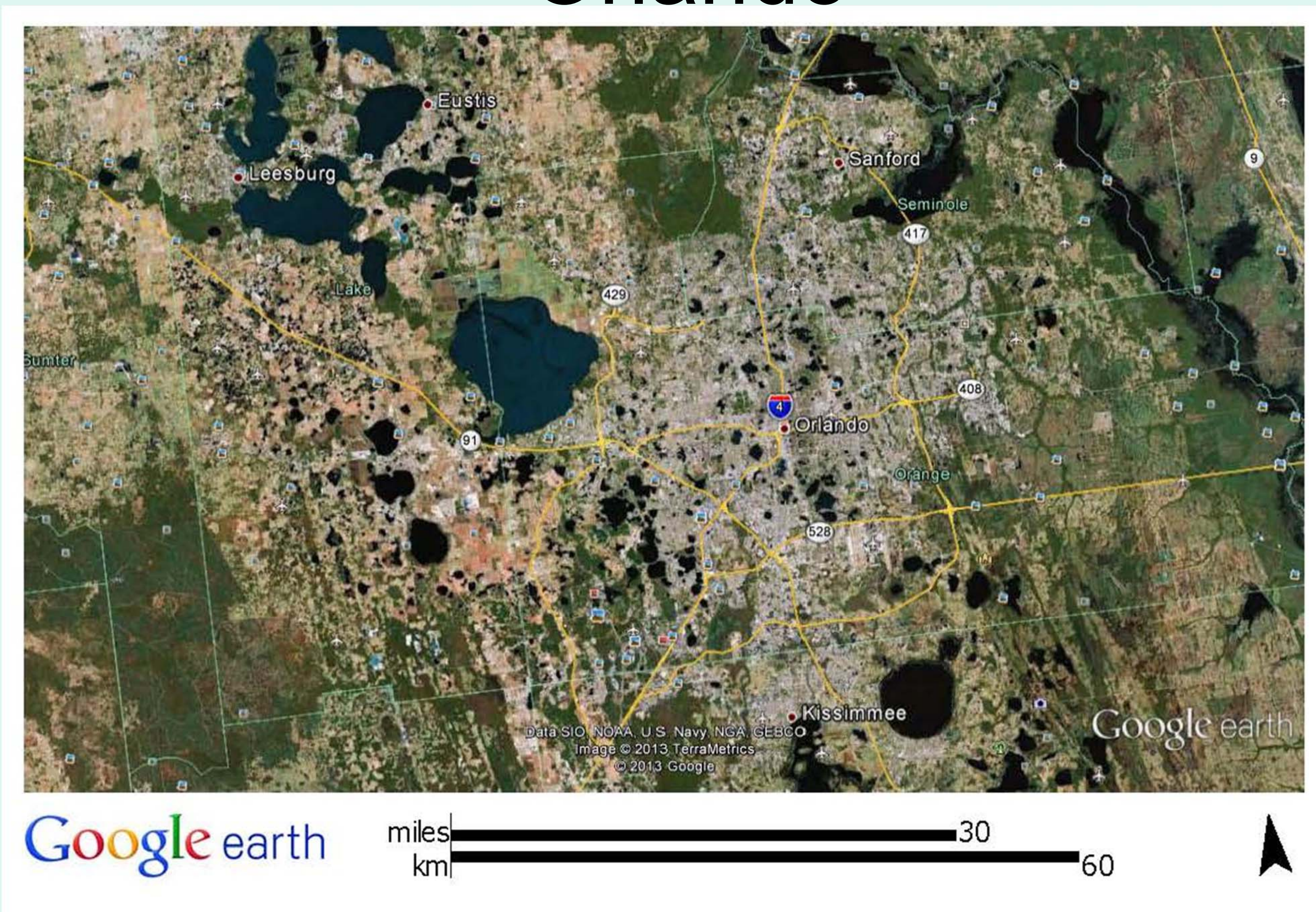


A.

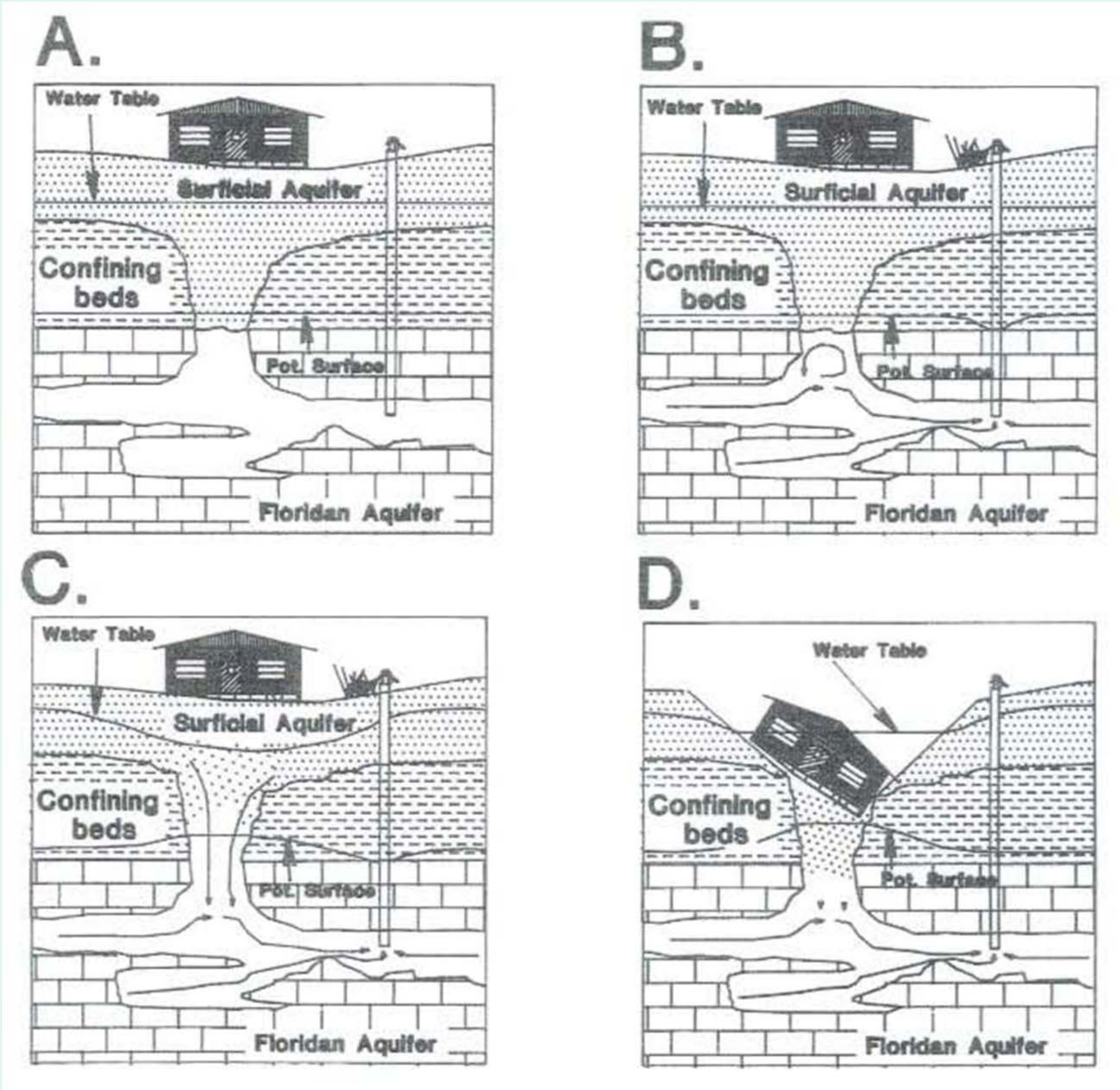
B.

Winter Park Sink Hole
Now Lake Rose off of Faibanks

Orlando


Eustis
Leesburg
Sanford
Seminole
417
429
Lake
Sumter
408
4
Orlando
91
Orange
528
9
Kissimmee
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2013 TerraMetrics
© 2013 Google
Google earth
Google earth
miles
30
km
60

Erosion Features - Karst Topography and Sinkholes



Karst Topography

Water Beneath the Surface

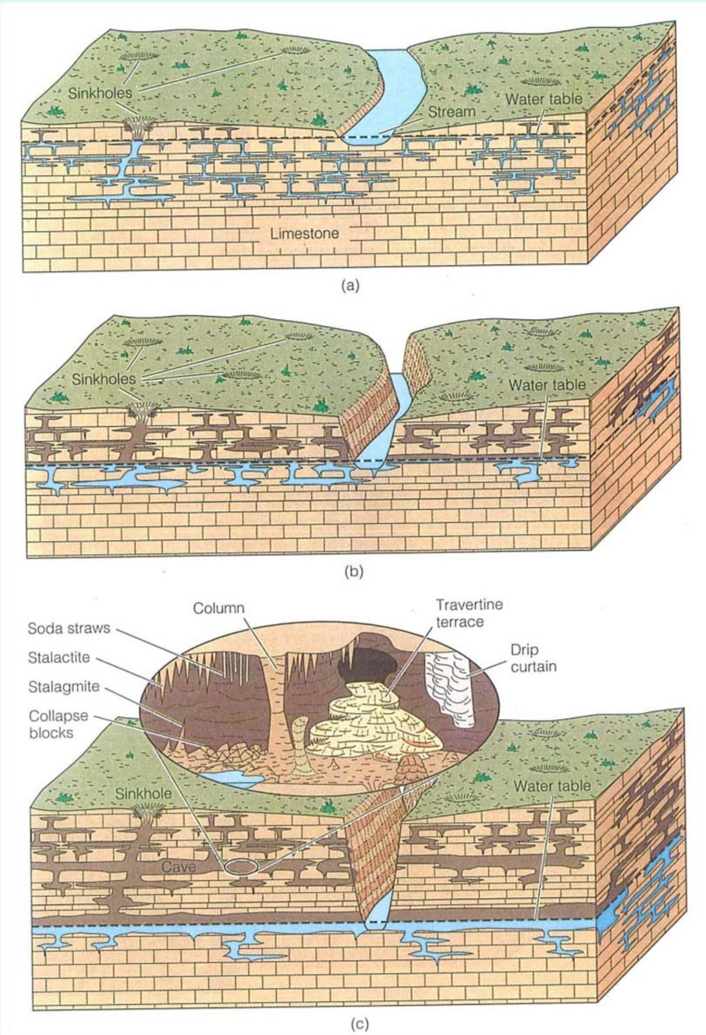
- Geologic work of groundwater
  - Groundwater if often mildly acidic
    - Contains weak carbonic acid
    - Dissolves calcite in limestone
  - *Caverns*
    - Formed by dissolving rock beneath Earth's surface
    - Formed in the zone of saturation

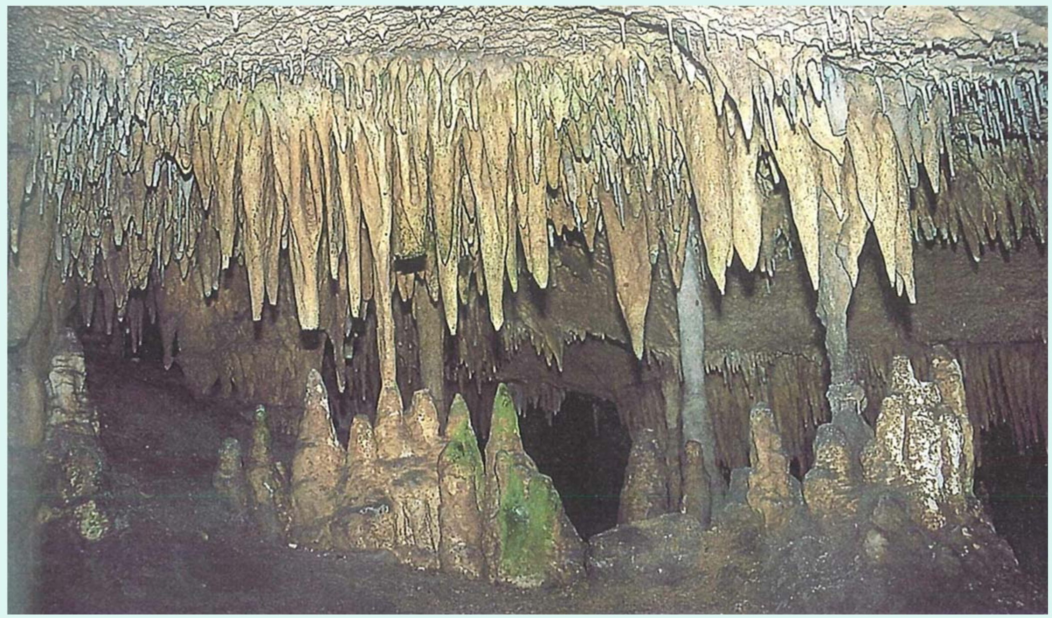
Water Beneath the Surface

- Caverns
  - Features found within caverns
    - Form in the zone of aeration
    - Composed of dripstone
    - Calcite deposited as dripping water evaporates
    - Common features include *stalactites* (hanging from the ceiling) and *stalagmites* (growing upward from the floor)

Water Beneath the Surface

Formation of Caverns

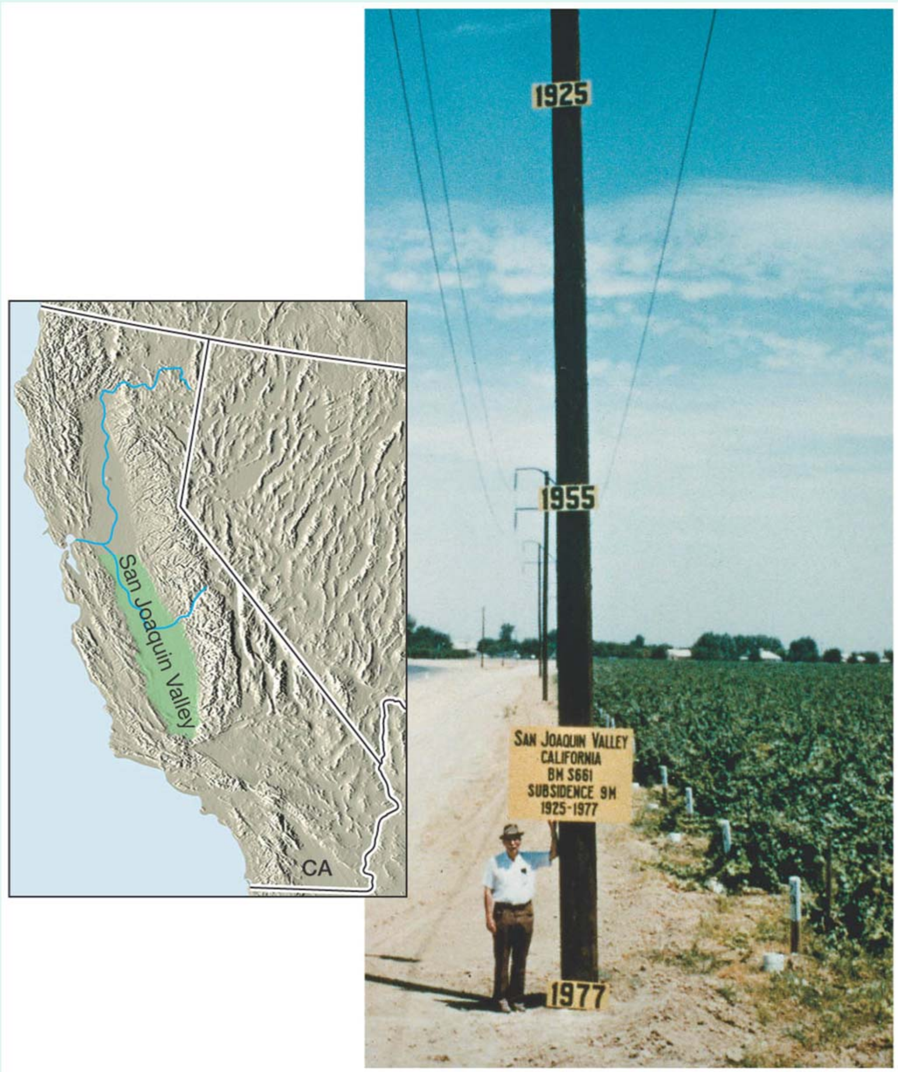




Water Beneath the Surface

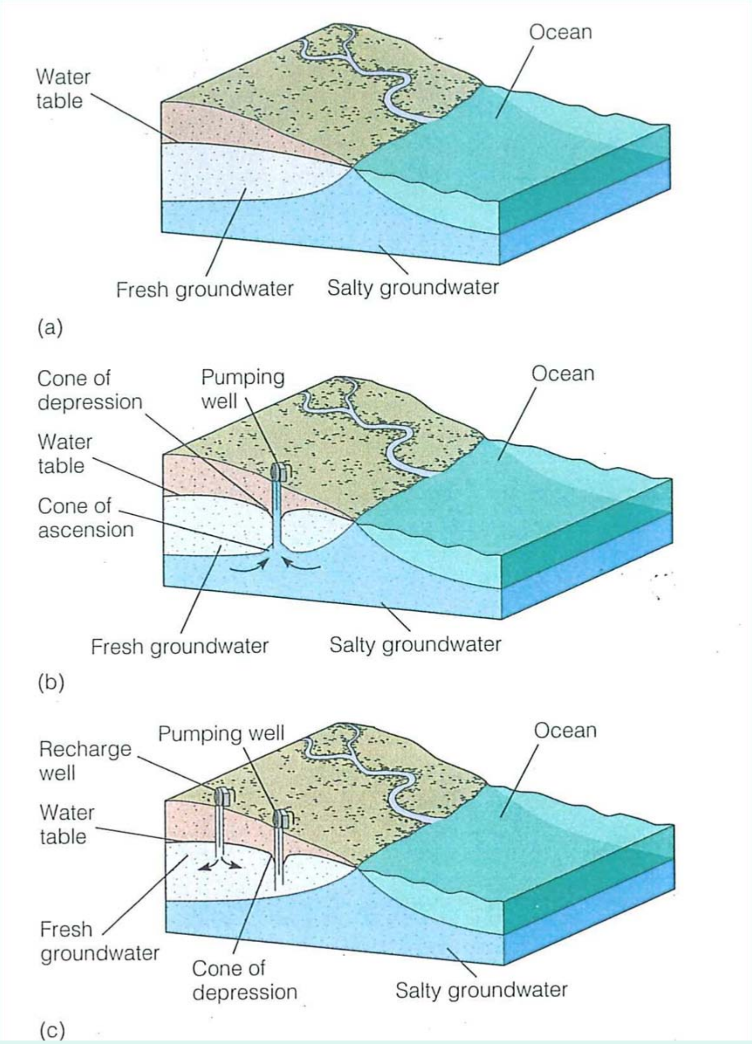
- **Environmental problems associated with groundwater**
  - **Treating it as a nonrenewable resource**
  - **Land subsidence caused by its withdrawal**
  - **Contamination**
  - **Salt Water Intrusion**

Environmental Problems - Subsidence

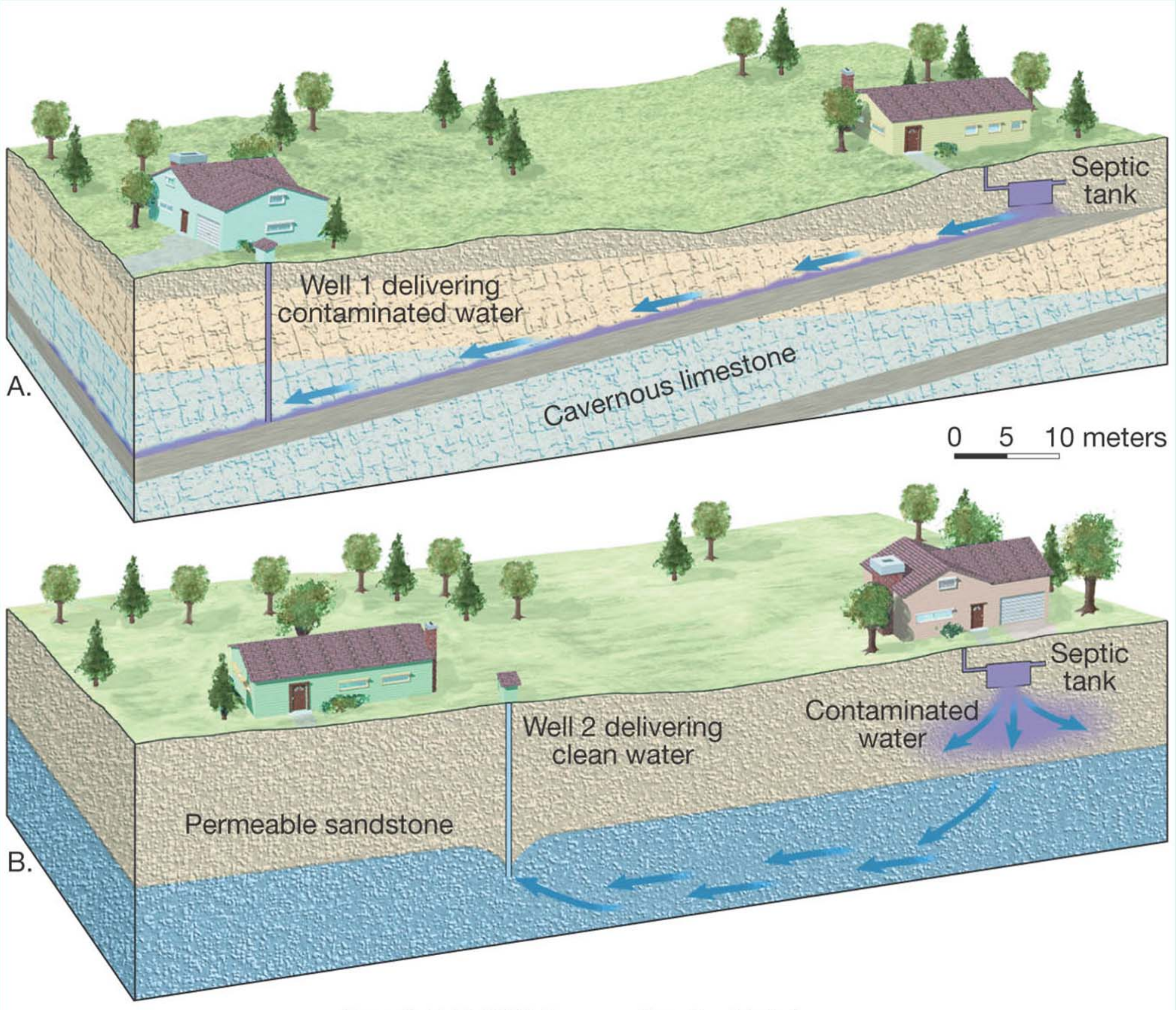


Environmental Problems

Salt Water Intrusion



Environmental Problems



Environmental Problems

Environmental Problems

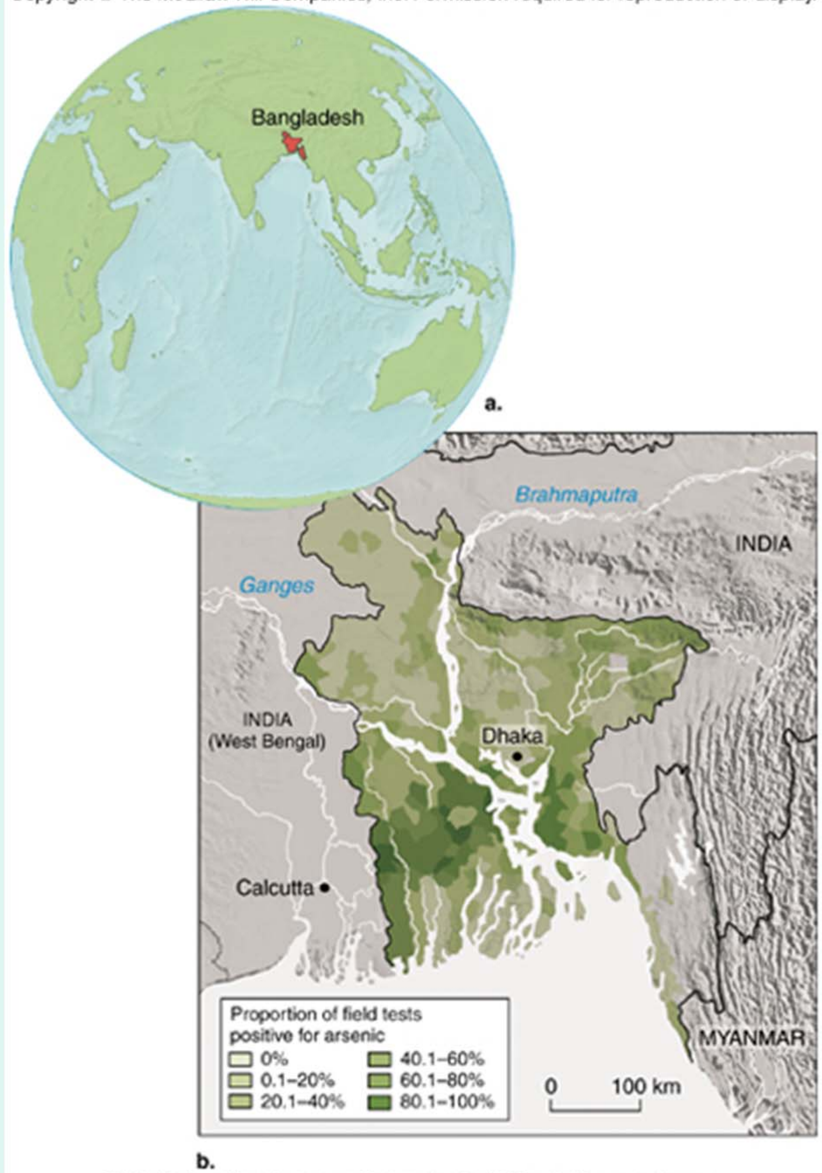
High concentrations of arsenic in the water – discovered after wells were already in use.

On map – darkest greens are highest proportion of wells contaminated by arsenic.

Worst affected wells are south of the confluence of the Ganges and Brahmaputra rivers.

These two rivers are sourced from the Himalayan foothills – the rocks there contain unusually high natural concentrations of arsenic.

~Half the population of Bangladesh (60 million people) may be exposed to arsenic levels above the WHO standard.



© http://international.usgs.gov/images/projects/big_pics/bg-map-lrg.png

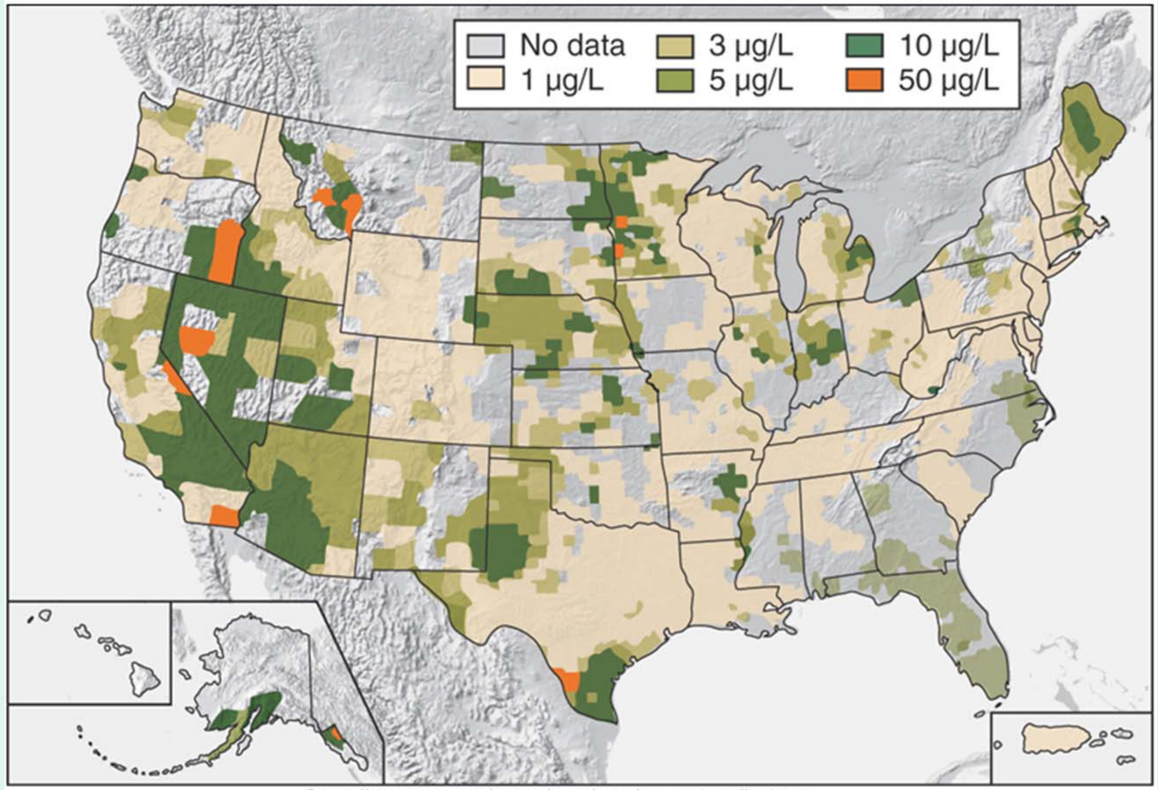
Groundwater Systems

In the U.S. the standard for arsenic in drinking water is 10 ppb (parts per billion, or 0.05 milligrams per liter, as set by WHO).

In Bangladesh, the standard is 50 ppb.

Some wells in Bangladesh have levels as high as 2,000 ppb.

Arsenic levels tend to be higher in western states that have more igneous and metamorphic rocks.



© http://water.usgs.gov/nawqa/trace/pubs/geo_v46n11/fi g2.jpeg

Viktor Yushchenko

End of Chapter 3

Next Week – First Hourly Test
25 MC Questions
(50 Points)
5 Short Answer
(50 Points)