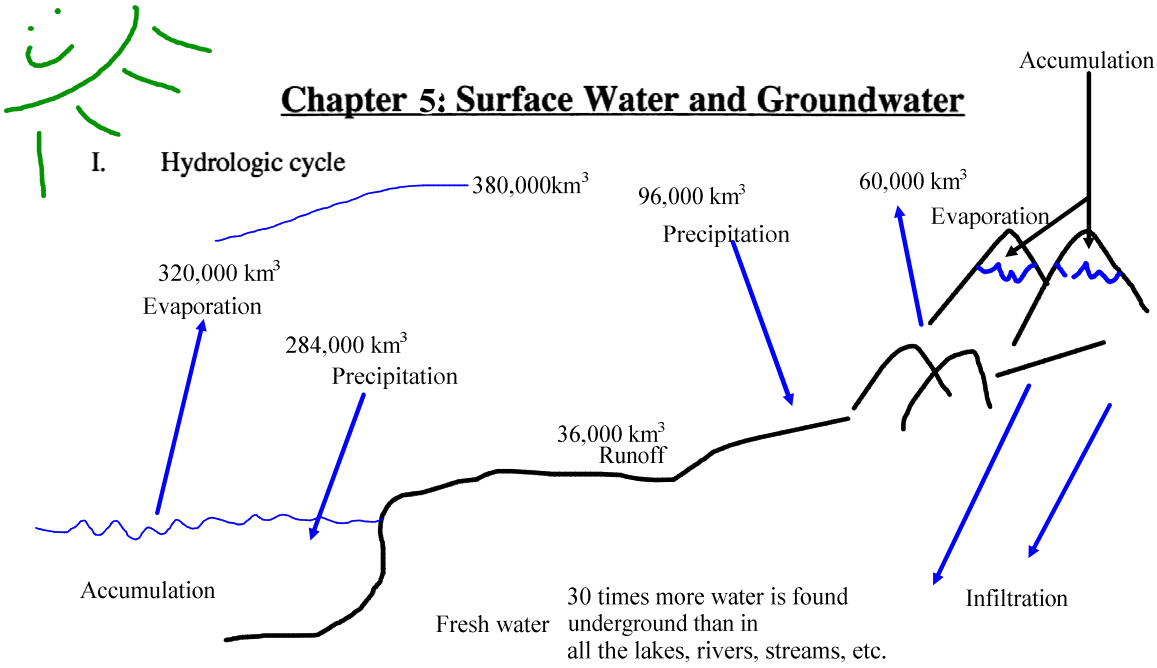
Chapter 5: Surface Water and Groundwater

I. Hydrologic cycle



World water = 100% 97% salt water (oceans) 3% fresh water
2% frozen (icecaps, glaciers)
1% available fresh water
.97% underground .03% surface water

A. Illustrates the circulation of Earth's water supply

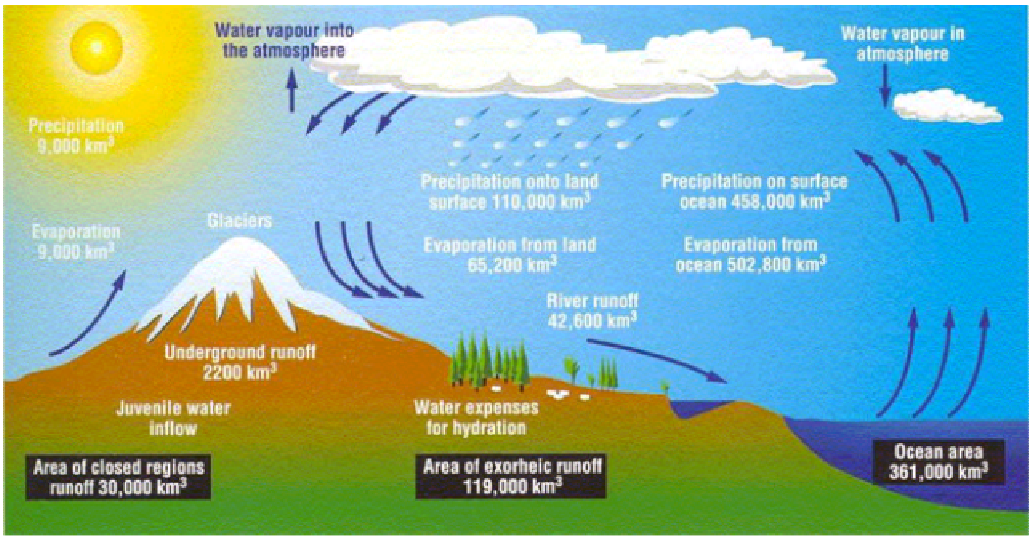
B. Processes involved in the cycle

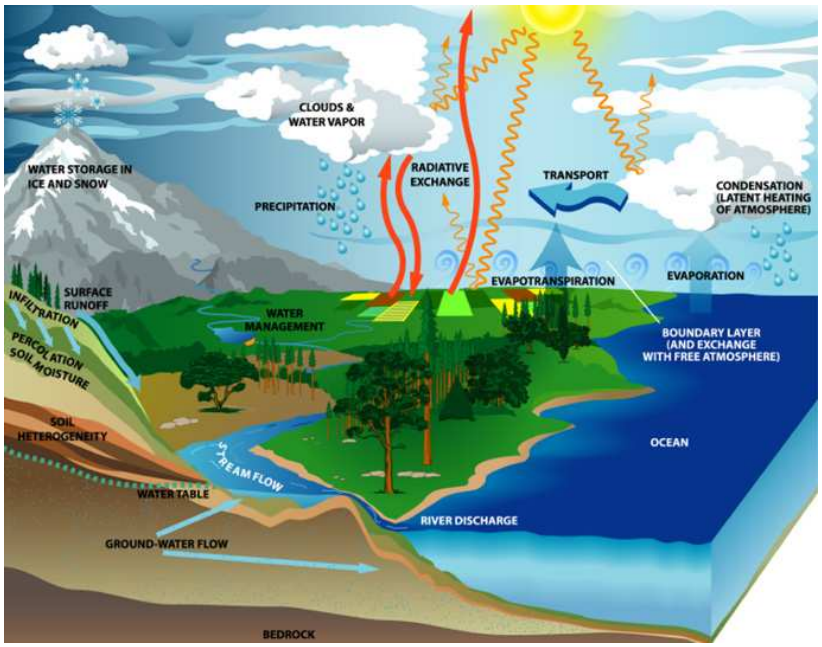
1. Precipitation
2. Evaporation — Phase changes of water; Driven by the one way energy from the Sun
3. Infiltration
4. Runoff
5. Transpiration — evaporation from plants (Evapotranspiration)

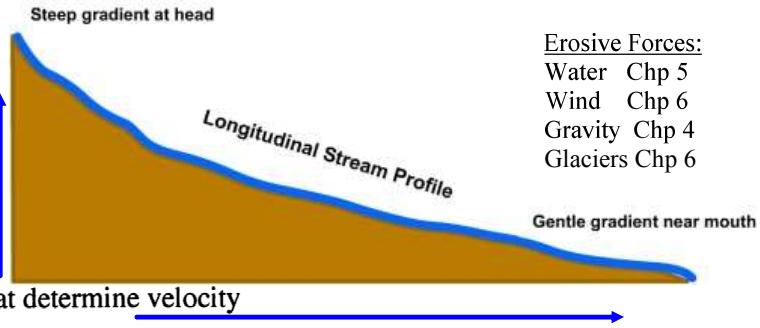
C. Cycle is balanced

Thermodynamics - Energy and matter are never created or destroyed, they simply change form.

When matter or energy change form, energy is always lost to the environment. High quality energy / matter is converted into low quality energy/ matter


Water vapour into the atmosphere
Water vapour in atmosphere
Precipitation 9,000 km³
Precipitation onto land surface 110,000 km³
Precipitation on surface ocean 458,000 km³
Evaporation 9,000 km³
Glaciers
Evaporation from land 65,200 km³
Evaporation from ocean 502,800 km³
River runoff 42,600 km³
Underground runoff 2200 km³
Juvenile water inflow
Water expenses for hydration
Area of closed regions runoff 30,000 km³
Area of exorheic runoff 119,000 km³
Ocean area 361,000 km³


CLOUDS & WATER VAPOR
WATER STORAGE IN ICE AND SNOW
RADIATIVE EXCHANGE
TRANSPORT
CONDENSATION (LATENT HEATING OF ATMOSPHERE)
PRECIPITATION
EVAPOTRANSPIRATION
EVAPORATION
SURFACE RUNOFF
INFILTRATION
WATER MANAGEMENT
BOUNDARY LAYER (AND EXCHANGE WITH FREE ATMOSPHERE)
PERCOLATION
SOIL MOISTURE
SOIL HETEROGENEITY
OCEAN
STREAM FLOW
WATER TABLE
RIVER DISCHARGE
GROUND-WATER FLOW
BEDROCK



Erosive Forces:
Water Chp 5
Wind Chp 6
Gravity Chp 4
Glaciers Chp 6

II. Running water

A. Streamflow

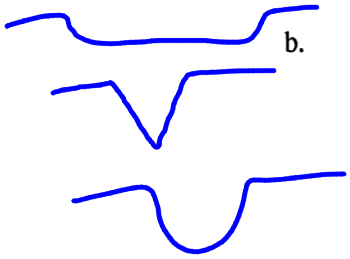
1. Factors that determine velocity

a. Gradient, or slope

b. Channel characteristics

gradient = rise / run

so many feet / mile



i. Shape

ii. Size

iii. Roughness

c. Discharge volume

feet^3 / sec or meter^3/ sec

B. Upstream-downstream changes

1. Profile

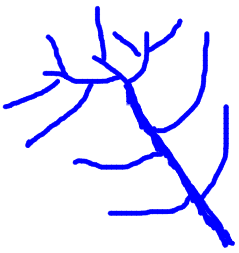
a. Cross-sectional view of a stream

b. From head (source) to mouth

i. Profile is a smooth curve

ii. Gradient decreases from the head to the mouth

2. Factors that increase downstream



a. Velocity speed

b. Discharge volume

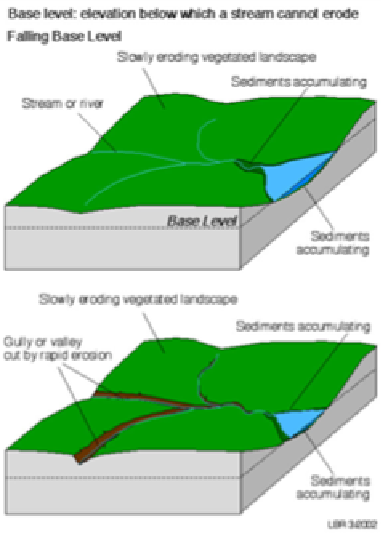
c. Channel size

3. Factors that decrease downstream

a. Gradient, or slope

b. Channel roughness

c. # of channels

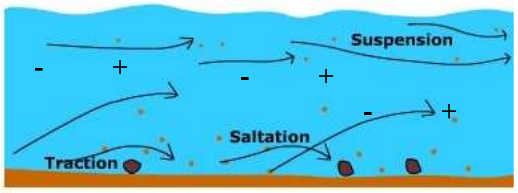


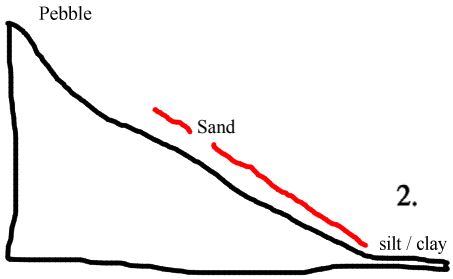
C. Base level

1. Lowest point a stream can erode to
2. Two general types
   a. Ultimate sealevel
   b. Temporary, or local
3. Changing causes readjustment of the stream

D. Work of streams

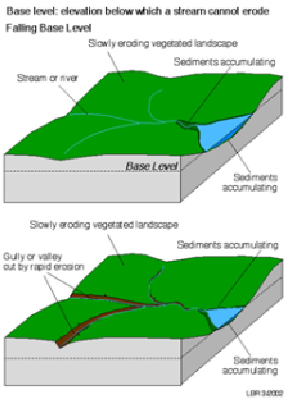
1. Erosion removal and incorporation of material in a mobile agent
2. Transportation
   a. Transported material is called the stream's load
      1. Types of load
         a. Dissolved load salt, minerals
         b. Suspended load silt - clay
         c. Bed load sand - pebbles

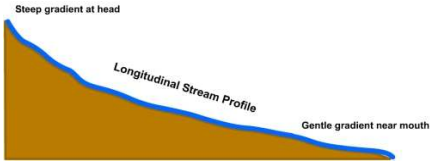


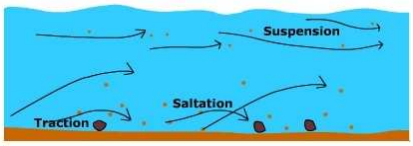


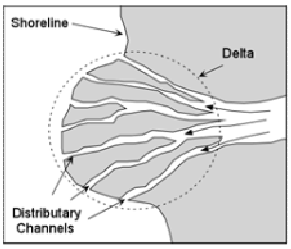
      2. Load is related to a stream's
         a. Competence
            1. Maximum particle size
            2. Determined by velocity
         b. Capacity
            1. Maximum load
            2. Related to discharge volume of water

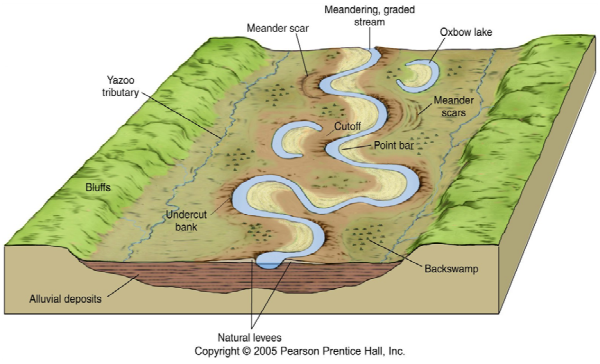
3. Deposition
   a. Caused by a decrease in velocity
      1. Competence is reduced
      2. Sediment begins to drop out


Base level: elevation below which a stream cannot erode
Falling Base Level
Slowly eroding vegetated landscape
Sediments accumulating
Stream or river
Base Level
Sediments accumulating
Slowly eroding vegetated landscape
Gully or valley cut by rapid erosion
Sediments accumulating
Sediments accumulating


Steep gradient at head
Longitudinal Stream Profile
Gentle gradient near mouth


Suspension
Saltation
Traction


Shoreline
Delta
Distributary Channels


Meandering, graded stream
Meander scar
Oxbow lake
Yazoo tributary
Meander scars
Cutoff
Point bar
Bluffs
Undercut bank
Backswamp
Alluvial deposits
Natural levees
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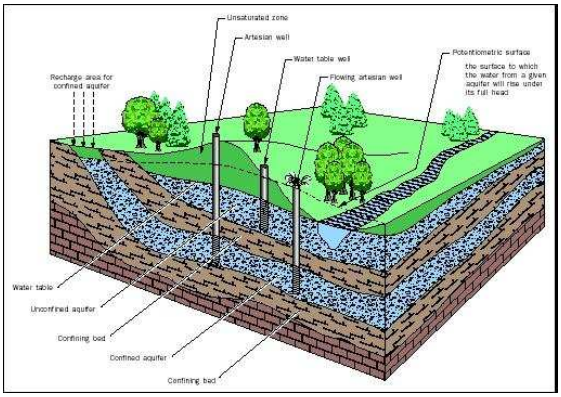
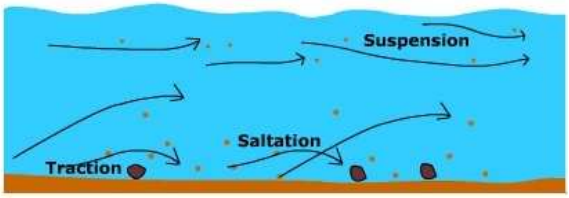
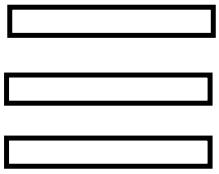
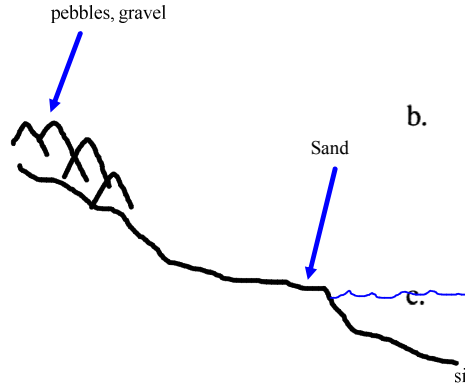

Unsaturated zone
Artesian well
Water table well
Potentiometric surface
the surface to which the water from a given aquifer will rise under its full head
Flowing artesian well
Recharge area for confined aquifer
Water table
Unconfined aquifer
Confining bed
Confined aquifer
Confining bed

Sediment Transport





1. Solution - sediment that is dissolved (salts, mineral)
2. Suspension - sediment that is suspended in the stream (silt clay) muddy
3. Bedload - Sediments bounce, roll. along the stream bed (pebbles, sand)
   Rounded sediments (conglomerate)



Fluvial - flow
Colluvial - more than one force

b. Stream sediments

1. Called alluvium

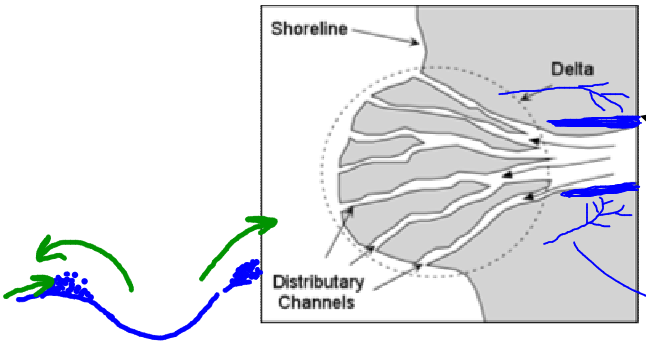
2. Well-sorted deposits

c. Features produced by deposition

1. Deltas

a. Exist in oceans or lakes

b. Distributaries often form in the channel



2. Natural levees

a. Form parallel to the stream channel

b. Area behind the levees may contain

1. Back swamps

2. Yazoo tributaries

E. Stream valleys

1. Valley sides are shaped by

Headward Erosion- streams elongate or develop in a headward direction.

a. Weathering

b. Overland flow — sheet erosion, rills, gullies

c. Mass wasting

2. Characteristics of narrow valleys

a. V-shaped

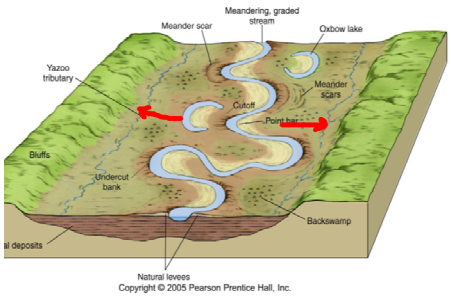
b. Downcutting toward base level

c. Features often include

1. Rapids

2. Waterfalls

3. Characteristics of wide valleys



a. Stream is near base level

b. Downward erosion is less dominant

c. Stream energy is directed from

d. Floodplain

e. Features often include

1. Meanders
2. Cutoffs
3. Oxbow lakes

F. Drainage basins and patterns

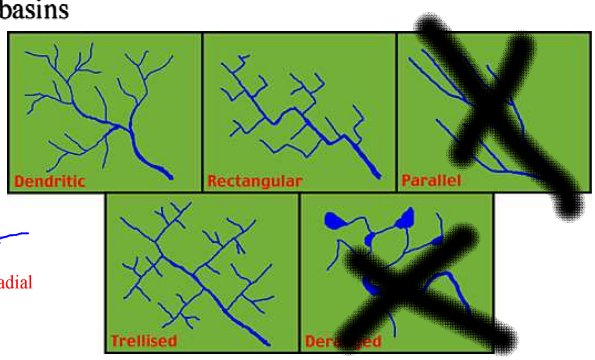
1. A divide separates drainage basins
2. Types of drainage patterns

a. Dendritic

b. Radial

c. Rectangular

d. Trellis



G. Stages of valley development

1. Youth

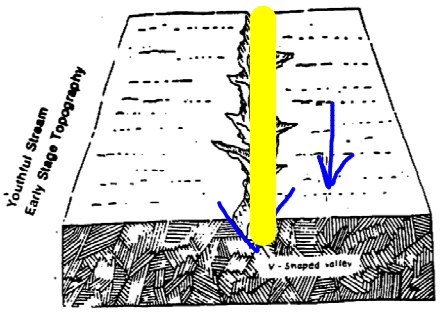
a. Rapids and waterfalls

b. V-shaped valleys

c. Vigorous downcutting

d. Steep gradient

Young / Youthful



PRINCIPAL CHARACTERISTICS OF THE STAGES OF STREAM DEVELOPMENT

Youthful stage

high stream gradient (generally greater than 10 ft/mi)

narrow, V-shaped stream valley

little or no floodplain developed

few, if any, meanders

vertical erosion dominant

Mature stage

moderate gradient (generally less than 10 ft/mi, possibly as low as 1 or 2 ft/mi)

wide, flat-bottomed stream valley with well defined valley walls

floodplain well developed

meanders common; individual meander loops may occupy the full width of the stream valley

transportation and lateral erosion dominant

very low gradient (generally less than 2 ft/mi, often less than 1 ft/mi)

extremely wide valley, perhaps with indistinct valley walls

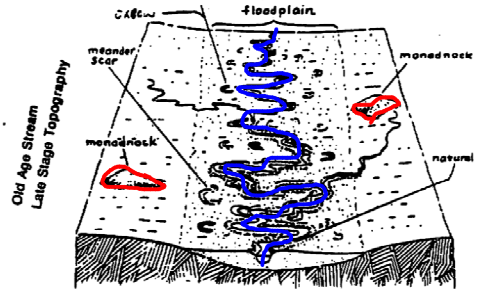
extensive floodplain, with features such as natural levees

extreme meandering; a distinct meander belt may be developed

deposition dominant

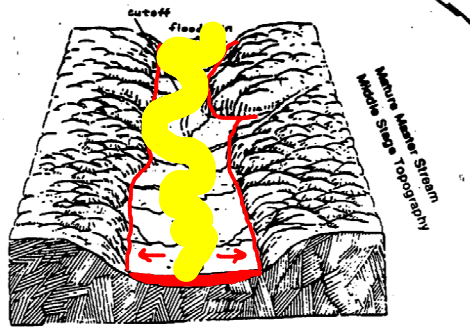
Rejuvenated stage

Tectonic uplift of a region or a lowering of base level may cause the stream gradient to be steepened and an old age or mature stream may be thus rejuvenated. The characteristic feature to look for is the presence of **entrenched meanders** which show that the stream once achieved a low gradient, but that the gradient has since been steepened, reinitiating downcutting. Increased rainfall due to climatic change may also initiate rejuvenation.



Old Age Stage

Mature



PRINCIPAL CHARACTERISTICS OF THE STAGES OF TOPOGRAPHIC EVOLUTION:

Early stage

regional dissection very incomplete, with broad uplands unaffected by erosion

poorly developed drainage system

few streams, mostly in the youthful stage, separated by broad, uneroded interstream divides

local relief **due to erosion** is generally low

Middle stage

regional dissection advanced, few areas unaffected by erosion

well developed drainage system, with maximum number of tributaries

many streams, mostly in the youthful stage, separated by narrow, rounded interstream divides

master streams mature or old age

local relief **due to erosion** is at its maximum development

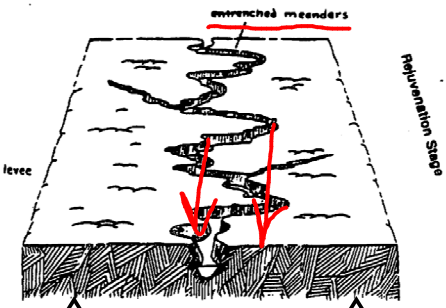
Late stage

master stream drainage dominates the region, with the master streams in the old age stage

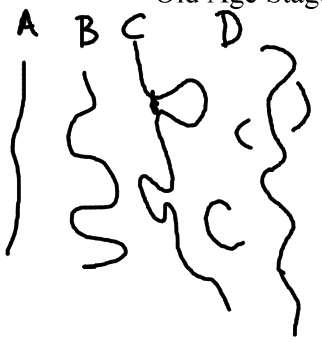
fewer streams than in middle stage due to the merger of stream valleys as interstream divides are completely destroyed by erosion

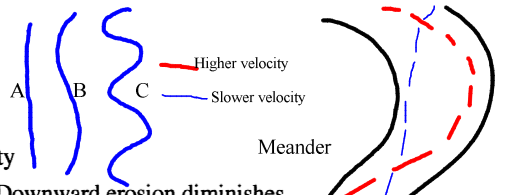
remaining interstream divides are broad and low

local relief **due to erosion** is once again low, except where monadnocks (erosional remnants) remain



Rejuvenated





2. Maturity
   a. Downward erosion diminishes
   b. Lateral erosion dominates
      Side to Side
   c. Floodplain beginning
   d. Gradient lower than at youth

3. Old age
   a. Large floodplain
   b. Widespread shifting of the stream
   c. Characteristic features
      1. Natural levees
      2. Backswamps
      3. Yazoo tributaries

Oxbow Lake

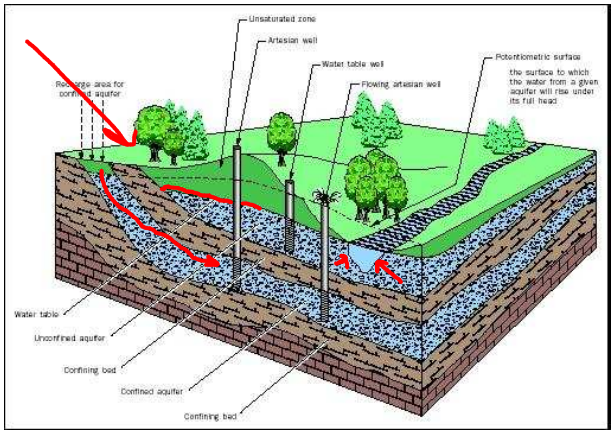
4. Rejuvenation
   a. "Made young again"
   b. Characteristic features
      1. Entrenched meanders
      2. Terraces

III. Water beneath the surface (groundwater)

A. Largest freshwater reservoir for humans

B. Geological roles

1. As an erosional agent, dissolving by groundwater produces
   a. Sinkholes
   b. Caverns
2. An equalizer of streamflow

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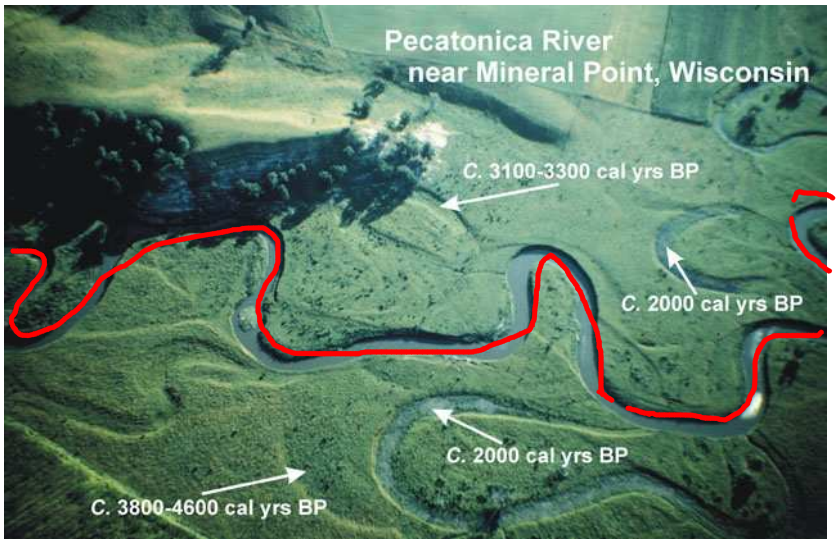
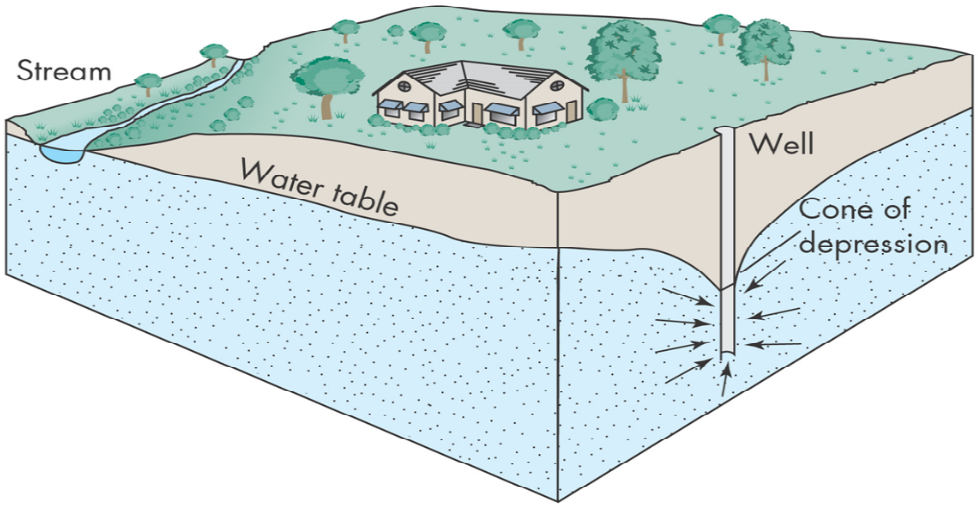
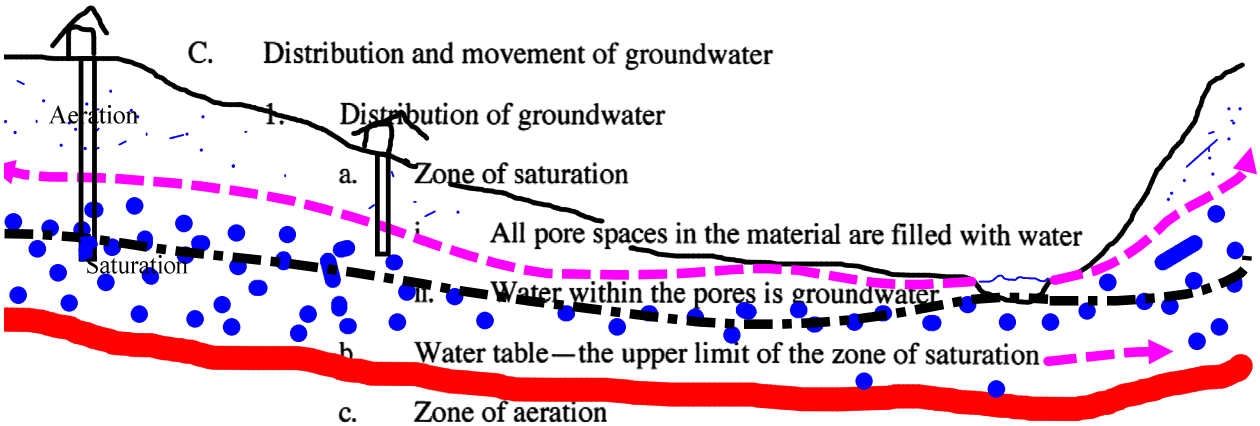

Pecatonica River
near Mineral Point, Wisconsin
C. 3100-3300 cal yrs BP
C. 2000 cal yrs BP
C. 2000 cal yrs BP
C. 3800-4600 cal yrs BP





C. Distribution and movement of groundwater

1. Distribution of groundwater

a. Zone of saturation

i. All pore spaces in the material are filled with water

ii. Water within the pores is groundwater

b. Water table—the upper limit of the zone of saturation

c. Zone of aeration

i. Area above the water table

ii. Pore spaces in the material are filled mainly with air

2. Movement of groundwater

a. Porosity Water storage

i. Percentage of pore spaces

ii. Determines how much groundwater can be stored

b. Permeability Water flow

i. Ability to transmit water through connected pore spaces

ii. Aquiclude—an impermeable layer of material

3. Aquifer—a permeable layer of material

D. Water features

1. Springs

a. Hot springs

1. Water is 6-9 C warmer than the mean air temperature of the locality

2. Heated by cooling of igneous rock

b. Geysers

1. Intermittent hot springs

2. Water turns to steam and erupts

2. Wells

a. Pumping can cause a drawdown (lowering) of the water table

b. Pumping can form a cone of depression in the water table

3. Artesian wells

a. Water in the well rises higher than the initial groundwater level

b. Types of artesian wells

1. Nonflowing

11. Flowing The Bubble

E. Environmental problems associated with groundwater

1. Treating it as a nonrenewable resource

2. Land subsidence caused by its withdrawal

3. Contamination

F. Features produced by groundwater

1. Groundwater is often mildly acidic

a. Contains weak carbonic acid

b. Dissolves calcite in limestone

2. Caverns

a. Formed by dissolving rock beneath Earth's surface

b. Formed in the zone of saturation

c. Features found within caverns

I. Form in the zone of aeration

II. Composed of dripstone

a. Calcite deposited as dripping water evaporates

b. Common features

1. Stalactites hanging from the ceiling

2. Stalagmites developing on the cave floor ground

3. Karst topography

a. Formed by dissolving rock at, or near, Earth's surface

b. Common features

1. Sinkholes

a. Surface depressions

b. Formed by

1. Dissolving bedrock

2. Cavern collapse

2. Caves and caverns

a. Area lacks good surface drainage